The Phenomenology of Problem Solving

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Abstract

I outline a provisional phenomenology of problem solving. I begin by reviewing the history of problem-solving psychology, focusing on the Gestalt approach, which emphasizes the influence of prior knowledge and the occurrence of sudden insights. I then describe problem solving as a process unfolding in a field of consciousness against a background of unconscious knowledge, which encodes action patterns, schemata, and affordances. A global feeling of wrongness or tension is resolved by a series of field transitions, which are guided by peripheral experiences of coherence or "rightness." I treat the distinction between reproductive thought (in which we rely on existing strategies to solve a problem) and productive thought (in which we struggle to identify new strategies) as a difference in field structure. With reproductive thoughts and actions, we perform operations to solve a problem in a semi-automatic sequence. In productive thought, by contrast, a kind of parallel search occurs. This may explain the otherwise obscure phenomenology of struggling to break an impasse.

Keywords: Problem Solving, Phenomenology, Insight, Gestalt Psychology, Edmund Husserl, William James, Aron Gurwitsch, Otto Selz, Max Wertheimer

1 Introduction

Spend a few minutes trying to solve the following problem (as you do, intermittently reflect on the process):

> You are given a 4-gallon jug and 3-gallon jug. How can you use them to measure out exactly 2 gallons of water?

The answer is in this footnote.[1] You now have a few minutes of phenomenological data. To speak as a Husserlian working in the style of David Woodruff Smith: what parts and moments, intentional contents, and horizon contents occurred in your stream of experience during those few minutes?

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[1] Fill the 3-gallon jug with water and pour it in the 4-gallon jug. Now fill the 3-gallon jug again and top off the 4-gallon jug, so that 2 gallons remain.

Here are my own observations, together with reports I've received when asking several groups to solve this problem. We imagine water being poured in and out of the jugs. We associate the jugs with numbers (e.g., 3 and 4 gallons) and perform mathematical operations (addition and subtraction) on those numbers. We have some sense of the goal of solving the problem, and (especially in group settings), experience a desire "win" by being first to solve the problem. Some report a sense of how close they are to solving the problem. Some kind of inner thought or speech unfolds. At times, there is a feeling of struggle or striving, of trying to figure something out. People are also aware of their perceptual surroundings, of other people and of the objects around them. Some report "trying to figure out what the trick is" or just mind-wandering to other topics. In informal settings, people ask questions and talk about the problem with me and with one another. Some enjoy the challenge; others find it annoying.

I believe that there is potential to develop an account of many of these features of problem solving, within a broadly "California style" approach to phenomenology, the kind of approach associated with David Woodruff Smith's work.[2] Smith and his collaborators systematically connected two disparate areas—Husserlian phenomenology and philosophical semantics—in the 1970s. I focus on a different set of parallels: one between Husserlian phenomenology and the psychology of problem solving.

After reviewing the history of problem solving in psychology, and laying out some of the main results and controversies associated with the field, I develop a provisional phenomenology of problem solving. Here are the main features of the account.

First, problem solving unfolds in what Aron Gurwitsch, drawing on the Gestalt psychologists, called a "field of consciousness" (Gurwitsch 1964). The problem is felt as a kind

[2] Classic works in this tradition are (Føllesdal 1969; Smith and McIntyre 1982). On the history of the "California School" see (Yoshimi, Smith, and Tolley forthcoming) and the introduction to (Smith 2004).

of tension or gap in the field that we strive to resolve. Possible solution strategies are dimly experienced in a periphery or fringe surrounding focal experience. We pursue strategies that feel "right" (Mangan 2003), based on their overall coherence with our sense of the problem. Problem solving involves the progressive resolution of a global sense of tension via a series of rightness-guided field transitions. As we try to solve a problem, other contents unfold in the field (we see people, get up and walk around, etc.) and influence the problem-solving effort, often in unconscious ways.

Second, the phenomenology of problem solving involves an interplay between the field of consciousness and an unconscious repertoire of action patterns encoded in background knowledge. Specific actions or mental operations that have previously been reinforced are afforded by a given problem-solving context. As we gain more experience with a particular type of problem we add more action sequences to our repertoire. Classic results in problem-solving psychology can be understood in these terms. The fact that successful action patterns tend to be reused explains *set effects*, whereby people fixate on strategies that have worked on the past, even when better strategies are available. With *functional fixedness* (e.g., failing to use a box as a platform when filled with matches), background knowledge motivates irrelevant actions or no actions at all.

Third, this apparatus can be used to develop an account of the distinction between reproductive and productive problem solving (Selz 1924), i.e., solving a problem using existing strategies in background knowledge vs. struggling to solve a problem when existing strategies fail or are unavailable. Reproductive processes unfold via a distinctive type of field process, in which previously acquired strategies are applied in a smooth, "transparent" way. Productive processes involve the creation or acquisition of new knowledge when existing strategies fail, i.e., when an agent is blocked, or stuck at an impasse. The phenomenology of being at an impasse may correspond to a form of parallel search, in which potential solutions are peripherally experienced as more or less right.

2 The Psychology of Problem Solving

Problem solving involves many psychological processes: learning, concept acquisition, reasoning, language, and memory, among others. Thus the history of problem-solving psychology is virtually coextensive with the history of psychology (Davidson and Sternberg 2003; Dominowski and Bourne Jr 1994). However, there is a set of classical problems and studies in the field, and a major theoretical rift, between the *insight* theories of the Gestalt school, and the *search* based theories of early Artificial Intelligence (AI) research. We can get a pretty good feel for the area by focusing on these approaches and the classic studies associated with them.

2.1 Insight Theories and the Gestalt School

Max Wertheimer, a Gestalt psychologist who spent much of his later career studying the psychology of thought, opens *Productive Thinking* by asking "What occurs when, now and then, thinking really works productively? What happens when, now and then, thinking forges ahead? What is really going on in such processes?" (Wertheimer 1959, 1). Productive thinking is contrasted with reproductive thinking, which, according to Adriaan De Groot, "consists primarily of the execution of mental operations by which relational facts that are present in memory are activated and reproduced as such" (De Groot 1946, 61).[3] Productive thinking is a kind of

[3] De Groot is summarizing the distinction as it is developed by Otto Selz (Selz 1924).

creative problem solving: processes in which "no previously formed knowledge complex can provide an immediate answer" (De Groot 1946, 61). In these situations, agents don't simply rely on existing knowledge structures, but must learn or do something new.[4] Wertheimer sought to approach the question of productive thinking scientifically, and as part of this project to determine an "inventory of basic operations in thinking" (Wertheimer 1959, 2).

Here are some salient features of his account. (1) The operations involved in thinking only occur relative to a person's high level understanding of a situation, her "mental set" or *Einstellung* ("attitude", compare Husserl's use of the term), or what Wertheimer calls "whole characteristics" (p. 189). (2) The field of thought evolves in the direction of "structural improvement" (compare the Gestalt perceptual principle of *Prägnanz* or pithiness). (3) When the answer to a problem is not known, "gaps", "trouble regions" and "disturbances" (p. 235), "create strains, stresses, tension in the thinker" (p. 239). (4) We sometimes get blocked, intensifying the tension. The thinker tries to restructure her knowledge until the tensions are resolved. (5) Wertheimer describes this as a step-wise process of changing one's mental state by "operations" on the situation in the direction of "vectors" which indicate "the direction of helping the situation, of straightening it out structurally" (p. 238). (6) Wherever a short-cut is possible, there is a preference to take it. People tend to rely on what they already know, operating reproductively or habitually. (7) People dislike the "fog" of a lacking answer (p. 244), but great thinkers make the effort to apply a sequence of operations which restructures the field to yield a solution.

Similar ideas were pursued in animal studies and human experiments by subsequent Gestalt psychologists. At the primate research station in the Canary Islands, Wolfgang Köhler

[4] Wertheimer studied the "birth of genuine ideas" (a process he acknowledges occurs only rarely, though in some more than others).

wrote *The Mentality of Apes* (Köhler 1924), a landmark both in psychology and ethology. Köhler studied a small group of apes (as well as some hens, dogs, and children) for four years. He presented the apes with a series of increasingly difficult tasks, mostly involving the acquisition of visible but out-of-reach food. He begins with the "fundamental" task of obtaining food visible through a grating but obtainable only by turning around and "back-tracking" around an obstacle. In this situation, hens "are quite helpless; they keep rushing up against the obstruction when they see their objective in front of them through a wire fence" (Köhler 1924, 14). Chimps and dogs solve the problem easily, in what can be described as an insight pattern: a period of hesitation followed by a sudden transition to direct movements towards the goal. For example, Köhler describes a dog who "sees [the food], seems to hesitate a moment, then quickly turns at an angle of 180 degrees and is already on the run in a smooth curve, without any interruption, out of the blind alley, round the fence to the new food" (Köhler 1924, 13).

His most famous experiments involved chimps obtaining food: by stacking objects, fashioning tools from sticks, pole-vaulting, and combining these and other techniques. Here he describes Sultan, in a situation that required that he combine several previously learned techniques:

> After moving the box to and fro a while, he left it alone, and began in a more careful way to look about him (obviously seeking an implement), and now saw a stick hung from the roof. At once he made for the box, pulled it under the stick, stepped up, tore down the stick, hurried to the bars, and pulled down the fruit. From the moment he caught sight of the stick, his actions were perfectly definite, clear and continuous (Köhler 1924, 177).

Köhler's work gave rise to an extensive literature. It was shown that when an ape found a working solution strategy, it could easily redeploy it in the future, and could adapt working strategies to new tools (e.g., using a branch instead of a stick to retrieve food). Others showed that time spent with similar objects facilitated a quick response. For example, (Birch 1945) found that “a few days’ experience playing with sticks (in ways other than reaching) substantially helped young chimpanzees succeed in using sticks to retrieve food” (Dominowski and Bourne Jr 1994, 25). More recently Janet Metcalfe and David Wiebe (1987) have shown that insight corresponds to a specific class of problems in which subjects don’t report a feeling of progress on a problem until just before they solve it (with non-insight problems, e.g., multi-step algebra problems, subjects report feelings of incremental progress).

Karl Duncker (1945) studied factors impeding problem solving, specifically “functional fixedness,” a tendency to perseverate on the familiar affordances of an object, for example, only seeing a chair as something to sit in, as opposed to a weapon or a source of kindling. Duncker refers to Köhler’s ape studies, noting that when a branch is “fixed” as a “visual figural unit ‘tree’,” the ape initially fails to notice that it can be used to retrieve food (Duncker 1945, 85). Duncker studied functional fixedness using a series of experiments, most famously his “box and candles problem.” In this experiment subjects sit before a table of objects, including candles, tacks, and a few boxes. The subject’s goal is to mount the candles side by side on a door. In one condition the boxes are filled with the candles, tacks, and other items. In the other conditions the boxes are empty and sit alongside the candles and tacks. The solution to the problem is to tack the boxes to the door and use them as platforms for the candles. Subjects have a harder time solving the problem when the boxes are full, indicating that the function of containing things fixates their thought process and makes it harder for them to see them as platforms.

Abraham Luchins, an American student of Wertheimer, studied a similar type of perseveration, using the water-jug problems we opened with. He showed that once a solution strategy was found—e.g., using the three-gallon jug to first fill, and then top off a four-gallon jug, leaving two gallons in the three-gallon jug—subjects would fixate on these methods to the exclusion of other, sometimes better, strategies. Here again we see the importance of unconscious prior knowledge. Luchins, drawing on Wertheimer, referred to this as a subject's "mental set" or "*Einstellung*", and defined it as a frame of mind "developed by the sequence of events in the actual experimental situation" (Luchins and Luchins 1959, 111). He studied these cases using a series of "set-inducing" or "E" problems.

The study of unconscious influences on problem solving continued with Norman Maier, who showed that subjects who could not initially solve a problem could sometimes find a solution when hints were given. Subjects were generally unaware that any hint or aid had been provided, which further suggests that unconscious (or, conscious, but non-focal) factors can play a role in problem solving. One of Maier's most famous problems was the two-rope problem, which he described as follows:

> The experiment was carried on in a large room which contained many objects such as poles, ringstands, clamps, pliers, extension cords, tables and chairs. Two cords were hung from the ceiling, and were of such length that they reached the floor. One hung near a wall, the other from the center of the room. The subject was told, "Your problem is to tie the ends of those two strings together" (Maier 1931, 182).

The problem had at least four solutions, but the experimenters were interested in a specific solution which involved tying a weight to one of the cords, swinging it, quickly retrieving the second cord, and catching the first cord as it swung back. If a subject could not find this solution to the problem, a series of hints were given. The first was this:

> The experimenter walked about the room, and, in passing the cord which hung from the center of the room, he put it in slight motion a few times. This was done without the subject knowing that a suggestion was being given. The experimenter merely walked to the window and had to pass the cord (Maier 1931, 183).

Subjects would often solve the problem after this hint had been given, but reported no knowledge of the hint having occurred.

Maier also introduced the 9-dot problem into psychology (Maier 1930). In the 9-dot problem subjects are presented with the grid shown in FIGURE 1 and asked to connect them using no more than 4 straight lines, without lifting their pen. The solution requires creating straight lines that extend beyond the figural square the dots produce. People "are so dominated by the perception of a square that they do not 'see' the possibility of extending lines outside the square" (Kershaw and Ohlsson 2001, 1).

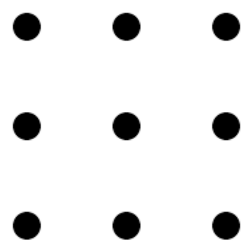

Figure 1. Maier's 9-dot problem.

A common theme in these studies is the influence of prior knowledge in problem solving. Past experience determines how we approach a problem. As much as possible we rely on *reproductive* thinking, on habit, on reusing what's worked in the past. As Luchins showed with his jug problems, once a working strategy is found, people tend to use it, even to the exclusion of better strategies. Our sense of the "normal" use of an object dominates our use of it, so much so that a branch isn't initially seen as a tool to retrieve food, and a box is not seen as a possible platform. Moreover, these influences on our behavior are often unconscious. (For example, Maier's subjects could solve the rope problem when hints were given, without even realizing they'd been given a hint.) These ideas were sometimes framed in neural terms; Köhler, for example, claimed that perceptions leave malleable memory traces in the brain that inform subsequent behavior (Köhler 1970).

2.2 Early Artificial Intelligence and Search-based Approaches

The second main line of thought in the problem-solving literature largely originates in the work of Allen Newell and Herbert Simon,[5] who argued that human problem solving involves goal-directed search in a space of possible solutions to a problem (Newell and Simon 1972). Evaluation of moves in chess provides a familiar example: “if I move my knight there, then I expose my bishop to attack; if I move that pawn then my opponent can take it….” Newell and Simon studied logic problems, algebra problems, crypto-arithmetic, the Towers of Hanoi, and other puzzles and games.[6] They studied these cases by comparing the think-aloud protocols of human problem solvers with computer simulations of reasoning processes, most famously the “general problem solver” (GPS).[7] GPS worked by setting a goal state, comparing the current state of the system with that goal state, and then either setting a new sub-goal or searching for a state closer to the goal. They illustrate the basic idea with an example

> I want to take my son to nursery school. What’s the difference between what I have and what I want? One of distance. What changes distance? My automobile. My automobile won’t work. What is needed to make it work? A new battery... (Newell and Simon 1972, 416).

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[5] Newell and Simon drew on Selz and de Groot, so that the two main lines of problem-solving research have a shared history.
[6] Cryptoarithmetic involves mappings from words to numbers such that, for example, one can explain how it is that “DONALD + GERALD = ROBERT”. In Towers of Hanoi, disks on rods must be moved in accordance with a few simple rules.
[7]In think-aloud protocols subjects report on their thought processes while they perform a task. The method (arguably) has affinities with introspection and phenomenology.

GPS was one of the first general-purpose problem-solving systems in AI, and probably the first example of a "cognitive architecture," i.e., a model of cognition implemented in a computer system. It evolved into the SOAR cognitive architecture, which is still in use today. Newell and Simon provided evidence that GPS was an adequate model of human problem solving by comparing the internal steps GPS took in solving problems to verbal protocols they collected from human subjects solving the same problems. For example, one line of a trace of GPS solving a logic problem read "Apply R3 to L2; rejected, not desirable." This was compared to the following human protocol: "Well...then I look down at R3 and that doesn't look any too practical" (Newell and Simon 1972, 457).

Subsequent work on search examined the specific search strategies or "heuristics" humans appeared to use, in particular, hill-climbing (making moves that bring one closer to a correct solution) and means-ends analysis (when blocked, identify what is blocking a solution and produce a new sub-goal). By the 1970s, simple versions of the search approach had come under attack, both by philosophers (Dreyfus 1972) and psychologists (Bassok and Novick 2012). Hubert Dreyfus (drawing on the Gestalt psychologists) argued that problem solving does not generally involve the application of rules to atomistic facts, but rather begins with an overall understanding of a situation, relative to which particular rules are applied. Psychologists studying problem solving observed that human problem solvers often rely on domain knowledge (e.g., details of how boats, ropes, candles, and jugs work), and that GPS only seemed to work for problems that were abstracted from domain-specific knowledge.

This concludes my review of the problem-solving literature, though it should be noted that the field remains extremely active. Current areas of research include: the relation between problem solving and intellectual ability; differences between novice and expert problem solvers; the role of creativity, motivation, working memory, and mood in problem solving; the design of systems to assist learners and problem solvers; collective problem solving; and analogical transfer between problem types. For review see (Bassok and Novick 2012; Davidson and Sternberg 2003). A useful meta-level study of the field of problem-solving research is (Kotovsky 2003). There is also a separate European tradition of studying complex problem-solving tasks, which cannot be factored into simple sequences of perceptual and cognitive operations (Frensch and Funke 2014).

3 The Phenomenology of Problem Solving

In this section I integrate the psychological results surveyed above with ideas from a range of classical and contemporary phenomenologists, including James, Husserl, Gurwitsch, Smith, and Mangan. My goal is to develop a first pass at a "naturalized" phenomenology of problem solving (Mangan 1991; Yoshimi 2016b; Zahavi 2010).

3.1 Problem Solving has a Dynamical Field Structure

According to Gurwitsch, the *field of consciousness* corresponds to everything a person is aware of at a time, including a focus of attention and a structured periphery of inattention (Gurwitsch 1964; Yoshimi and Vinson 2015). Gurwitsch describes the periphery as a "thematic field," which corresponds to the "fringe" in James, and one kind of "horizon" in Husserl.[8] (This

[8] Gurwitsch distinguishes two types of peripheral experience: the thematic field and a separate type of "marginal consciousness." To simplify matters, and given that the distinction has been questioned (Yoshimi and Vinson 2015), it is ignored here. Also note that Husserl uses the term "horizon" in several senses: in particular, an "immanent" and a "counter-factual" sense (Yoshimi 2016a). The "immanent horizon" corresponds to an immediate sense of one's

unfortunate overloading of terminology is a fact of life in this area; I will prefer the term "periphery".) Gurwitsch conceives of the field as dynamically unfolding via "field transitions" in which focal items recede to the periphery and peripheral items become focal. The periphery contains vaguely experienced information that unfolds in parallel with the focus. Examples of peripheral contents during problem solving include a dim sense of our goal, our environment, our current strategy, and, most prominently in Gurwitsch, a vague sense of other potential solution strategies. Gurwitsch refers to an "indistinct, dim, and penumbral" sense we have, at any moment, of "references to the possible solutions of the problem," "directions in which a solution might be found" and "consequences which follow from a tentatively considered solution" (Gurwitsch 1964, 1).

Drawing on Wertheimer's work, we can add an account of *disturbance resolution* to Gurwitsch's field theory. (Gurwitsch himself drew on Wertheimer, but did not develop this connection). According to Wertheimer, when a problem is considered, a *tension* is introduced into the field. The field has a natural tendency towards simplicity and good order, and away from disorder. We dislike the "fog" of an unanswered question. We sense the unsolved problem as a form of disorder and try to transform the situation in the direction of structural improvement, towards "a state of affairs that is held together by inner forces as a good structure in which there is harmony in the mutual requirements [of the situation]" (Wertheimer 1959, 239).

Bruce Mangan (1993, 2001, 2003), drawing on the work of William James and on several lines of research in cognitive psychology, has argued that focal experience is guided by a peripheral feeling of "rightness", a sense of global coherence that determines what direction we should take at any moment during a thought process. He describes rightness as a "summary

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surroundings. The counter-factual horizon is more abstract; it describes how we would react, were various possibilities to occur. Both will play a role in this account.

index of cognitive integration, representing, in the fringe, the degree of positive fit between a given conscious content and its parallel, unconsciously encoded context" (Mangan 1993). On this account, as we work through a problem we transition to peripheral items that are felt to be most right, most resonant with our current focal experience, our sense of our goals, etc.

Mangan (2001, 2003) has also developed an account of wrongness (the "polar opposite" of rightness), which connects his views with Wertheimer's. According to Mangan, rightness, wrongness, and other types of experience (such as familiarity and novelty) can co-occur in the fringe. In personal communication, he has speculated that what Wertheimer calls "gaps" or "tensions" serve as a global signal of wrongness that we are motivated to remove, while rightness functions as a more local, moment-to-moment signal guiding our problem-solving activities. Here is how he describes the process of successfully solving a problem:

> First we want to move from a sense of wrongness, that *something* doesn't fit, to a state of maximal coherence which, once achieved, maximizes the feeling or rightness (good Gestalt). We could feel at the initial stage of problem solving that something is wrong (i.e., doesn't fit into our existing context information which is why it's a problem) and yet at the same time have a sense of a direction to go in that promises to be right; and if ultimately successful, increase the feeling of context-fit or rightness until the solution has been found. So over the course of temporally extended problem solving, the feeling of wrongness (i.e., lack of context fit) is more and more overpowered by the feeling of progressively moving toward a solution. At that point the sense of wrongness has gone, and just rightness and probably an Aha! experience of intense rightness remains.

We have thus far emphasized the phenomenology of our focal problem-solving efforts. However, in an extended problem-solving activity many other types of contents will occur in the field. We sometimes get bored by the problem or get stuck and shift our attention to something else. Maybe we look at our surroundings or talk to someone about the problem. Other contents that are irrelevant to the problem (sounds, people milling around, body aches, etc.) also co-occur in our experience while we work on the problem. As Gurwitsch says:

> While… dealing with our problem, we… have some vague awareness of both our actual environment and of ourselves. We perceive the room in which we are sitting, and the things which happen to be in the room. When we deal with our problem while walking in the street, we see the houses, the people who pass by, we hear noises, we may feel warm or cold. While walking down the street, we are aware of our walking and may anticipate that our walk will continue for some time, or else that we will soon reach our goal. Absorbed though our attention may be with our problem, we never lose sight of our actual surroundings nor of ourselves as situated in those surroundings (Gurwitsch 1964, 1).

There is evidence that these multiple elements of the overall field, some of them seemingly unrelated, can influence each other in surprising, often unconscious ways. For example, judgments of the slopes of inclined planes are changed when a person wears a weighted backpack, and judgments of funniness change when a person holds a pencil in their teeth, forcing a smile (Yoshimi and Vinson 2015). These effects are largely unconscious. Compare Maier's two-rope problem, where people who perceived ropes swinging in the environment while trying to solve the two-rope problem could sometimes find a solution to the problem (when they previously couldn't), without realizing that this "hint" had played a role in how they solved it. Maier's results suggest that separate field contents—the effort to solve the problem and the perception of a swinging rope—unconsciously influenced one another during the problem-solving process.

3.2 Problem Solving and Background Knowledge

The field of consciousness unfolds relative to a substrate of background knowledge that we dimly sense in the periphery. (Compare the Gestalt concept of a memory trace, and the general cognitive concepts of unconscious processing and schemata).[9] Husserl, extending James' stream metaphor, says consciousness leaves "sediments" or "precipitates" which in turn

[9] Useful discussions of schema theory include (Arbib 1992) and (Rumelhart et al. 1987).

shape subsequent experience, so that our phenomenology involves an ongoing interplay between consciousness and background knowledge.

David Woodruff Smith (2004) has further developed this idea, arguing that the phenomenal character of a person's intentional experience (experiences of objects) depends on that person's background knowledge. We would not see things the way we do were it not for a vast unconscious reservoir of implicit knowledge. The presence of such a structure is phenomenologically evident in what we find surprising or not, how we would answer questions about something if asked, etc. I see a dot in the distance moving towards me *as a bird* only if it's the case that I would be surprised to discover it was an airplane, would call it a "bird" if a child asked what it was, etc.[10] That I see the dot as a bird implies the existence of background knowledge that encodes how I would react to the dot in various circumstances. Similarly, for skilled behavior: the specific patterns of actions involved in riding a bike or walking along a path imply the existence of a background structure encoding those action patterns. In this way "the domain of phenomenology—our own experience—spreads out from conscious experience into semi-conscious and even unconscious mental activity" (Smith 2016).

There is a great deal to say about these encoded action patterns, but I will only give a brief account here.[11] First, we should think of action in a broad sense that includes *cognitive actions*, i.e., what Wertheimer, Newell and Simon referred to as "operations" that progressively lead, when successful, to the solution of a problem. Second, we can understand action patterns as a kind of tree structure, where at each moment what we are likely to do (which branch of the tree we follow) is determined in part by the current field, which contains our sense of our

[10] A formal treatment of this idea is in (Yoshimi, 2016), chapter 3.4, which argues that visual experiences of objects supervene on expectations about how that object would manifest itself relative to different movements.
[11] I hope to develop and formalize the idea that this is an "action horizon" whose structure is the symmetrical counterpart of what Husserl calls a "perceptual horizon" (in the counter-factual sense of that term).

environment, our goals, available actions, etc. When we ride a bike with the goal of getting to work, we move the bike left and right, and pedal harder or softer, as the terrain changes, as obstacles appear before us, as other bikers pass us, and so forth. Action patterns thus involve a cycle of responsiveness to the current situation. Third, when actions succeed relative to current goals in a situation, we reinforce those actions. We add them to our repertoire of goal-directed reactions to a situation. As we develop a skill we can respond to increasingly many situations in increasingly specific ways. Think of learning to play tennis, ride a bike, or cook an omelet. As we get better we can respond in more effective and specific ways to more contingencies, and can thus achieve our goals more effectively. Expertise in a domain corresponds to the development of particularly rich and detailed repertoires of action patterns. Fourth, moment to moment experience involves a kind of parallel and largely unconscious search through encoded problem-solving strategies. At any moment, those actions or cognitive operations that are most coherent with our current goals—that feel most "right", in Mangan's sense—are pursued.

These ideas generalize to more cognitive forms of problem solving. In learning to solve elementary algebra problems, for example, we acquire repertoires of strategies. Every time a strategy works, it is reinforced. Over time we can deploy increasingly many strategies to solve increasingly many problems. When, having mastered algebra, we work through a simple problem, we know just what to do at each stage. Specific thoughts and actions (e.g., written computations) are motivated as the field unfolds.

The Gibsonian concept of an affordance (Gibson 1986) can be understood in terms of encoded action patterns. A pan handled while cooking affords specific hand movements, the trail in daylight affords a certain kind of bike riding, etc. In another context (the pan on a shelf, the trail at night), these same objects might not motivate any actions at all, or different actions.

These ideas explain *set effects*, whereby people fixate on strategies that have worked in the past, even when better strategies are available. We over-rely on background knowledge in proceeding through a problem. We keep doing the same things in the water-jug problem, even where there is a better way, because we are drawing on previously reinforced action patterns. Affordances also explain functional fixedness on typical uses of an object. In these cases, background knowledge motivates fewer reactions (or wrong reactions) to an object relative to the current field. The branch in the context of the tree does not afford swinging, digging, and other action sequences to the same extent or in the same way a detached branch does. Actions like that have never occurred relative to an attached branch, so they are not motivated by it. Similarly, a box full of objects is seen primarily as a container. It does not motivate the actions associated with building things in the same way an empty box alongside other tools does.

3.3 The Phenomenology of Reproductive and Productive Problem Solving

What Selz called “reproductive processes” involve the re-use of previously acquired strategies. Reproductive processes occur when Köhler’s animals make decisive motions to obtain food; when a Rubik’s cube is solved using previously mastered techniques; and when a grandmaster easily wins against an amateur opponent. In such cases the problem solver is “in the zone.” Dreyfus, Jennings and others have persuasively argued that this is a special type of process, one in which we are “entrained” to the task (Jennings 2015), or in Dreyfus’ Heideggerean terms, “transparently coping ” (Dreyfus 1991). Gurwitsch describes field transitions in this type of case as “smooth and continuous” and says “we have the feeling that our thought moves in a right direction… along lines traced out by the very fringes escorting and surrounding the theme" (Gurwitsch 1964, 309–310). There is no sense of tension, none of the "disturbance" or "wrongness" associated with an impasse (or perhaps just some vague global sense of tension, insofar as the problem is not yet solved).

When we rely on what has worked before we sometimes make errors or solve a problem in a suboptimal way. Examples include reusing a previously successful technique in a water-jug problem when a better technique is available (set effects), or reverting to a familiar but suboptimal strategy in a game of chess.

In productive thought, by contrast, we don't immediately know how to proceed. We are at an impasse. Behaviorally, we have comparative disorder: faced with unobtainable but visible food, hens rush about "all a-fluster" (14), while chimps make gestures of entreaty and despair (Köhler 1924, 14, 32). Humans report blanks, frustration, and an experience of striving.

The account of peripheral experience and background knowledge developed in sections 3.1 and 3.2 suggests a way of expanding on the otherwise obscure phenomenology of struggling to break an impasse. At an impasse, there is no previously-reinforced action pattern to activate. No strategy is immediately experienced as "right", in Mangan's terms. The fringe does not select anything for focal articulation, because background knowledge fails to provide any actions or operations that are sufficiently coherent with current goals. In these cases, a parallel search process occurs. Peripheral experience is trying but failing to find a good fit relative to current goals in background knowledge. Metaphorically, it is *reaching*. Experientially, we are striving. Fragments of solutions, or other ideas, come and go in to the focus. These fragments might be combined and tested for their coherence with current goals.

If we manage to break the impasse, peripheral experience latches on to something that feels subjectively right. Perhaps we realize that an old action plan used for something else might work (this is called “analogical transfer” in the problem-solving literature). Or the thematic field, through its parallel search, manages to recombine existing elements of background knowledge in a new way. In these cases we have a transition, behaviorally, from chaotic or confused motion to the determinate motions of an agent that has figured out how to solve a problem. This is the moment of insight that gives insight approaches their name. This aha or eureka moment seems produce a kind of cognitive euphoria, which may correspond to a momentarily elevated experience of rightness.[12]

4. Conclusion and Future Work

These ideas can be further developed in the spirit of analytic clarity and interdisciplinary openness associated with the California school of phenomenology, and David Smith’s work in particular. To begin with, the account developed above is provisional and in need of further development. For example, the account of action patterns could be formalized and linked with computational accounts of reinforcement learning. Another area of potential development is in relation to Newell and Simon’s search-based approach to problem solving. Dreyfus persuasively argued that heuristic search is problematic as a general account of the phenomenology of problem solving. Still, it may have something to offer. We do seem, in certain contexts, to “think a few moves” ahead. Moreover, the generic idea that problem solving can be understood in terms of a space of possible solutions is broadly consistent with dynamical systems approaches to cognition. We can, on a dynamical-systems approach, conceive of the field of consciousness as unfolding in a space of possible fields of consciousness, using what I have elsewhere called “cognitive maps” (Yoshimi, 2017). These maps provide a concrete framework for studying the

[12] Mangan, drawing a wide range of cases, in particular cases of aesthetic experience, describes this as a kind of “hyper-meaning” (Mangan 1991).

relationship between neural and phenomenological processes. It may be possible to use these maps to visualize the neural basis of reproductive and productive problem solving as characterized above, as well as cases where agents explicitly think ahead.

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References

Arbib, Michael A. 1992. "Schema Theory." In: *The Encyclopedia of Artificial Intelligence* 2: 1427–43.

Bassok, Miriam, and Laura R. Novick. 2012. "Problem Solving." In: *Oxford Handbook of Thinking and Reasoning*, 413–32.

Birch, Herbert G. 1945. "The Relation of Previous Experience to Insightful Problem-Solving." *Journal of Comparative Psychology* 38 (6): 367.

Davidson, Janet E., and Robert J. Sternberg. 2003. *The Psychology of Problem Solving*. Cambridge University Press.

De Groot, Adriaan D. 1946. *Thought and Choice in Chess*. Ishi Press International.

Dominowski, Roger L., and L. E. Bourne Jr. 1994. "History of Research on Thinking and Problem Solving." Edited by Robert Steinberg. *Thinking and Problem Solving*, 1–35.

Dreyfus, Hubert. 1972. *What Computers Can't Do.* Harper & Row.

———. 1991. *Being-in-the-World*. Mit Press.

Duncker, Karl. 1945. "On Problem-Solving." Translated by Lynne S. Lees. *Psychological Monographs* 58 (5).

Føllesdal, Dagfinn. 1969. "Husserl's Notion of Noema." *The Journal of Philosophy* 66 (20): 680–87.

Frensch, Peter A., and Joachim Funke. 2014. *Complex Problem Solving: The European Perspective*. Psychology Press.

Gibson, James Jerome. 1986. *The Ecological Approach to Visual Perception*. Psychology Press.

Gurwitsch, Aron. 1964. *Field of Consciousness*. 2. Duquesne University Press.

Jennings, Carolyn Dicey. 2015. "Consciousness Without Attention." *Journal of the American Philosophical Association* 1 (02): 276–95.

Kershaw, Trina C., and Stellan Ohlsson. 2001. "Training for Insight: The Case of the Nine-Dot Problem." In *Proceedings of the Twenty-Third Annual Conference of the Cognitive Science Society*, 489–93.

Köhler, Wolfgang. 1924. *The Mentality of Apes.* Translated by Ella Winter. Routledge.

———. 1970. *Gestalt Psychology: An Introduction to New Concepts in Modern Psychology*. WW Norton & Company.

Kotovsky, Kenneth. 2003. "Problem Solving–Large/Small, Hard/Easy, Conscious/Nonconscious, Problem-Space/Problem-Solver." *The Psychology of Problem Solving*, 373-83.

Luchins, Abraham S., and Edith Hirsch Luchins. 1959. "Rigidity of Behavior." *Eugene, OR: University of Oregon Books*.

Maier, Norman. 1930. "Reasoning in Humans. I. On Direction." *Journal of Comparative Psychology* 10 (2): 115-43.

Maier, Norman. 1931. "Reasoning in Humans. II. The Solution of a Problem and Its Appearance in Consciousness." *Journal of Comparative Psychology* 12 (2): 181–94.

Mangan, Bruce. 1991. "Meaning and the Structure of Consciousness: An Essay in Psycho-Aesthetics."

———. 1993. "Taking Phenomenology Seriously: The' Fringe' and Its Implications for Cognitive Research." *Consciousness and Cognition* 2 (2): 89–108.

———. 2001. "Sensation's Ghost." *Psyche* 7: 18….

———. 2003. “The Conscious ‘fringe’: Bringing William James up to Date.” In *B. J. Baars, W. P. Banks, & J. B. Newman (Eds.), Essential Sources in the Scientific Study of Consciousness*, 741–59. MIT Press.

Metcalfe, Janet, and David Wiebe. 1987. “Intuition in Insight and Noninsight Problem Solving.” *Memory & Cognition* 15 (3): 238–46.

Newell, Allen, and Herbert Alexander Simon. 1972. *Human Problem Solving*. Vol. 104. 9. Prentice-Hall Englewood Cliffs, NJ.

Niv, Yael. 2009. “Reinforcement Learning in the Brain.” *Journal of Mathematical Psychology* 53 (3): 139–54.

Rumelhart, D. E., P. Smolensky, J. L. McClelland, and G. E. Hinton. 1987. “Schemata and Sequential Thought Processes in PDP Models.” In: *Parallel Distributed Processing: Explorations in the Microstructure of Cognition, Vol. 2*. MIT Press, 1-57.

Selz, Otto. 1924. *Die Gesetze Der Produktiven Und Reproduktiven Geistestätigkeit*. Bonn: Friedrich Cohen.

Smith, David Woodruff. 2004. *Mind World: Essays in Phenomenology and Ontology*. Cambridge University Press.

———. 2016. “Phenomenology.” In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Winter 2016. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/win2016/entries/phenomenology/.

Smith, David Woodruff, and Ronald McIntyre. 1982. *Husserl and Intentionality: A Study of Mind, Meaning, and Language*. Vol. 154. Springer Science & Business Media.

Wertheimer, Max. 1959. *Productive Thinking*. Edited by Michael Wertheimer. Harper New York.

Yoshimi, Jeff. 2016a. *Husserlian Phenomenology: A Unifying Interpretation*. Springer.

———. 2016b. “Prospects for a Naturalized Phenomenology.” In: *Phenomenology and Philosophy of Mind*, edited by Daniel Dahlstrom, Walter Hopp, and Andreas Elpidorou. Routledge, 287-309.

Yoshimi, Jeff. 2017. “Modeling Consciousness Using Cognitive Maps. ” *Mind and Matter* 15 (1): 29-47.

Yoshimi, Jeff, David W. Smith, and Clinton Tolley. *forthcoming.* “California Phenomenology.” In *The Reception of Phenomenology in North America*, edited by Beatrice F. Michela. Springer.

Yoshimi, Jeff, and David W. Vinson. 2015. “Extending Gurwitsch’s Field Theory of Consciousness.” *Consciousness and Cognition* 34: 104–23.

Zahavi, Dan. 2010. “Naturalized Phenomenology.” In *Handbook of Phenomenology and Cognitive Science*, 2–19. Springer.