Heuristics: Solving Problems Rapidly

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Heuristics
Solving Problems Rapidly

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November, 2008
Heuristic

noun: A fallible method for solving a problem or making a decision

• Examples:
  • “Plant your corn early!”
  • Pull on the handle, push on the plate.
  • Problems are cheaper to fix the earlier they’re found.
Heuristic

adjective: “serving to discover”

• Examples:
  • a heuristic approach
  • heuristic guidewords
  • heuristic models
Heuristics

- Fallible, “fast and frugal” methods of solving problems, making decisions, accomplishing a task.

“The engineering method is the use of heuristics to cause the best change in a poorly understood situation within the available resources.”

Billy Vaughan Koen

Discussion of the Method
Heuristics Are Fallible

- Heuristics use guidance and control of skilled practitioners.
- They’re heavily context-dependent.
- They may be useful even when they contradict each other—especially when they do!
- They can substitute for complete and rigorous analysis.
- Because they are reasonable, low-cost shortcuts, heuristics can present more valuable solutions for the present circumstances because they’re less complete.

“Heuristic reasoning is not regarded as final and strict but as provisional and plausible only, whose purpose is to discover the solution to the present problem.”

- George Polya, *How to Solve It*
Guideword Heuristics

- Words or labels that help you access the full spectrum of your knowledge and experience as you analyze something.
- Often provided in the form of a taxonomy, a classification system in (typically) a hierarchical structure.
Guideword Heuristics for
The Most Expensive Test Project In History

Describe Using Monocular: (15 Min)
1 Near Field (define location by angle and distance from LM)
   A Features
      1 General Surface
      2 Plains
      3 Craters
      4 Rays
      5 Cones
      6 Boulder Fields
      7 Rilles, Faults, Grabens
      8 Rock Fragments
      9 Loose Ground-Mass Material
     10 Coatings

B General Surface
   1 Texture - smooth, flat, gentle rolling, rough, jagged
   2 Materials - dust, sand, pebbles, rocks, boulders [note size, angularity, and roundness], cinders, ash fall or flow, lava, pahoehoe, aa, ejecta

Report Features During Descent And Determine LM Location With HOU (5 Min)
Trigger Heuristics

• Ideas associated with an event or condition that help you recognize when it may be time to take an action or think a particular way.

• Like an alarm clock for a slumbering mind

• When you notice that you don’t have questions, ask “Why don’t I have any questions?”
Subtitle Heuristics

• Help you reframe an idea so you can see alternatives and bring out assumptions during a conversation.

“No user would ever do that.

“No user that I’ve thought of, and that I like, would do that on purpose.”
Heuristic Model

- A simpler representation of a more complex idea, object, or system that helps you to understand, control, observe, or explore it.
Models Link Observation and Inference

• A model is an idea, activity, or object…
  such as an *idea in your mind*, a *diagram*, a *list of words*, a *spreadsheet*,
  a *person*, a *toy*, an *equation*, a *demonstration*, or a *program*

• …that represents (literally *re-presents*) another idea, activity, or object…
  such as something complex that you need to work with or to study.

• …whereby understanding the model may help you understand or manipulate what it represents.
  - A *map* helps navigate across a terrain.
  - 2+2=4 is a model for adding two apples to a basket that already has two apples.
  - *Atmospheric models* help predict where hurricanes will go.
  - A *fashion model* helps understand how clothing would look on actual humans.
  - *Your beliefs about what you test* are a *model of what you test*. 
General Systems Thinking: The Science of Simplification

• …and the simplification of science.
• “X is the study of those systems for which the approximations of X work successfully.”
• Concerned with general observations and patterns in identifying systems, their components, and their relationships.
• Saying things concisely, while recognizing the potential for hidden or dangerous assumptions.
• Any general law must have at least two specific applications—and at least two specific exceptions.
Heuristic Procedure or Rule

• A plan of action or guideline that may help solve a class of problems.
  • It’s dangerous to drink and drive.
  • A bird in hand is worth two in the bush.
  • Nothing ventured, nothing gained.
  • If your computer is behaving strangely, try rebooting. If it’s very strange, reinstall Windows.
  • When you’re learning to drive, don’t look at the end of the hood. Aim high instead.
  • If it’s a genuinely important task, your boss will follow-up, otherwise, you can ignore it.
Example Heuristics

• The Rumble Strip Heuristic
  • You might get a warning before a crash. Pay attention!

• The Iceberg Heuristic
  • A little problem on the surface might be big down below.

• The Dead Bee Heuristic
  • Even though you can’t hear it any more, you want to see the dead bee before you relax your guard.

• The Piñata Heuristic
  • Whack on the program until the candy pours out.

• The Rumsfeld Heuristic
  • There are known unknowns, and unknown unknowns. We need to move both towards the known.
Focusing Heuristics

To test a \textit{simple} product very thoroughly, \textit{part} of a complex product very thoroughly, or to maximize test \textit{integrity}...

1. Start the test from a \textit{known} (clean) state.
2. Prefer \textit{simple, deterministic} actions.
3. Vary One Factor At a Time (OFAT)
4. Trace test steps to a \textit{specified model}.
5. Follow \textit{established and consistent} lab procedures.
6. Make \textit{specific} predictions, observations and records.
7. Make it \textit{easy to reproduce} (automation helps).
To find *unexpected problems*, *elusive problems* that occur in sustained field use, or more problems *quickly* in a complex product…

1. Start from *different states* (not necessarily clean).
2. Prefer *complex, challenging* actions.
3. Vary Many Factors At a Time (MFAT).
4. Generate tests from a *variety* of models.
5. *Question* your lab procedures and tools.
6. Try to see *everything* with open expectations.
7. Make the test *hard to pass*, instead of easy to reproduce.
An oracle is the *heuristic* principle or mechanism by which you recognize a problem.

“..it works”

really means...

“...it appeared at least once to meet some requirement to some degree.”

One or more successes!
All Oracles Are Heuristic

• There is no single oracle that can tell us whether a program or feature is working correctly at all times and in all circumstances.
• Oracles are fallible and context-dependent.
• Oracles can be contradicted by other oracles.
• Multiple oracles may increase our confidence, but even combinations of oracles are fallible. A problem revealed by a single oracle may devastating.
• Recognizing a different problem usually requires a different oracle.
• A test designer need not be aware of an oracle in advance of the observation, unless the test is designed to be run by rote.

Any time you see a problem, you must be using an oracle ...so what is it?
Consistency ("this agrees with that") is an important theme in oracles

<table>
<thead>
<tr>
<th><strong>History</strong></th>
<th>The present version of the system is consistent with past versions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image</strong></td>
<td>The system is consistent with an image that the organization wants to project.</td>
</tr>
<tr>
<td><strong>Comparable Products</strong></td>
<td>The system is consistent with systems that are similar or comparable in some way.</td>
</tr>
<tr>
<td><strong>Claims</strong></td>
<td>The system is consistent with what important people say it’s supposed to be.</td>
</tr>
<tr>
<td><strong>User Expectations</strong></td>
<td>The system is consistent with what users could reasonably want.</td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>Each element in the system is consistent with comparable elements in the same system.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>The system is consistent with its purposes, both explicit and implicit.</td>
</tr>
<tr>
<td><strong>Statutes</strong></td>
<td>The system is consistent with applicable laws or relevant standards.</td>
</tr>
</tbody>
</table>
So is Inconsistency

**Familiarity** • The system *is not consistent* with patterns of familiar problems.

- To remember the list, use a mnemonic

**HICCUPPS (F)**

*(In)consistency heuristics rely on the quality of your models of the product and its context.*
Tests Are Oracles PLUS Coverage

According to Jerry Weinberg, “it works”

really means...

“We haven't tried very hard to make it fail, and we haven't been running it very long or under very diverse conditions, but so far we haven't seen any failures, though we haven't been looking too closely, either.”

Zero or more successes!
How to Capture a Heuristic

• Notice yourself solving a problem or making a decision *without* an infallible procedure.
• Identify a non-obvious thought or process that seems to help you solve it.
• Find an evocative label or phrase for that thought or process.
• Try using the label or phrase next time you have the problem, or when you are talking about the problem with someone else.
• Does it help? If not, drop it. If so, see if it sticks.
• If you find yourself resisting your own heuristic, either there is something wrong with the heuristic, or the problem isn’t sufficiently interesting to you.
Ground Rules for the Book-Writing Process

- Lessons begin with a declarative or imperative sentence.
- Each lesson stands alone.
- Each lesson is peer reviewed.
- Each lesson has a champion who has final say on edits.
- Any author may decline to endorse any lesson.
- Only include lessons that:
  - *are non-obvious or deserve special emphasis.*
  - *at least one of the authors strongly believes in.*
  - *we wished we had learned earlier in our careers.*
  - *can be outlined usefully in a few paragraphs.*
  - *are grounded in the direct experience of at least one author.*
- We do not have to be complete; just helpful.
Lessons Learned in Software Testing
*a banquet of heuristics!*

#19 Testing is in your head.
#20 Testing requires inference, not just comparison of output to expected results.
#24 All "tests" are an attempt to answer some question.
#25 All testing is based on models.
#27 To test, you must explore.
#33 Use implicit as well as explicit specifications.
#37 Use heuristics to quickly generate ideas for tests.
#39 You're harder to fool if you know you're a fool.
#42 Confusion is a test tool.
#43 Fresh eyes find failure.
#44 Avoid following procedures unless they followed you first.
#45 When you do create test procedures, avoid "1287."
Heuristics in Medicine: A Case Study

- There are three ways to direct people to treatment:
  - Clinical Intuition
  - Complex Statistics
  - Fast and frugal rules of thumb
What To Do?

A man is rushed to hospital with severe chest pain

Decision:
- coronary care unit?
- regular nursing bed (with a heart monitor)?

Problem:
- based on long term risk factors (family history, male, advanced age, smoking, diabetes, high cholesterol, hypertension) doctors sent about 90% of patients to coronary care.
- care unit became crowded, quality of care decreased, cost went up
Research

- Doctors sent most patients to the CCU
- Sent patients who should have been there just as often as those who shouldn’t have
- The decision was no better than chance.
# Heart Disease Predictive Instrument

This table, with the aid of a long formula and a pocket calculator, helped doctors to make better CCU assignments.

## Chest Pain = Chief Complaint

<table>
<thead>
<tr>
<th>History</th>
<th>ST&amp;T Ø</th>
<th>ST↔</th>
<th>T↑↓</th>
<th>ST↔</th>
<th>ST ↔ &amp; T↑↓</th>
<th>ST ↑↓ &amp; T↑↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>No MI &amp; No NTG</td>
<td>19%</td>
<td>35%</td>
<td>42%</td>
<td>54%</td>
<td>62%</td>
<td>78%</td>
</tr>
<tr>
<td>MI or NTG</td>
<td>27%</td>
<td>46%</td>
<td>53%</td>
<td>64%</td>
<td>73%</td>
<td>85%</td>
</tr>
<tr>
<td>MI &amp; NTG</td>
<td>37%</td>
<td>58%</td>
<td>65%</td>
<td>75%</td>
<td>80%</td>
<td>90%</td>
</tr>
</tbody>
</table>

## Chest Pain NOT Chief Complaint

<table>
<thead>
<tr>
<th>History</th>
<th>ST&amp;T Ø</th>
<th>ST↔</th>
<th>T↑↓</th>
<th>ST↔</th>
<th>ST ↔ &amp; T↑↓</th>
<th>ST ↑↓ &amp; T↑↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>No MI &amp; No NTG</td>
<td>10%</td>
<td>21%</td>
<td>26%</td>
<td>36%</td>
<td>45%</td>
<td>64%</td>
</tr>
<tr>
<td>MI or NTG</td>
<td>16%</td>
<td>29%</td>
<td>36%</td>
<td>48%</td>
<td>56%</td>
<td>74%</td>
</tr>
<tr>
<td>MI &amp; NTG</td>
<td>22%</td>
<td>40%</td>
<td>47%</td>
<td>59%</td>
<td>67%</td>
<td>82%</td>
</tr>
</tbody>
</table>

## No Chest Pain

<table>
<thead>
<tr>
<th>History</th>
<th>ST&amp;T Ø</th>
<th>ST↔</th>
<th>T↑↓</th>
<th>ST↔</th>
<th>ST ↔ &amp; T↑↓</th>
<th>ST ↑↓ &amp; T↑↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>No MI &amp; No NTG</td>
<td>4%</td>
<td>9%</td>
<td>12%</td>
<td>17%</td>
<td>23%</td>
<td>39%</td>
</tr>
<tr>
<td>MI or NTG</td>
<td>6%</td>
<td>14%</td>
<td>17%</td>
<td>25%</td>
<td>32%</td>
<td>51%</td>
</tr>
<tr>
<td>MI &amp; NTG</td>
<td>10%</td>
<td>20%</td>
<td>25%</td>
<td>35%</td>
<td>43%</td>
<td>62%</td>
</tr>
</tbody>
</table>
Method

• The doctors were told to
  • find the right probabilities for each patient
  • type these into a calculator with a long formula
  • press ENTER
  • read off the result
  • compare it to a threshold number
  • route the patient to the CCU or a regular bed

Accuracy went up.
But…

- Even though accuracy was up…
- Even though overcrowding eased…

The doctors hated it.
They didn't understand it.
Testing the Conclusions

• The researchers tested the efficacy of the method and the calculations.
• They took the tables and calculators away.

Accuracy remained high.

• After the doctors had been exposed to the chart, their intuitions improved permanently.
Conclusions on the Method

- When systems with heavy calculations and many probabilities conflict with intuition, doctors resist the complex solution.
- When there is high uncertainty, simple diagnostic methods tend to be more accurate.
- This led to the development of a fast and frugal tree...
The Fast and Frugal Tree

EKG ST Segment Changes?
- No
- Yes

Chest pain the chief complaint?
- No
- Yes

Any one of NTG, MI, ST ↔, ST ↓↑, T?
- No
- Yes

Coronary Care Unit
- Yes
- No

Regular Nursing Bed
Heuristics Win!

Patient CCU Assignments

- Ideal (all hits, no false positives)
- Fast and frugal tree (top result for safety AND reduced false positives)
- HDPI (complex calculation, all over the place)
- Individual doctors (mostly right, lots of false positives)

Incorrect Assignments to CCU (expensive overcrowding)
Correct Assignment (patient helped)
Heuristic: A vs. THE

When trying to explain something, prefer "a" to "the".

- Example: “A problem…” instead of “THE problem…”
- Using “A” instead of “THE” helps us to avoid several kinds of critical thinking errors
  - single path of causation
  - confusing correlation and causation
  - single level of explanation
Heuristic: To Me

When someone makes some pronouncement, silently add "to me".

- “Finding defects is not the main focus in acceptance testing...to me.”
Heuristic: Unless...

Try adding "unless..."

- When someone asks a question based on a false or incomplete premise, try adding “unless…” to the premise
- When someone offers a Grand Truth about testing, append “unless…”
Heuristic: The Helpful Rule

No matter how much it looks otherwise, everyone is trying to help.

• Take responsibility for the communication
• Make it clear that you too are trying to help
Heuristic: The Data Question

What did you see or hear (smell, taste, touch) that made you believe...?
Heuristic: The Rule of Three

• Special case of the Rule Of At Least Three:

   If you can’t think of at least three explanations for something, you probably haven't thought about it enough.
Tying It All Together: Thirty-Six Testing Heuristics

James Bach, The Heuristic Test Strategy Model
Project Environment (Context)

- **Customers**
  - *Anyone who is a client of the test project.*

- **Information**
  - *Information about the product or project that is needed for testing.*

- **Developer relations**
  - *How you get along with the programmers.*

- **Team**
  - *Anyone who will perform or support testing.*

- **Equipment & tools**
  - *Hardware, software, or documents required to administer testing.*

- **Schedule**
  - *The sequence, duration, and synchronization of project events.*

- **Test Items**
  - *The product to be tested.*

- **Deliverables**
  - *The observable products of the test project.*
Product Elements (Coverage)

- Structural
  - *Everything that comprises the physical product.*

- Functional
  - *Everything that the product does.*

- Data
  - *Everything that the product processes.*

- Platform
  - *Everything on which the product depends (and that is outside your project).*

- Operations
  - *How the product will be used.*

- Time
  - *Relationships between time and the product, from nanoseconds to month-end*
Quality Criteria (Coverage)

CRUSSPIC STMPL

- Capability
- Reliability
- Usability
- Security
- Scalability
- Performance
- Installability
- Compatibility
- Supportability
- Testability
- Maintainability
- Portability
- Localizability

Many test approaches focus on Capability (functionality) and underemphasize the other criteria
General Test Techniques (Activities)

- Function testing
- Domain testing
- Stress testing
- Flow testing
- Scenario testing
- Claims testing
- User testing
- Risk testing
- Automatic Testing

For any one of these techniques, there’s somebody, somewhere, who believes that is the *only* way to test.
How We Use Heuristics

• We use them naturally and efficiently
• We often use them quite unconsciously
• So: try remain consciously alert to:
  • the fact that we’re using heuristics
  • which ones we’re using
  • how they can work
  • how they might fail
  • what heuristics might support or challenge them
Exercise

Set up a Heuristics Science Fair
Exercise

Choose a heuristic, and think of at least two instances where it would succeed and two where it would fail.
Exercise

Use the subtitle heuristic to reframe some commonly-heard sentences.
Exercise

Gather a list of heuristics and apply while testing a product.
Exercise

Think of a rule in testing that *isn’t* a heuristic.
Books on Heuristics

Discussion of the Method, Billy Koen
Gut Feelings, Gerd Gigerenzer
Simple Heuristics That Make Us Smart, Gerd Gigerenzer
Sciences of the Artificial, Herbert Simon
How To Solve It, George Polya
Books OF Heuristics

Lessons Learned in Software Testing

Exploring Requirements: Quality Before Design (Gerald M. Weinberg)