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Agile Science

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Synonyms

Design thinking; Evaluation; Experimental design; Implementation science; Iteration; Prototyping

Definition

Agile science (Hekler et al. 2016) is a process for creating useful and usable behavior change interventions and corresponding usable evidence for supporting decision-making of individuals/patients, practitioners, and policy-makers. Agile Science moves scientific inquiry from asking "what works on average?" to "what works for whom and in what context?"

M. Gellman (ed.), *Encyclopedia of Behavioral Medicine*,
https://doi.org/10.1007/978-1-4614-6439-6_101944-1

To do so, it uses evolution-inspired iterative creation, optimization, and reuse to develop repurposable interventions and components organized by when, where, and for whom they work. The process starts with *creating* many variations of plausible behavior change interventions for a "niche," i.e., specified people, places, and times, with clear metrics of success defined. This is followed by *optimizing* those behavior change interventions for that targeted niche. Optimization tests whether the interventions produce the desired real-world success, with definitions of success and failure called optimization criteria. If the interventions are useful for a given niche, they are repurposed for others who might benefit from them. *Repurposing* involves either modularizing interventions or providing decision policies that match interventions with other peo-ple, places, and times (niches), or both. Modularization is modeled on how technology tools, such as application programming interfaces (APIs), reduce a service to its most fundamental use to increase its potential to be repurposed, think of Google Maps used across a variety of contexts. Similarly, agile science reduces its interventions down into the smallest, meaningful, and self-contained elements possible to enable repurposing to other domains. The creation and evaluation of decision policies for matchmaking uses scientific methods that study an intervention and its components, as well as the decision poli-cies used to select one intervention over another. Complementary to this, agile science uses techniques from informatics to organize and *curate* scientific knowledge across studies.

Description

Process Overview

The agile science process (Hekler et al. 2016) was inspired by evolution. Specifically, central to the create phase is the production of variability in terms of behavior change interventions, niche specification (i.e., meaningful clustering of people, places, and times for use of the interventions), and specification of competing definitions of success (e.g., the classic design trope; you can design a system to be fast, cheap, or good; pick 2), called optimization criteria. Variations of behavior change interventions, niches, and optimization criteria, along with causal models that provide a structure on how these elements are linked, are the basic building blocks of the next stage, optimization. In evolution, out-compete other organisms via natural selection; in agile science, the analogous approach is optimization, which maps on to methods being advanced in the multiphase optimization strategy most, (Collins et al. 2016). If behavior change interventions are useful for a given niche, meaning that in an optimization trial, the optimization criteria/definition of success is met, then the next step is warranted. In the case of evolution, this is niche expansion, and the analogous processes within agile science involve:

- Modularizing an intervention to its smallest, meaningful, and self-contained element
- Engaging in a science of matchmaking that systematically studies the decision policies used to match interventions with other people, places, and times.

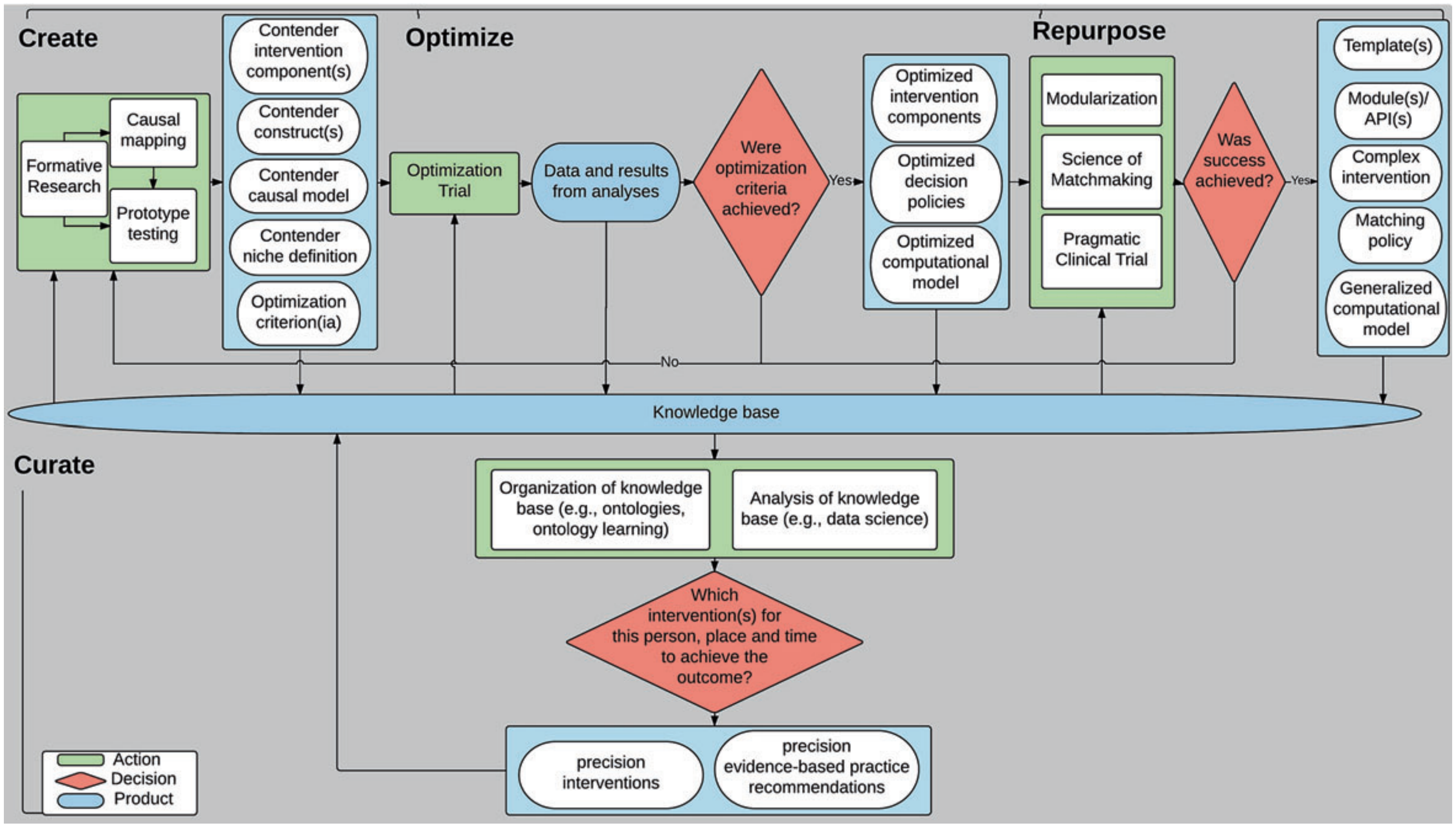
The ultimate goal is to produce both the specific tools (e.g., software, treatment protocols, templates) that enact an intervention, *and* the corresponding evidence of when, where, for whom, and in what state to use a given tool. As the goal is making both tools and evidence usable in real-world context, there is a requirement for a robust process for curating the scientific knowledge-base to maximize the usability and repurposability of all tools and evidence (Fig. 1).

Create Phase

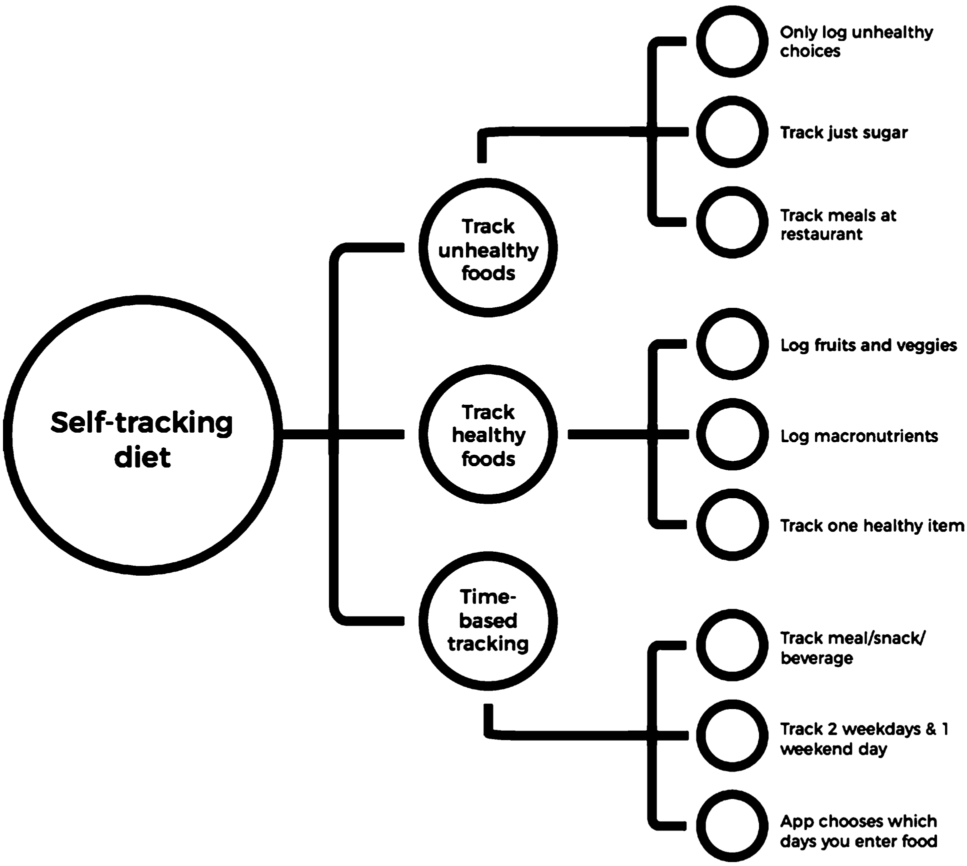
The create phase maps on to human-centered design with added features. Unique to agile science, the goal of the create phase is not only to create specific solutions for specific problems (arguably the focus of human-centered design) but also to establish a subsequent research agenda of these specific solutions. Based on this, the create phase emphasizes dramatically increasing the variability and number of ideas in early research. This provides a grounding for individuals to think more carefully about exactly *what* they are studying and, perhaps more importantly, what they are *not* studying *at this time*. Is it an abstract idea, with many possible implementations, or a concrete implementation that may not be representative of a broader abstract idea? This is well-illustrated with a mind-map visualization that begins with a contender abstract concept, from which variations are created, then potential prototypes are chosen (Fig. 2).

Within the create phase, another product is a causal model. A causal model illustrates beliefs about how an intervention influences targeted outcomes in a series of steps within a given niche. For example: Variable daily step goals maintain novelty of app use, which drives ongoing self-monitoring, and that is known to increase motivation, which can lead to achievement of physical activity goals. One key purpose of causal modeling is to recognize the preconditions that must be present for an intervention to produce a desired effect. In the above example, the ability, opportunity, and motivation to change walking behavior in a given moment are “preconditions” and can be specified in a causal model. Preconditions are particularly valuable to understand for repurposing, because they provide insights on for whom, when, and where a given intervention might be useful.

The final targeted product from the create phase is optimization criteria. Inspired by the MOST (Collins et al. 2016), optimization criteria define the success and failure of a given intervention. Clear definitions of success and failure can be used to judge, and thus, iteratively improve and optimize, an intervention for a target niche. In the steps example, imagine that success for this intervention is walking 10,000 steps per day for



Agile Science, Fig. 1 Process v0.4. The above figure is a diagram of the overall agile science process, which involves creating, optimizing, repurposing, and curating behavioral tools and evidence



Agile Science, Fig. 2 Mindmap of Intervention Varia. This figure visualizes different levels of abstraction for a concept. The circle on the left is the most abstract whereas the nine variations on the right are plausible, concrete operationalizations of the abstract concept. This map is used to provide clarity on what an abstract concept is by recognizing plausibly meaningful variations on how to operationalize it

1 week. That concrete, specified target enables a wide range of experimental designs to be used in the optimize phase, such as between-person factorial trials, micro-randomization, and control systems engineering trials.

Optimize Phase

The optimize phase tests and, if necessary, supports data-driven iterative improvement of interventions in relation to optimization criteria for a target niche. This builds on the logic of optimization methods from MOST with at least four different types of optimization trials:

1. Between-person factorial trials as screening experiments for intervention components.
2. Sequential multiple assignment randomized trial (SMART) to optimize adaptive interventions that are structured after clinical care.
3. Micro-randomization trials to optimize digital interventions that involve frequent adaptation, and may require optimization of the timing of the delivery of an intervention.
4. Control engineering optimization trials can optimize digital health interventions that likely require a high degree of personalization and frequent adaptation (e.g., daily).

If the optimization criteria from these trials are met, it provides evidence that the intervention has value for producing the desired outcomes for a targeted niche.

While the primary target of these optimization trials is often components of interventions, there are two other products that can feasibly come out of these optimization trials. One is a computational model that quantifies how interventions, individuals, and context interact, vetted via an optimization trial, particularly either a control engineering optimization trial or a micro-randomization trial. An optimized computational model is a better specification, and thus testable translation, of the causal model from the create phase. While not always produced, it can be valuable for the repurpose phase.

The second feasible target of the optimize phase is an optimized decision policy that provides insights on the selection of interventions for a given person, place, or time. It provides an answer (at least partially) to this question: "Which behavior change intervention(s) should be used for this individual, at this time, in this context, to achieve a desired outcome?" Model predictive control, recommender systems, agent-based modeling, and Bayesian network analysis are a few (of many) ways to specify decision policies, which can be vetted using the optimization trials described above.

Repurpose Phase

Once interventions are optimized for a niche, they are repurposed for other niches that might benefit from them. This phase either modularizes an intervention or evaluates decision policies that support broader repurposing. The creation and evaluation of decision policies for matchmaking uses similar scientific methods from the optimization phase but, at this point, the focus becomes more squarely on systematically testing utility across niches and, thus, requires a wider range of niches to be present. Modularization is modeled on how technology tools, such as APIs, reduce a service to its most fundamental use to increase its potential to be repurposed, think of Google Maps used across a variety of contexts. Similarly, agile science reduces its interventions down into the smallest, meaningful, and self-contained elements possible to enable repurposing to other domains. The optimization methods described above each have the potential to be used to support a science of matchmaking whereby moderation hypotheses are articulated about the match/mismatch of intervention components to target niches and then, through strategies such as stratification or measurement of time-varying moderators (e.g., stress, busyness), the decision policies that define when, where, and for whom to use one intervention type or dose can be studied.

Curate Phase

The curate phase is focused on making scientific knowledge and tools accessible and up-to-date for all. In this phase, which occurs synchronously to all the other phases, information that could be valuable to others, such as empirical results or hypotheses, is extracted from scientific publications (a process called ontology learning). The extracted information is then organized to make it easily searchable and otherwise accessible for purposes beyond those specified by the original research. The organization of information relies on taxonomies and ontologies that enable rigorous querying of the scientific knowledge base. For example, front-end tools like www.metabus.org can support automated meta-analysis of research questions by incorporating all potentially relevant data.

Cross-references

- ▶ Behavior Change
- ▶ Behavior Change Techniques
- ▶ Causal Diagrams
- ▶ Construct Validity
- ▶ Digital Health
- ▶ eHealth and Behavioral Intervention Technologies
- ▶ Evidence-Based Behavioral Medicine (EBBM)
- ▶ Experimental Designs
- ▶ Implementation in Digital Health
- ▶ Intervention Theories
- ▶ Just-in-Time Adaptive Intervention
- ▶ Translational Behavioral Medicine
- ▶ Usability Testing

References and Further Readings

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