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Making Sense of Mastery:

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– A Theoretical Analysis

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Making Sense of Mastery:

Toward a Behavioral Interpretation of Expert Performance

– A Theoretical Analysis

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Abstract

Expert performance is a phenomenon that is receiving increasing attention in mainstream psychology. At the forefront of this research field is the view that deliberate practice – performing exercises as directed by a teacher – is the number one predictor for achieving expert behavior. Another view is that implicit learning leads to tacit knowledge (silent knowledge) which serves an important role in expert performance. One could argue that giving these summary labels explanatory status obfuscates further investigation. From a behavior analytical point of view, the fundamental question is: what are the generic and specific behavioral principles involved in building expert repertoires? Inspired by Catania's emphasis of the interplay of contingency shaping and rule-governance in expert performance, this paper aims to answer that question with a behavioral interpretation. The first two sections will cover generic and particular verbal and non-verbal behavior necessary for acquiring the behavioral repertoire called expert performance. A third section points out the role of aesthetic reactions – as presented by Francis Mechner – in acquiring expertise, performing expertly, and in establishing success criteria. The three sections will cumulate in a five-stage interpretation of expert performance followed by a brief discussion of context-specific patterns of behavior occurring within the stages, and practical implications thereof. Supplementing the main theoretical framework of behavior analysis, concepts are imported from other research traditions such as mainstream psychology. A general plan for research on domain-specific repertoires using mixed research methodologies and non-experimental participatory designs is outlined, as well as areas of further research.

Keywords: Expert performance, atomic repertoires, behavioral cusps, rule-governance, heuristics, aesthetic reactions

Making Sense of Mastery:

Toward a Behavioral Interpretation of Expert Performance – A Theoretical Analysis.

The old Italian adage *traduttore traditore* (the translator is a traitor) points to the fact that when translating a text from one language to another, something is bound to be lost in the translation. This holds true for a practitioner who is trying to teach the craft which they master. Words aimed at explaining the crafts methods and practices are destined to fall short of what it actually takes to perform. Neither is this translational verbal repertoire a requirement in becoming an expert performer of a craft. Behavior analysts have a long track record of operationalizing target behaviors and interventions in order to secure similar practice for social educators and therapists, providing a meta-view that fosters cooperation and results (e.g. Cooper et al., 2020; Ferster, 1967). Thus, they are apt translators. A behavior analytical translation has just barely reached the field of expert performance, which is the topic of this paper. When the expert is performing, the actions are so self-evident that they can be hard to explain. Yet, for aspiring practitioners, the expertise observed seems mystical and enigmatic, echoing Arthur C Clarke´s third law that, “Any sufficiently advanced technology is indistinguishable from magic” (Clarke, 1962, p. 196). For as this paper will posit, expert performance is developed with a technology of behavior. Historically, this has happened in master-apprentice relationships. Today, results of expert performance affect many aspects of our lives, as in the technologies we use, whether in providing clean water or building smart phones. Another important result is art and science. Accordingly, developing knowledge about the acquisition and teaching of expertise may improve progress. As illustrated by two recent anthologies on expert performance totaling around 2800 pages (Ericsson et al., 2018; Ward et al., 2020), the research field of expert performance has grown during the past few decades.

An age-old debate stands out concerning expertise; nature versus nurture. In this paper we will investigate the nurture side of development, for the simple reason that nurture is what we can readily do something about. The view that expertise can be learned is in line with the deliberate practice tradition that prevails in the research literature, which originated with the landmark article by Ericsson et al., (1993), asserting that it is not experience, talent, or knowledge that best predict expert performance, but deliberate practice. Inadvertently, that paper also established the 10000-hours-to-mastery convention. The contemporary level of analytical specificity in the deliberate practice view – derived from statistical studies – is summarized in two claims: expertise is acquired gradually, and training on tasks assigned by a teacher can lead to large improvements in performance (Hambrick et al., 2020). The phenomenon of performance plateaus (c.f. arrested development) is a conundrum in mainstream psychological literature (e.g. Ericsson et al., 2018, p. 753). Another prominent view represented in these anthologies is that tacit knowledge – the result of implicit learning – is essential to expert performance (Cianciolo & Sternberg, 2018). However, an operationalization of what this "hidden" or "silent" knowledge consists of is not offered. Both Ericsson and Hambrick call for a concrete analysis of the acquisition of expertise currently lacking in the deliberate practice view. They request further research efforts that "objectively describe the structure of acquired performance by each trainee as well as the process of their skilled teacher..." (Ericsson & Harwell, 2019, p. 16; Hambrick et al., 2020); a view echoed by Cianciolo and Sternberg (2018) regarding tacit knowledge. Neither of the two anthologies on expertise contains a behavior analytic contribution, so presenting an interpretation of the concept of expert performance can be a golden opportunity for integrating behavior analysis and mainstream psychology.

One barrier to a detailed analysis of expert performance may be found in the experimental methods themselves. Expert behavior does not easily lend itself to laboratory settings, since much of expertise is context-specific, and both performance and assessment subject to complex criteria. In his 2013 textbook *Learning*, A. Charles Catania touches on the subject of expert performance (pp. 401–402), stating that expert performance entails interaction between contingency shaping and rule-governance, and that this interaction develops or matures through stages referencing the Dreyfusian phenomenology of expertise (Dreyfus & Dreyfus, 1986). Another behavior analytic approximation to the subject is Constantine (2012), who learned stone carving and described conditioned seeing as an achievement thereof. The exploration of skilled performance by Francis Mechner (1995) may be the closest behavior analysis has come to a general account of expert performance to date. Mechner combined research from four separate fields in an exceptional analysis, with concepts like covert and overt routines; faulty practice and errorless training; immersion; concurrent and sequential routine assembly, and much more. Subsequently, Mechner and colleagues has published work on a wide array of topics that go beyond the 1995 investigation. Most relevant to expert performance are papers on locomotion (Mechner, 2009), heuristics and thinking (Mechner et al., 2013), and the role of aesthetic reactions (Mechner, 2019). Mechner's take on aesthetic reactions is a recent contribution to the behavior analytic canon (e.g., 2019), presenting a way to differentiate and measure reactions that are difficult to describe objectively, and which are critical to expert performance.

What may be helpful is a specialized language dealing with expert behavior in general. Although it has not specifically been put to use in this context, behavior analysis has developed analytical concepts and technical terms, along with descriptive units of analysis, well suited to deal with such a challenge. This contextualist science treats functional behavior-environment relations in ways that enable both prediction and control, distinct from mainstream psychology's goals of correspondence and prediction (Dougher, 1995). Another difference is that behavior analysts eschew the use of summary labels for explanatory purposes (e.g. Holth, 2001). The concepts and technical terms of behavior analysis are generic, which means that a general overview of the acquisition of expert behavior, regardless of field, should be within reach. However, as current behavior "...results from a prolonged history of selection – usually incompletely know to an observer – experimental analysis must be supplemented by the interpretation of behavior" (Donahoe & Palmer, 1994, pp. 125-126). Thus, a behavior analytic interpretation of expert performance is what can be offered, which differs from mere speculation since it relies on principles established through experimental analysis and concepts thereof. Due to the constraint of length in this paper the sections cover pieces of a larger puzzle that is expert performance. On this view, it should be emphasized that the concepts and technical terms used to interpret should be considered in the Babylonian sense, not the Greek, to draw a parallel from the Feynman-differentiation of math and physics (e.g. Feynman, 2012). That is, the concepts should be used to inform aspects of performance when appropriate, to show interactions, not to be understood as a complete description of expert performance as a whole starting from axioms and built upward.

The purpose of this paper is to present an interpretation of the interaction of selected behavior analytic concepts and technical terms in the acquisition of expert performance, organized according to the Dreyfusian five stage model, from novice to master (Dreyfus & Dreyfus, 1980). While they are relevant, the treatment excludes systemic (institutional), peer (those you are learning with), and personal contingencies (dealing with the life-journey in general). The paper is structured in three main sections that cover different aspects of expert performance: Contingency shaping and differential reinforcement, rule-governance and verbal behavior, and the role of aesthetic reactions. A clear distinction between the concepts and technical terms is only possible in theory. In reality, they overlap and interlock in a variety of ways when analyzing the behavioral stream. For purposes of simplicity, examples from the practice of log-house building will be utilized throughout the paper in relation to technical terms and concept application. Whenever points need additional examples for clarity, these will be selected from music, creative writing, and art history. Expert performance, expert behavior, expert skill and ability are terms that will be used interchangeably. The words technical term and concept are not interchangeable, as the first is theoretically coherent, but the latter may or may not be (Donahoe & Palmer, 1994, p. 129). When denoting both, the abbreviation C&TT will be used for efficiency. Ethical consideration will not be part of this account, as the article is an intellectual exercise, but a note on the matter can be found as an appendix. The benefit of this work is hopefully to act as a probe (heuristic) aimed to demonstrate the potential for enhancing learning and teaching of expert behavior using behavior analytic concepts, which in turn may contribute to important developments in society. Lastly, a clear-cut definition of the term expert performance will not be given and is not given in the handbooks on expertise either. However, it may be that the resultant behavioral repertoire – refined through the Dreyfusian stages – is a way to generally define it.

Contingency Shaping and Differential Reinforcement

"Men act upon the world, and change it, and are changed in turn by the consequences of their actions" (Skinner, 1957, p. 1). This section covers concepts that are related to the technical terms contingency shaping and differential reinforcement. These are essential in a functional description of the process of acquisition and refinement of behavioral repertoires, in human and non-human species alike. Shaping is both a procedure in the laboratory and in the applied treatment setting, as well as a process that occurs naturally in our lives. The result of shaping is the operants which constitute atomic repertoires and behavioral chains. In turn, these form the basis from where behavioral cusps can emerge. This can happen without verbal behavior being involved in the behavioral flow (e.g. Epstein et al., 1984), but for the subject matter of expert performance, verbal behavior and rule-governance are characteristic (fig 1). Punishment will be regarded as the presentation of a negative reinforcer or the withdrawal of a positive reinforcer contingent upon a response in this paper. It is recognized that such events have complex effects, such as eliciting respondent behavior, and notably acting as the discriminative stimulus for negatively reinforced behavior (c.f. Holth, 2005; Skinner, 1953). The next section describes an example that incorporates some relevant terms and concepts.

Learning to hand-hew an upper-joint in log-house building (fig.2). A group of students stands before a log lifted three feet off the ground. The teacher gives a step-by-step recipe of how to mark the log for hewing out a joint, concurrent with marking the log, encouraging the students to take notes. The teacher proceeds to hand-hew the joint with his axe, explaining as he performs in the same step-by-step manner. The students are then assigned a log to practice this performance and told that the teacher will come around to take questions. John (a student) looks at his notes and picks up a pencil, a lever, and his measure. After he has finished his markings, he uses a saw to make two cuts in the middle of the joint. He then proceeds to use his axe for the hewing task, which entails tracking his markings. The goal is a smooth and straight surface. Starting with a corner John chops with his axe and it gets stuck. He pulls it out and tries again, this time with more power. He manages to cut through, removing a piece of wood, but the axe traces through into the other side making an unwanted mark. Adjusting his strength, John repeats his action and manages a correct chop. He continues hewing nearing his markings. The last run, he is on the line but his axe bites too hard into the wood crossing the marking. John lets out a sigh, and a perplexing look finds his face. The teacher comes around, looks at the joint, and asks John “how is it going?” “I went over the line,” John blurts out. Smiling, the teacher assures him that it’s no problem and askes John to show him how he uses the axe. From his display, the teacher nods, and moves into hewing position. “You wanna use circular motions, when you need to be precise,” he says. Then the teacher demonstrates in 10 seconds what took John five minutes to accomplish. “You see?” he asks. John nods and tries the technique, but the axe bounces off the wood. He grips harder the next time, and he chops off some wood. “Relax, when you hit the wood. If you tense up, you tire faster, and the result will be imprecise.” John nods again and is on his way to building log houses. He proceeds to mark and hew out the top-joint ten times over. Each time decreasing the time needed, from one hour the first time to 12 minutes his tenth.

Reinforcement, Atomic Repertoires, and Behavioral Chains

The first aspect of the hewing example to be addressed involves the interaction of positive and negative reinforcing events. Positively reinforcing events are approximations to a reinforcer (conditioned reinforcement), stimulation from it (unconditioned reinforcement), and/or adding strength to the reinforcing stimulus. The unconditioned reinforcing events are set goals and/or products of performance, whether permanent (objects) or semi-permanent (words in a presentation, or live music). Four types of negative reinforcement are noted in Cooper et al (2020): Removal of aversive stimulus (escape), reduction of aversive stimulation, postponement of aversive conditions, and avoidance of aversive condition. To simplify, we can call behaviors that approximate positive reinforcement pro-behavior, and behavior that avoids or escapes contra-behavior. Usually, contra-behavior goes through stages, depending on mastery of the related situation: from escape through avoidance, to omittance (fig. 3). In the hewing example, it is clear how negative and positive reinforcement interact when John is either chopping too hard or to soft, as well as gripping to hard or to soft. Here, putting in effort without receiving any reward, is an example of a mild aversive event (c.f. contingent effort), as a chop(s) gone wrong demanding correctional responses would be another example of. Another source of reinforcement is comparing your current performance to previous performance. Here, the polarity of reinforcement can change as you progress, from being aversive to rewarding events. A more detailed analysis would be e.g., to demonstrate how the proprioceptive stimuli from the grip strength paired with the aversive result, will condition the proprioceptive stimuli from that same strength-hold to be the occasion for loosening the grip.

Hard gripping is then systematically omitted in the specific context. Chop by chop, differential reinforcement refines the behavior, on a poly-sensory stimulus level comprising of cross-modular stimulation (of either eyes, ears, nose, mouth, hands and skin). When operants are sequenced to complete a task as this, we use the term behavioral chain. Much of expert performance entails the execution of such chains, be it playing a song, or marking and chopping a log-joint. Palmer (2012) called this a fine-grained repertoire, noting that such is the nature of expert performance in ballet, music, and sports. Two main behavioral chains have been learned in the hewing example: marking and hand-hewing the upper-joint (fig. 2).

A different aspect in the acquisition of expert abilities is the term automatization, taken from the motor-behavior field (Kinesiology). Mechner (1995) describes the end product of automatization writing that when a behavior becomes – in lay terms – second nature, the nerve signals initiate directly from the spine. He further notes that after only two faulty repetitions the motor system has made a connection, which must be unlearned. Thus, errorless training is an important principle, practicing slow and steady with correct repetitions and then increasing the tempo. This insight permits the conjecture that success criteria for the atomic repertoires in behavioral chains should be such automatization. This involves fluency, a standard target in Precision Teaching (Lindsley, 1992), and the last thing John does in the hewing example. In the case where the behavioral chains are long, and parts are learned independently only to later be put together, what Mechner (1995) calls routine assembly. Moreover, automatization gives the organism capacity to focus on or learn other things. It also fosters the incorporation of more complex stimulus control, for instance, of interoceptive and proprioceptive stimuli. Automatization of actions is equivalent to reaching a new level of behaving that enable the organism to access new reinforcing contingencies. Such levels are called behavioral cusps in the behavior analytic canon, a topic we turn to next.

Behavioral Cusps

The concept of behavioral cusps was introduced by Rosales-Ruiz and Baer (e.g. 1997). A behavioral cusp is "…any behavior change that brings the organism's behavior into contact with new contingencies that have even more far-reaching consequences" (Rosales–Ruiz & Baer, 1997, p. 533), giving the examples of learning to walk and to talk as major cusps. The validity of this concepts has been demonstrated in the laboratory setting with pigeons (Epstein et al., 1984), has been used to describe the development of anti-social behavior (Bosch & Hixon, 2004), problem behaviors in persons with developmental disabilities (Robertson, 2015), as well as being used to describe the development of many other useful behaviors (Hixon, 2004). Rosales-Ruiz and Baer explicate the concept with the metaphors of steps in an orderly path and branches of a tree (1997, p. 541). Cusps can be large or small, difficult or easy to achieve. However, when concerned with expert performance, the cusps are usually difficult to achieve, or at least require repeated effort. The authors (Ibid.) use the example of starting elementary school as an easy cusp. A contrary example in the context of expertise is being admitted to Juilliard for a music degree, which demands years of intense effort to achieve. In the case of building log houses, sharpening a tool, learning how to hew, learning the recipe for marking joints, how to use a lever, etc., all are considered cusps (c.f. hewing example). In music, examples of cusps are reading chord charts, tuning your instrument, playing modal scales, and following a beat etc.

Some cusps are generic, such as fluency (or fluent component skills), economy of motion, orderliness, and persistence at arduous tasks (partly, Hixon, 2004). Whether or not these cusps are generalizable across tasks in-field or between fields remains to be seen. As numerous tasks demand creative and unconventional usage of tools, the performer is developing what has been called "wise hands" (Tesfaye, 2013). This is a cusp best described as the result of many hand task performances being automatized, which leaves your hands capable of doing things independently from thinking about steps, in general. All the performer needs is to see the result, adhering to an internal model (Mechner, 1995), and the hands can do the work. In jazz improvisation on piano or guitar, this symbiosis is typically achieved through singing the notes simultaneously as you play them. Before long, you can play exactly what you “hear” in your head. This is what Palmer (1996) called achieving parity, and what Constantine (2012) called conditioned seeing when making stone sculptures. Furthermore, being capable of performing an atomic repertoire as a whole is yet another type of cusp (rudimentary or capacity expanding nature) and perhaps a little-known source of transfer effects. That is, learning a complex repertoire with the attended complex stimulus discriminations should leave the organism changed in such a way that acquiring a new fine-grained repertoire happens faster compared with a person not knowing any complex repertoire. Locomotion is another example of a similar type cusp, which is equally involved when traversing a landscape, reading a book, or reading a piece of music (Mechner, 2009).

In sum, behavioral cusps can be identified, operationalized as behavior-environment relations, and targeted in a teaching/learning context with, e. g., multiple exemplar training. Figure 4 is a representation of such an operationalization in log house building. The effects of differential reinforcement are increasingly complex exemplified by an expanded fine-grained repertoire, new behavioral chains, and domain-specific, generic, and rudimentary behavioral cusps. All of which makes a true moment-to-moment analysis a challenge. To further increase complexity, we now move on to verbal behavioral repertoires in expert performance.

Rule-Governance and Verbal Behavior

"…it is not the delayed outcomes but rather the rules stating those delayed outcomes that more directly control the actions" (Malott, 1989, p. 283). This section covers essential verbal behavior involved in expert performance, as types of rules, types of responses to rules, how concepts are formed, heuristics and some of its uses, and the role of threshold concepts. When dealing with expert behavior, the impact of verbal behavior and necessity of rules can hardly be overstated. A verbal repertoire is a prerequisite for responding to rules at all. This paper will regard thinking as equivalent to speaking (mainly covertly) to oneself, and as subject to the same learning principles as non-verbal behavior. As such, automatic verbal responses may play an important role in the case of expert performance (Mechner et al., 2013). In any field of expertise there is a domain-specific verbal repertoire, more or less elaborate, that serves to remedy ambiguity and facilitate communication of complex information, which enables appropriate responses to classes of occasions, as well as further rule-generation. With the verbal repertoire to name and separate independent and dependent variables, both replication and systematic replication is made possible (Sidman, 1960). In addition, rule-transfer from master to student becomes possible, something that without words would resemble the hot-and-cold game, at best. On a theoretical level, rules can occasion much deliberation. Why do rules work? Why not, when they do not? We make statements, formulate principles, that summarize and elaborate our rules. This verbal behavior then occasions new verbal contingency specifications that are confirmed or falsified in practice through the process of differential reinforcement, which leads on to systems of organization and theories with methods; a specialized language for a specialized purpose evolves. Verbal behavior gives us the means to condition ourselves in relation to environmental events.

Rules

A complete rule must specify antecedent, response, and consequence. An incomplete rule gives some of the three (Cooper et al., 2020). According to Skinner (1969) rules can be differentiated in four categories: Promise, advice, warning, and threat. Thus, two rules specify positive reinforcement and two rules specify aversive consequences. In real life situations, complete rules are not usually the norm. Insinuating, prompting, and alluding-to with humorous comment, are common practices, as is the usage of stories, analogies, and domain-specific parables. The implications of a rule are not necessarily stated, which is both a strength and a weakness of rules (efficiency versus accuracy). In the hewing example the teacher presents an incomplete rule in the form of an advice when he says “You wanna use circular motions when you need to be precise.” This implies the warning, if you don’t use circular motions, you will be imprecise, as well as the promise that if you do this you will succeed. This could also be said by the teacher making eye contact with the student from afar and proceeding to prompt by pretending to chop in the air with circular motions, especially after the initial verbal instruction. Another point from the hewing example is that rule-generation took place in between the weak axe chop and its correction, e.g., in the form of thinking “I have to chop harder.” This, in turn, has all of the implications listed above.

Although the interplay of rules and responses in relation to rules (table 1) may sometimes be too complex to be teased apart in practice, three stages in relation to the behavioral cusp automatization concerning its prerequisite atomic repertoire can be identified. The first stage is when rules are provided by a teacher who gives instructions or a recipe. This could include the correction of previously obtained rules by the student, which may be ineffective, and the strengthening of those who are effective. After application in-practice (experience) this results in the second stage – rule-transfer – where the student provides the rules to themselves without an external aid. The third stage is the omission of rules, when positive practice is automatized, and performance consists of approximating a target outcome. Additionally, there are sayings that proliferate in any field of expertise. “Measure twice, cut once,” or “Don’t go against the grain” are examples from woodworking. These can be viewed as periphery rules in a specific expertise culture. Other rules are general for all expertise fields, like “nothing ventured, nothing gained” or “no mud, no lotus.”

There are hierarchies of rules in a practical sense, and just like in law, there are some rules that are usually better to follow, except in specific cases (c.f. Lex superior and Lex specialis). A novice hewing a top-joint in log house building is following more than one rule at a time. These could be rules dealing with technique and work position, that could be occasioned by aversive proprioceptive stimuli from the act of hewing or aversive stimulation from the lower back, as well as poor results from hewing. The latter could also prompt sharpening of the axe, but a dull axe can make do if you adjust and chop harder (Lex specialis). An overarching rule might appear in the form of “practice makes perfect” contingent upon struggling and could be seen as a prompt for the generic behavioral cusps of “persistence at arduous task” otherwise known as not giving up when facing adversity. As the student advances, the hierarchy of rules becomes exceedingly abundant. For behavior to be successfully rule-governed, domain-specific concepts need to form, and tacting of the essential parts of practice has to occur. If not, instructions will not make sense and correct stimulus control will be not be established.

Formation of Concepts and Technical Terms

The difference between a concept and a technical term is that a technical term is theoretically coherent, whereas a concept need not be (Donahoe & Palmer, 1994). The latter is usually developed as a consequence of experimental control in the laboratory. Both concept and technical term (C&TT) are acquired by a student by identifying two types of features; must-have and can-have attributes (Layng, 2019). These attributes are what Skinner (1957) called abstract tacts. As multiple stimuli or configurations of stimuli are to control responding in expert performance, tacting of these features is needed. Metaphorically extended tacts are also vividly used in expertise and become generic extensions of tacts in many fields (Skinner, 1957, pp. 94), like the legs of tables, the shoulder of roads, eye of the needle, or the strings in string theory. A type of concept analysis resulting in what Tiemann and Markle (1990) call a rational set – a set of examples and nonexamples – is one way of organizing the can-have, must-have, and cannot-have features. The rationale set can be presented with multiple exemplars and non-exemplars. When C&TT´s are formed, four actions are enabled; establishment of accurate tacts (stimulus classes) as in naming; determination of performance components; explaining tool use and maintenance, and pointing-out the relevant discriminative stimuli for approximation and the relative success criteria (c.f. Schlinger & Blakely, 1987). On this subject, Holth (2017) brings up the important point that tacts are not necessarily generalizable, and often times they must be trained instance by instance. An example would be that learning the names of the parts of an axe head (neck, edge, curvature of the edge etc.) does not transfer to naming the parts of a log-joint. Synonyms might also be learned, as there are many dialects in fields of study. Beyond differences in dialects, it bears mention that for instance in music, pedagogy, or psychology, different *schools* utilize distinct theories and concepts which can differ greatly, and consilience may or may not be possible (Wilson, 1998). In jazz music, the diatonic, the lydian dominant, and the Barry Harris approach are good examples of this, where each school has arranged the twelve tones uniquely, almost incommensurably.

After C&TTs are established and practical application has enabled automatization of a non-verbal repertoire, the possibility for further elaboration has been primed. These elaborations are underlying domain-specific principles, termed *threshold concepts* in pedagogical literature (e.g. Kinchin, 2010). These concepts have purpose far beyond elaboration, as a facilitator of dot-connection and stepping stones for further advancement.

Threshold Concepts

A threshold concept (TC) is defined as "… a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learning cannot progress" (Meyer & Land, 2006, p. 3). In biology, the example is natural selection (Kinchin, 2010). Without this threshold concept, facts of biology related to evolution become hard to understand and piece together. In behavior analysis, selection by consequences is arguably the principal threshold concept, without which reinforcement, extinction, schedules, etc., become difficult to grasp. In the world of woodworking, grain-direction, raw edge, and log scribing are examples. Threshold concepts provide context for other concepts, (re)organizing classes of stimuli and responses derived thereof. Kinchin (2010) proposes five criteria for classifying a concept as being a threshold: it must be transformative, irreversible, interactive, bounded, and troublesome (see table 2 for a tentative application in log-house building). Notably, the effect of non-formation of a threshold concept can be developmental stasis (Kinchin, 2010). This is similar to developmental plateaus as mentioned above and could provide another piece to the puzzle of arrested development. If you rely on rules instead of threshold concepts, you may be at a higher likelihood of failing in new situations not covered by known rules. You are more likely to generate appropriate rules in new situations if you know the appropriate threshold concept. Mastering threshold concepts serves as verbal behavioral cusps.

The extent of verbal behavior intricacies in expert performance would not be approached if the next subject was ignored. There are ways of organizing inquiries and probe subject matter that serve many purposes.

Heuristics

Any expert performance involves much more than can be explained and taught directly. Students need to acquire knowledge and experience by themselves. This can be achieved in part with the verbal repertoire of heuristics, a type of thinking skill. Mechner et al., (2013) details how they teach heuristics in a New York private school. They teach heuristics for reflection, conceptual thinking and building, creativity, thinking ahead, or to make distal nodal connections by "…formulating thinking skills as sets of heuristics that are applicable to certain situations or challenges, and conceptualizing these heuristics as behavior that takes the form of questions and decision trees, a wide range of thinking skills becomes definable and teachable" (Mechner et al., 2013, p. 292). A key point concerning this verbal repertoire is that it too becomes automatized. "We make them *(heuristics)* so fluently and automatically that we forget we once had to learn them…" (Mechner et al., 2013, p. 288). These can occur so fast that we barely register anything save for the answers provided in response. Heuristics can be applied to a wide range of situations, in the form of probes such as "What is the master doing to be successful?"; "What problem am I facing?"; "How can I solve this?"; "How can I learn that skill?"; "What am I missing?"; "What else do I need to learn?"; "How should I practice this skill?"; "What are relevant concepts?"; "Where else can I apply this idea?"; "What is a nonexample and what is an equivalent example?", and so forth. The possibilities of heuristics as Mechner et al (2013) view them are vast. Of special interest are heuristics for making distal nodal connections (equivalence relations) which entail class expansions and class mergers (e.g. Green & Saunders, 1998). However, a prerequisite for trans-nodal connection in-field seems to be "… a rich and fluently available conceptual repertoire" (Mechner et al., 2013, p. 291). Heuristics also play a part in the development of domain-specific maturation and taste.

In sum, technical terms, concepts, and abstract tacts, are parts of an expertise culture that comprises rule-governance and thereby brings future reinforcing effects to the present. There are many ways of differentiating between types of rules and responses to them. It may also be possible to distinguish between rules for establishing atomic repertoires, for automatization, for reaching cusps, and for generic cusps. Threshold concepts give depth and interconnect rules, actions, and statements of fact in a discipline. Heuristics serve to expand nodal connections and probe possibilities. Now we turn to the role of aesthetic reactions in expert performance, a type of intrinsic reinforcement that is dependent upon both verbal behavior and products of performance.

Aesthetic Reactions and Success Criteria

In the preface to his first short story collection, Phillip K Dick writes that the essence of sci-fi literature is a "...distinct new idea" that produces a "...shock of dysrecognition" (Dick, 2010, pp. 6-7). Dick's definition corresponds with Mechner's (2019) view of aesthetic reactions, who states that "...when appropriately primed, disparate cognitions, at least one of which is affectively charged, interact transformatively" (Ibid., p. 176), aesthetic reactions occur. A combination that is transformative can for instance be "...incongruous, unexpected, surprising, antithetical," or "...increase[s] coherence in some other way" (ibid., p. 177). That is, an initial conception is manipulated by another concept resulting in something new. A synergy occurs. As an example of something unexpected, Mechner uses the picture of a bicycle seat turned vertical with bicycle handles as horns (to resemble an ox). "The term aesthetic is also used for certain types of negative reactions like disgust or aversion" (ibid, p. 167). Mechner argues that since the biological utility of actions such as learning, exploration, and play is linked secondarily to eating, drinking, and reproduction (c.f. primary and secondary competencies, Winegard et al., 2018), the intrinsic reinforcing event of an aesthetic reaction has developed as a reinforcement bridge for modern cognitive competencies (MCC).

These MCCs are not self-maintaining (verbal behavior, inquiry behavior, music, and math are examples), but are integral to many categories of behavior (see Table 4). Mechner elaborates thus:

> “The essence of the theory is that aesthetic reactions, when they occur, are evoked by certain kinds of interactions among such cognitions rather than by their mere occurrence. To evoke an aesthetic reaction, at least one of the interacting cognitions must be affect-charged (must have an “emotional” component, as one might say colloquially). A cognition that is initially affectively neutral can become charged with affect via respondent conditioning events that occur from time to time in the normal course of life, that is, when cognitive events coincide, randomly and fortuitously, with unrelated affective events or situations. When such coincident pairings occur, the cognition may acquire conditioned stimulus (CS) functionalities. The unconditioned stimulus (US) in such conditioning events may be an affect-laden event of various possible origins” (Mechner, 2019, p. 182).

Art history shows how aesthetic reactions evolve through desensitization and the seeking of new aesthetic reactions, creating new artistic trends. The original acanthus ornament was beautiful, and 15th century aristocrats and royalty wanted it everywhere. Through mild manipulation of the basic image, acanthi adorned new places, new things, etc., from portals, walls and ceilings, to the silverware and tea pots. Once the aesthetic excitement wore out, a bigger change was needed. Asymmetry was substituted for symmetry and maritime artifacts and roses were added to the ornaments. Rococo was considered fresh and groundbreaking until the novelty wore off, and what emerged was art nouveau, a style that kept the asymmetric flow, but scrapped the acanthus. When desensitization occurs, chasing new aesthetic reactions is what we do as a species (see table 3 for two examples). Perhaps this is the wisdom in the Japanese aesthetic called Wabi sabi, that appreciates the beauty of the continuous process from seed, growth, bloom, and deterioration (Richie, 2007).

An important point here is that "…beauty and similar descriptors are not properties of stimuli or of aspects of the external world… they are our perceptions and reactions to these (stimuli)" (Mechner, 2019, p. 168). This corresponds with what Skinner (1957) writes on some instances of the metaphorical tact, where "...the common effect need not be the metaphor itself" (p. 97), but feelings that mediate the metaphoric extension. When we say it's a scary movie or funny comedy, we are tacting the aesthetic reactions within us and projecting them onto the source of stimulation. A different example would be a deep or thought-provoking book referencing an intricate story with ideas that occasioned reflection and reconsideration of established facts.

> "What they (aesthetic reactions) do have in common with operant learning is modification of the concept repertoire – the manipulation and elaboration of discriminations, generalizations, and relations, which always occurs in operant learning. Since this type of involvement of the concept repertoire is also always present in aesthetic reactions... one is tempted to conjecture that concept manipulation (which usually results in some learning) is one of the explanations for the reinforcing effects of aesthetic reactions. Another component of the explanation for the reinforcing quality of aesthetic reactions is their affective component..." (Mechner, 2019, p. 179).

Accordingly, there are two things that need to happen in order to evoke/elicit a new aesthetic reaction: One, manipulation of two cognitions, and two, transfer of respondent conditioning to one of the cognitions, as Pavlov did with the metronome (Catania, 2013). This is a plausible way to describe acquired tastes; how we expand our initial taste (aesthetic reactions) into all sorts of depts and peripheries. The extreme example of late modal jazz is illustrative.

Someone predominantly immersed in pop music may have to be slowly weaned on to a jazz diet for them to eventually enjoy *A Love Supreme* by Coltrane (1965). Which relates to the fact that not infrequently, specific discrimination abilities (concepts and abstract tacts) are prerequisites to appreciating the arts, crafts, or musical performances, and have aesthetic reactions. Humor is a good example too. A stinging sardonic commentary might go by unnoticed for a person who loves slap-stick humor. Here, the threshold concepts are the likes of slap-stick, irony, sarcasm, and sardonicism. In academia and research fields, acquaintance with a vast terrain of existing literature is prerequisite for appreciation and fascination. An example is the string-theorist Edward Witten comparing the beauty of an equation to the beauty of a piece of music (Witten, 2020).

Another way to approach this aspect with regards to expert behavior, is to identify certain types of concept combinations that are connected with certain behavioral cusps. The first level of concept mingling happens to a novice by mixing false or no preconceptions with an appropriate concept introduced by the teacher. A different type of concept combination happens when using tools in new ways related to multiple exemplars, which is also a way of producing distal nodal connections, including new uses of concepts and combinations thereof. The third is the aesthetic reaction of the "expansion plot," an oft used plot type in creative writing (Sanderson, 2020). This occurs when a potent threshold concept is introduced as previous knowledge and experience is put in a new light that facilitate making distal nodal connections. More fleeting aesthetic reactions are appreciation of the tools, the craftsmanship involved, the effort and difficulty demanded, the creativity, and considering the utility of the end-result of performance products.

Aesthetic reactions are also implicit in criteria of success. In most cases, if an aesthetic reaction occurs, something was a success or a disaster. In a competition, this occurs when we assign the two concepts of winner(s) and loser(s) to the participants in the end (c.f. tension and release). If stimuli from one of the participants are affect charged, then an aesthetic reaction follows the result either way. When reading a book or watching a movie, aesthetic reactions vary from reactions resulting from the storytelling, imagery and music (as intended), to getting annoyed with the choices of overused clichés and turning it off. Furthermore, aesthetic reactions are highly involved in the development of the success criteria themselves, as in figure skating, ballroom dance, or big jump snowboarding competitions, where the criteria are stylized. That is, certain movements and executions are graded, and a performance is ranked by points, depending on difficulty, execution and perceived beauty. A different example would be in basketball or soccer where it isn't always about the goal, but how the goal was scored. That is, if the goal was done in a way that demands great insight into the game (ingenuity or shrewdness), showcases rare athletic feats, or happens in an underdog situation, this context potentiates the aesthetic reactions (c.f. tension). In a master–apprentice relationship, the master can experience many aesthetic reactions by recognizing the student's progress (two conceptualizations: past and present products) or lack of it. Some vocational crafts have criteria on a more open-ended scale, as the "good enough" criteria in carpentry is an example of, where utility is the predominant aesthetic (c.f. value or rule).

The previous sections have examined key concepts and technical terms that are important in the acquisition of expert performance, both verbal and non-verbal behavior, as well as the role of aesthetic reactions. There are several specific considerations worth noting, practical implications and conjectures to be made. First, an interpretation of the acquisition of expert performance using the steps in the Dreyfusian (Dreyfus & Dreyfus, 1980) phenomenology will be presented. A note on the five stages as presented below: The contents of the stages are stylized, and in real life would depend on teacher choices and vocational opportunities e.g.

The Five Stages, Context-Specific Patterns of Behavior, and Recommendations

Novice. Everything is new. The atomic repertoire needed to perform behavioral chains and the behavioral chains themselves must be learned. Learning happens by differential reinforcement of practical skills in combination with informal rule-generation, and by following formal rules presented by a teacher as recipes (steps) and checklists. The success criterion for having learned the basic repertoire is automatization of actions, reducing the need for explicitly stating rules during performance. When correct practices have been selected through their consequences, the rules generated to “fine-tune” performance are omitted along with faulty practices, and recipes are only needed occasionally for reference. This automatization now enables the performer to act in a new way which brings him/her in contact with new environmental contingencies; a major behavioral cusp has been reached. While the expert repertoire is far from established, the apprentice is on a level congruent with vocational participation and being part of a team. In the example of log-house building, this would amount to using two axes in two different ways involved in hand-hewing the upper joint, the lower joint, and the moss-line; to use the log-scribe to lower a log horizontally (level), and provisionally being able to sharpen the axes. A novice must learn how to think about the subject at hand in new ways, where preconceptions meet domain-specific concepts, abstract tacts, and technical terms as they are formed – MCCs – and thus this interaction occasion aesthetic reactions.

Competent. The atomic repertoire expands into other areas, involving new behavioral chains that through fluency (automatization) occasion new behavioral cusps. For instance; fitting new axe handles to suit one’s hands, shaping the curvature of the axe edge and its concave/convex profile, learning to make the roof (e.g. roof angle, fitting logs, and extending roof outside wall rafters, laying grass and/or stone roof, floor structure and insulation, windows and doors, and building safe scaffolding. At this point, several threshold concepts are introduced like that of the raw edge and log-scribe leveling (Fig. 4, level 2) which serves to connect the dots of why the rules given were necessary. Heuristics are learned to improve and expand rules and make them more appropriate and personalized, and are indispensable when approaching new, idiosyncratic problems in practice. Taken together, what follows is a massive expansion of the rule-complex and domain specific verbal behavior, which needs time to be automatized. The many varied tasks are now resulting is the beginnings of what has been termed *wise hands*.

Proficient. This level is all about getting experience with real life projects, applying all of the atomic repertoire many times. It is the time where the learner must find and fill holes in his abilities, which involves discussions of techniques and approaches, as well as planning, budgeting, and making work schedules. Additional atomic repertoire now encompasses the whole process, such as selecting trees and storing/drying them, separating roofing and wall material, choosing the right insulation, determining the appropriate type of foundation and doing foundation work (points or block in cement, large stones and dry stonework), right angle and type of roof, and types of finish like tar and oil stains etc. The behavioral cusp at this stage will be the ability to make full house from start to finish. A taste for aesthetics, both in terms of self-expression and in congruence with values could develop. Nodal connections, like connecting the effect of age and living conditions to the applicability of the material in a structure, are made. The performer's rule complex extends further, the cusp of *wise hands* is achieved, and heuristics become automatized.

Expert. At the expert stage it is all about multiple exemplars of all kinds of houses and building, e.g., out house, stables and barns, annex, house extensions, grain mills, traditional water saws, cabins, and houses. It is here that restoration of old houses comes in, changing roofing, insulation, replacing rotten logs or parts, straightening a house that has sunk on a side and much more. This requires an abundance of ability, knowledge, and experience. If there is a cusp here, it is when all these things have become second nature, in the sense that no matter what situation comes along, you have an adequate solution. That then is mastery.

Aesthetic reactions can occur at numerous times throughout the stages, as when you learn to use a familiar tool in a new way, when you are nearing the finish of a product and you can see it becoming, in planning the product (conditioned seeing), and when you connect dots as in tying a threshold concept to abstract tacts and concepts. Conversely, aesthetic reactions will also occur when you botch an attempt, are stuck in a process, or have to perform a repetitive task for an extended period.

Context-Specific Patterns of Behavior

A way to further explicate the development of expert behavior within this five-stage model is as context-specific patterns of behavior in the learning process. Due to the generic nature of the C&TT presented in the main section, a limited number of distinct patterns should exist. These patterns can act like a contingency trap (Baum, 2017). However, these "traps" should be considered beneficial. Some of these behavioral patterns might be a way toward operationalizing "persistence at arduous task". The first example of a behavioral pattern is as follows: Contingency shaping occasions rule-making, the rules occasion statement of facts, which again occasion further contingency shaping. A second example would be that learning a threshold concepts alters statements of facts, refines rules, and thereby changes practices. A third could be when a problem occasions applying heuristics successfully, leading through differential reinforcement to a solution and generation of a new rule. Fourthly: Heuristics for unpacking rules and practices are learned and applied which serves to connect dots; Why this rule? What is this telling me? Where else can I apply this? Why is he doing that? What is the benefit to standing like she does? *Is* there a benefit? Yet another behavioral pattern would be to look at external models performing a task, describing the behavior and its product (tacting target behavior and result), and then pursue differential reinforcement in copying the described behavior in practice, which leads to new rule-generation and new abilities. A sixth example is when metaphors, analogies, parables, and stories are told which elicits heuristics for dot-connection, rule-generation, rule implications, and new target behaviors or performance product possibilities. Seventh: A rule-complex learned either copied from a teacher or as a product of contingency shaping can occasion heuristics to uncover underlying principles or perhaps a threshold concept.

Taking these behavioral patterns together with the five stages above, certain insight and practical implications be derived. A few general recommendations will now be given and divided into preparations, implementations, and sources of stagnation.

Recommendations

In *preparation*, outlining the subjects or clusters of the atomic repertoire as well as target behavioral cusps would be a good start. Next, charting all abstract tacts and C&TT needed to follow the rules concerned in the recipes of the atomic repertoire, followed by making the rational sets of exemplars and non-exemplars. Another required behavior is to map out the many uses of each tool and how to teach them with tasks, as in multiple exemplars (fig. 4). This will create equivalence relations and make teaching and prompting in later settings easier. Threshold concepts (TCs) need to be charted and specified according to the five features (see table 2). If possible, the many ways a given TC integrates previous concepts, abstract tacts, experience and skills would be an asset to diagram. Mapping out the important generic behavioral cusps would help the teacher to give behavioral specific feedback describing those cusps and to identify when such a behavioral cusp is missing. In order to measure fluency (automatization) the teacher should time performance of the different behavioral chains and record time spent for later reference to student performance.

These preparatory efforts are necessary to secure a thoughtful *Implementation.* The five stages can be presented in the classroom along with learning principles which can give students insight into the whole acquisition process and promote learning how to learn. In order to encourage both heuristics for problem-solving and persistence at arduous task it is vital to let students struggle and give them a need to find a solution. As such, the rule-of-thumb given should be to struggle and persist before searching for the answer elsewhere. Introduce concepts, examples, and opportunities for making appropriate experience before introducing threshold concepts. As this is analogous to the training structures used in stimulus equivalence research, one could make the case for the early introduction of TCs, the One-To-Many (e.g. Green & Saunders, 1998). However, the introduction of threshold concepts usually occurs later, as in Many-To-One (Meyer & Land, 2006). Additionally, when presenting TCs, first present heuristics for discovering them, such as; *What do these examples have in common? What do the techniques have in common? What is the fundamental principle here? How can we simplify what underlies these examples?* Furthermore, the behavioral cusp of automatization needs to be achieved in motor operations and thinking skills, before moving on to more advanced skills or expanding to other parts of the atomic repertoire. This has to be told explicitly, and that therefore a select part of the atomic repertoire cluster will be targeted first before introducing more (c.f. fluency). This is especially important when the behavioral chains are long. Errorless training should be instructed ostensibly and thereafter sought deliberately by the students. The teacher should encourage structured journaling, focusing on challenges and how they were solved, and have group sessions where these occurrences are discussed, and principles of learning identified. When the students can tact the behavioral pattern, behavioral cusps, abstract tacting, concepts, and threshold concepts, this knowledge could be transferred further into the learning process as well as to other subjects.

There are many *sources of stagnation*. If the behavioral cusp of automatization is not reached before moving on to other parts of the atomic repertoire repeatedly, stagnation will inevitable ensue as the performer will reach the limit of what has been called working memory. This limit will be individual to each student, as a novice never comes into a craft as a *tabula rasa*. If generic behavioral cusps are not learned – as cleanliness and economy of motion – this too will impede progress. Persistence at arduous tasks is invaluable, and not achieving this cusp is detrimental. If threshold concepts are not grasped this will limit learning in many ways, notably in limiting dot-connection and creativity in solving new and unexpected challenges. Non-formation of a relevant TC is deemed a source of developmental stasis (Kinchin, 2010). Aside from these sources there are some behavioral patterns that can have unconstructive outcomes. Faulty practice is not a direct source of stagnation, but a way to postpone progress. Another example is procrastination being occasioned by a problem. If either a relevant heuristic is missing in the verbal repertoire, or the problem is too difficult for the performer at the current proficiency level, this context will act as a S^D first for escape and later for avoidance. Various forms of countercontrol (Delprato, 2002) would serve as ways to not follow the rules provided by a teacher (see table 1 for a list of countercontrol responses), and could also postpone the learning of important lessons indefinitely.

Limitations and Further Research

A broad presentation of some of the interactions of C&TT has been offered within the parameters of this paper. However, this is to be considered a starting point, as the level of detail could be greatly increased on most of the topics covered here and other topics could easily be added. Table 5 illustrates these possibilities, showing 55 distinct interactions between pairs of C&TTs. Experimental research on respondent conditioning, stimulus control, and stimulus equivalence would be next in line for inclusion in the interpretation, along with competition contexts as motivating operations, and conjunct and adjunctive reinforcement. Moreover, when tackling a field of study as vast as expertise (obviously multiply determined) and within the confines of a thesis spanning 40 pages, the list of relevant aspects and co-variables that cannot be addressed is uncomfortably long. Examples are: the concept of heuristics as related to self-efficacy and growth mindset; flow state as a cusp; finding limits on what we can learn in one session (information in the behavioral stream); expertise linked with vulnerability and openness; cognitive load theory; cognitive consonance and dissonance; expertise from a perspective of psychological flexibility (ACT); Solomon avoidance learning and hypervigilance (a state that occurs in high-risk professions like policing, military, ambulance personnel etc.) and expertise; interoceptive awareness, transcendental meditation and mindfulness in expert performance; bias and fallacies, and superstitious behavior in expertise; creativity and problem solving; talent and giftedness; sleep and restitution; morphic resonance; neurotransmitters; working out and nutrition; brainwaves; the non-cognitive skill *Grit*; historiographic considerations; the correlation between mental illness and genius; and motivation through sense of mastery and self-determination, are some examples in an non-exhaustive list.

Further Research

Specific domain application must occur to test the applicability of the interpretation presented in this paper. Expert performance is difficult to control in a laboratory setting and traditional experimental methods are likely to fall short. However, it is possible to systematize discovery with non-experimental and participatory methods, as discussed by Guerin (2018). Ethnographic possibility studies would be a promising place to start, along with backwards engineering of skills, making testable hypotheses about controlling variables. Embedded and intensive research methods accompanied by recording verbal behavior, as in protocol analysis and cognitive task analysis are further possibilities. Structured journaling (e.g. Watson & Tharp, 2007) is another method suitable in this context that could uncover important verbal and nonverbal atomic repertoires, as well as cusps and concept formation. A recommendation is to tackle a small skill in which an intermediate-skill level is attainable within a relatively brief period of practice, and that involve behavioral products easily assessable. Suitable examples are wood turning, chip carving, smithing a nail, drawing something (like a hand), a face, etc., writing a short story, fly-fishing, or playing video games like Hollow Knight, Super Mario 3, etc. Primitive skills like the bow drill or hand drill, basketry, pottery, and making traps (Paiute deadfall) are other appropriate examples. By conducting immersive investigation of the acquisition of a smaller skill, relevant rules of what-to-do and what-not-to-do may be uncovered: Which tools are needed and what does appropriate usage look like; a rationale set of the relevant C&TT, abstract tacts, and threshold concepts could be made; a chart of the distal nodal connections of respective threshold concepts could be made. Comparative studies of traditional crafts like smiting, wood carving, furniture carpentry, and log house building, would be a further step, where an operationalization of the repertoire required to reach official qualification could be made. Here, structured interviews with masters and apprentices would be a good place to start investigating and mapping out the steps and stages. Social skills would be another interesting area to investigate at different levels of school. The topic of motivation would be a great topic for further investigation related to sense of mastery, self-determination, self-efficacy, and growth mindset. Another angle of study that would be applicable across domains is under the heading teaching and troubleshooting. What are the common mistakes when acquiring expert behavior, and how can we ameliorate them? As mentioned, researching emerging patterns of learning which maybe generalizable across domains and possible to drill in smaller scale would be very interesting.

Conclusion

This paper has identified many relevant C&TTs from the science of behavior analysis to expert performance and arranged them in the Dreyfusian five-stage model to illustrate how expert behavior can be interpreted. The behavioral cusp of atomic repertoire automatization is of particular significance – from novice to master – whether involving verbal behavior as heuristics that become lightning fast, or non-verbal operants that can result in *wise hands*. Smaller context-specific behavioral patterns have also been recognized that reveal intricacies in the process of learning from moment-to-moment. This may be a way to approach an articulation of the mystery of tacit knowledge. Furthermore, the applicability of the interpretation is not exclusive to expertise and could readily be applied to ADL skills or abilities that don't have the high dynamic potential as expert performance fields do, as driving a car or making a meal. If advancing our knowledge of what expert performance involves, and how to produce experts more consistently are goals we want to approximate, I would argue that the theoretical foundation of behavior analysis is a superior alternative to the current psychological theories in-vogue. However, cooperation and consilience should be keywords in the continuation of this interpretative work, for it to have outreach and impact. The founder-effects of learning heuristics, threshold concepts, efficient rule-governance, and ability to persist in an arduous task etc., early on in a learning career are startling. As are the possibilities of the further research outlined above. Taken together, this paper should be considered a probe (a heuristic) into how behavior analysis can approach the research area of expert performance. The steps taken toward a behavioral interpretation of expert performance point to a path that can avoid the traitorous tendencies of the translator, and dispel the magic referred to in Clarkes' third law at least momentarily.

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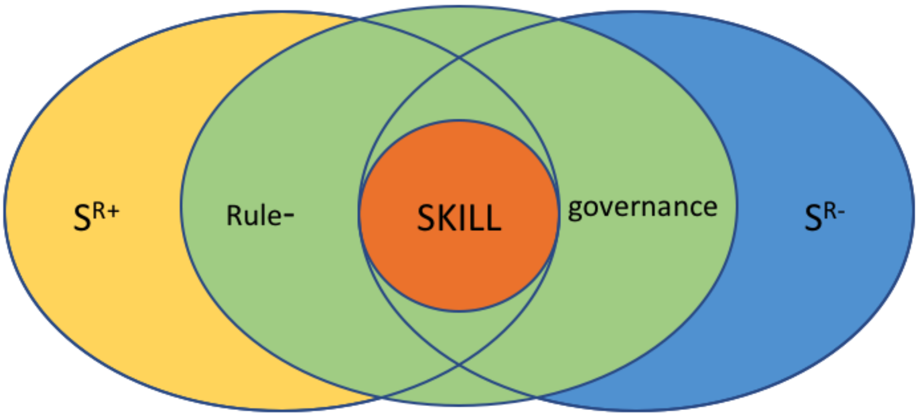
Figures and Tables

Figure 1

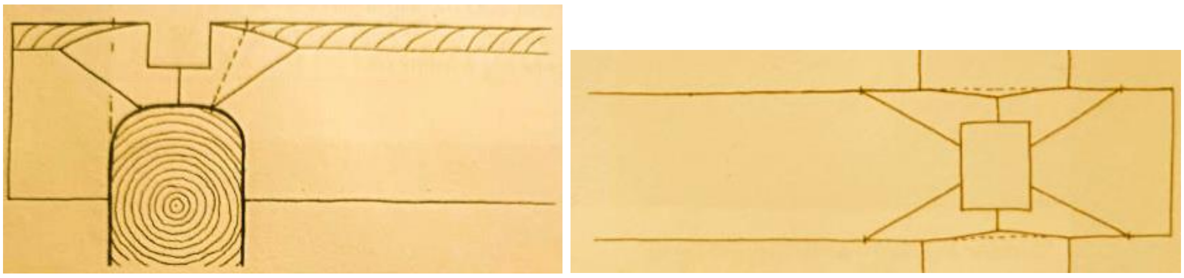
Interaction Between Reinforcing Contingencies and Verbal Behavior in Learning a Skill



Note. Positive and negative reinforcing events provide the occasion for rule-generation and thereby rule-governance in the acquisition of a skill. This is a process that continues to the point where a rule is found that corresponds with a practice that is acceptable in terms of effort and result.

Figure 2

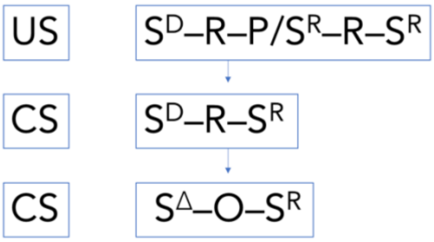
Upper Barke-Joint



Note. A representation of the basic Barke-Joint (Godal et al., 2015, p. 211). The left figure is in side-view, and the right in top-view. There is a recipe of steps both for marking and hewing this joint.

Figure 3

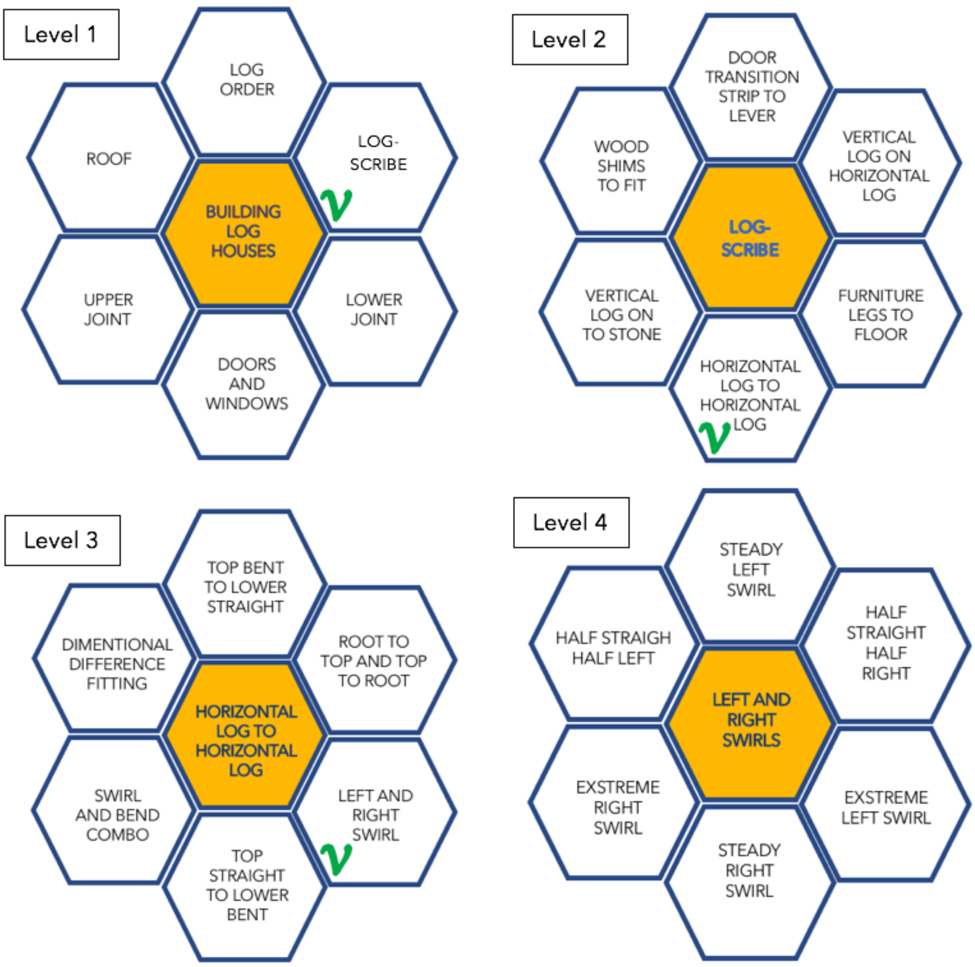
Stages of Contra-Behavior



Note. From top down: US – an unconditional aversive stimulation facilitates an escape response. CS – avoidance of the aversive stimulation. CS – avoidance become so effective that it is not visible; a delta stimulus occasions omittance.

Figure 4

Category Levels of Behavioral Cusps and Multiple Exemplars



Note. Levels of depth in studying log-cabin building marked with a green V. The category level is described in the middle orange hexagons.

Table 1

Types of Rules and Rule-Related Responding

Types of rules	Promise, advice, warning, threat
Rule-related responding	Rule-following, rule-making/generation (from observation or from experience or from others experience), rule-bending, rule-breaking, rule-improvement, rule-transfers, rule-extension, rule-discarding, reflecting on implications of a rule, reflecting on the limitations that comes with a rule, rule-reinterpretation and more
Rule-context	Exemplar, practice, graded task, work-placement, work, etc
Countercontrol	"attack, aggression... military desertion, religious apostasy, religious reformation, protest, revolt, rebellion, revolution, defection, dropping out, truancy, vandalism, absenteeism, criticism, sabotage, slowdowns, strikes, boycotts, inaction, failure to comply (as with medical or psychosocial recommendations or requests), active or passive resistance, inattention, daydreaming, quitting, feigning illness, cheating, disrupting classes or meetings..." (Delprato, 2002, pp. 2-3)

Note. These are some of the ways in which people respond to and present rules.

Table 2

Threshold Concepts in Log-House Building

	Raw Edge	Grain Direction	Log-Scribe Leveling
Transformative	Now you know why your axe won't sharpen	Now you know why the wood flakes off, and how to accommodate	All the rules and procedures now make sense.
Irreversible	You will not sharpen axes naively after	You won't make the same mistake again	You will know why, and this will be hard to unlearn
Integrative	Relates to knives, gauges, chisels etc.	Relates to wood carving, wood turning, furniture making et.	Relates to many ways of lowering logs–vertically and horizontally
Bounded	Applies to sharp edges	Within the realm of wood work	Highly specific applicability
Troublesome	Hard to see and discover	Non-uniform and challenging in practice	Takes time to practice and is very complex

Note. This is a tentative application of threshold concepts in log-house building. The three categories of threshold concepts are on the top row, and the five aspects on the left-side vertical.

Table 3

Aesthetic Reactions in Trends

Art	Baroque (symmetry and acanthus)	Rococo (asymmetry and acanthus)	Art neuve (asymmetry and non-descriptive flows)
Jazz	Big band (many changes and chord tone improvisation)	Bebop (Many changes and superimposed chord tone improvisation)	Modal (Few changes and superimposed chord tone improvisation)

Note. This is an oversimplification of a few steps in the evolution of art history and jazz. However, it serves the point of desensitization and trends.

Table 4

Six Activities

Interpersonal behavior	Acts of love, generosity, communication, collaboration, or protection
Maintenance of a culture's cohesion and continuity	Language, rituals, décor, dress, traditions, customs, art forms, and memes in general
Performances	Acting, dance, music, oratory, sports, comedy, or other displays of skill
Narratives	Relate or recall events, orally or via writing or film, or stimulate associations
Prevailing	In combat, competitive sports, games, or other types of competition
Provisioning	Creating collections and stores of items that may be useful in the future, like food, multiple dwellings, money, or other resources

Note. These are the types of activities where aesthetic reactions play an essential role, Mechner asserts (2019, p. 175).

Table 5

Matrix of Concepts and Technical Terms

Aesthetic reactions											
Heuristics											
Threshold concepts											
Concept formation											
Reacting to rules											
Rule-governance											
Behavioral cusps											
Automati-zation											
Behavioral chains											
Atomic repertoires											
Differential reinforce-ment											
	Differential reinforce-ment	Atomic repertoires	Behavioral chains	Automati-zation	Behavioral cusps	Rule-governance	Reacting to rules	Concepts formation	Threshold concepts	Heuristics	Aesthetic reactions

Note. A matrix showing the possible interactivity of the concepts and technical terms presented in this paper. There are 55 distinct relations of two and two. Considering interactions of three or more C&TTs the number of relational possibilities is astronomical.

Appendix

Ethical Considerations Regarding Expert Performance

“Making Sense of Mastery...” is a theoretical paper, and as the author I can take no responsibility for the research done in the studies cited or take any credit for developing the concepts and technical terms presented. Neither have I handled any personal or confidential data or information. Nor have I quoted any study that I deem unethical. The subject matter of expert performance seems to be one without much controversy. However, I will offer some thoughts on the topic of expertise.

Michael Sandel (2010) presents the trolley dilemma in the auditorium for his class at Harvard, called justice: what is the right thing to do? The dilemma for the hypothetical trolley driver is simple: either you continue on course and kill five men, or you change tracks and kill one man. Sandel poses three versions of this creating discussions and asking the students to reason why they made their stance. The point is that most of us would choose to do the lesser harm if we had the option. Most of us would choose to do what we perceive as good, if we had the opportunity. Experts change the world, and often for the better. Thus, along this line of logic one could argue that becoming an expert is the right thing to do. To this point, the hero’s journey (e.g. Campbell, 2008) is found in all cultures around the world. It is a teaching tool, a roadmap, and in inspiration to many. In pop-culture movies and books like Star Wars, Harry Potter, Lord of the Rings, Dune, etc., tells this tale. These stories resonate with us. Who doesn’t want to be a hero? Similarly, who doesn’t want to be an expert or a master craftsman? Yet, expert performance is exclusive to those who are able to go far beyond instant gratification and proceed in the extreme. To postpone reinforcement for years and years, discounting the easy choices (c.f. Green & Myerson, 2004). Those who say it’s about the journey, not about the goal. With whom the lines of Robert Frost resonate, “Two roads diverged in a wood, and I– took the one less traveled by...” (Frost, 1916, p. 131), or Thoreau’s

"I went into the woods, because I wished to live deliberately...." (Thoreau, 1854, p. 98). Mastery becomes an elusive goal, a moving target, and in a real sense a way of life. Great thinkers, artists, craftsmen, and engineers embrace this way and trailblaze beyond the norm. Simply put, they are "uncommon among uncommon people" (Goggins, 2019, 1:30.14).

The ancient Greeks valued virtues, and so do we. The ethical code for behavior analysts, for instance, list excellence and integrity as goals (BCBA Ethics Code). The right to effective treatment (Van Houten et al., 1988), was an earlier article that was influential in shaping behavior analysts ethical compass (Bailey & Burch, 2016). However, effective treatment is directly related to expert performance, in that without an expert no effective treatment could be prescribed. Perhaps one could extend the "right to effective treatment" to "the right to effective teaching?" The paper I have presented is a step towards this: Making sense of mastery: toward a behavioral interpretation of expert performance. More experts may contribute to more scientific discoveries and therewith a betterment of people's lives. If we can educate more experts faster, it will also save recourses in many ways, as in educational cost and in the efficiency of services given in society.

Equality of opportunities is where we should put in our efforts, I say. A lesser utopia than the contemporary alternative equity of outcomes. We don't choose our parents or where we grow up, but we can choose our friends and what to focus on in life. There is no shortage of successful athletes that give the message that hard work is the way. Like Ronaldo, "talent without work is nothing" (2023). It all depends on the goal we put in front of us. If happiness is a goal, then I would argue that the struggle towards excellence is one way to achieve it. It will give you sense of mastery, self-efficacy, self-agency, and the ability to make a difference. Brene Brown's viral TED presentation (2011) summarized years of research on the topic of happiness and unequivocally concluded that the happiest people are those who dear to try, who view vulnerability as a necessity. Those who have "...the willingness to say *I love you* first" (Brown, 2011, 10:17), who give before they can take, and also those who try and try again, never giving up. The sentiment from Brown is echoed in the morals derived from ACT (Hayes et al., 2012), which can be summarized by acting on values. A major value I personally have had and that has been with me in learning music, martial arts, primitive skills and bush craft, wood turning, wood carving, and log-house building is to preserve the cultural heritage of our species. Which was an inspiration for my paper; presenting a meta-view, about learning how to learn, and what it constitutes. The same with consilience, one of Wilson's main points in his book with the same name (1998) that advocates for cooperation among different sciences, instead of remaining in their solemn silos (c.f. Tett, 2016). This was also in the back of my mind when I wrote the paper.

I think most would agree that it is better to teach a man how to fish, than to give him a fish each day. However, when it comes to expert performance, you yourself have to put in the effort, as one hard fact remains: No one can build mastery for you. To paraphrase Gervais: no one became an expert behind their own back (Gervais, 2015, 10.47). You have to get behind the mule (Waits, 1999).