RPM Milestone 1:
Translating reason, first attempt

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Abstract—As a human, I reason through the ravens test visually - deduction occurs through steps without names. This series of Milestones aims to develop a working translation of the reasoning tested by Progressive Matrices tests.

1 INTRODUCTION

In this milestone we take a first attempt at describing how humans approach Progressive Matrices problems. In this paper we will study a sample of 2x2 matrices, each example relying on unique logic which our agent must be able to address, hopefully efficiently.

The approaches expressed in this paper may be second or third iterations, only the most efficient are preserved. Similarly, additional deliberation may reveal improved iterations from what's presented. Keep in mind each person, including the author of this paper is limited in their Matrix problem solving ability.

1.1 Human Approach

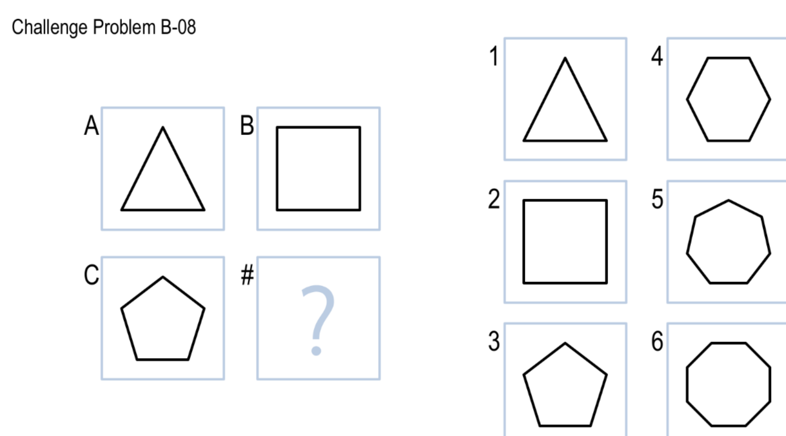

Figure 1—Challenge Problem B-08

1.2 Identify the characteristics

To a visual species, we're able to choose the best approach by identifying over all characteristics of the problem. It's best to review by example. In Figure 1, common characteristic between the given shapes A, B, and C, is they're all regular polygons, or polygons with vertices equidistant from the center.

The discriminant characteristic is 'number of sides'.

1.3 Reasoning

We see number of sides goes from 3 to 4, across the top row. If we follow the same operation on the bottom row, adding 1 side, the answer will be a 6-sided, regular polygon. We check to make sure this answer exists, and it does. It is given by Answer 5.

The pattern of adding 1 side to polygons in column 1 to get polygons in column 2, is satisfied.

We next check if our answer satisfies a consistent row-wise pattern: The pattern of adding 2 sides to polygons in row 1 to get polygons in row 2, is satisfied.

Should the answer not satisfy the row-wise pattern, We may have to re-examine our disriminant characteristics such that other relationships could be tested.

1.4 Reflection on human approach

How do we abstract the concept 'number of sides'? Even if we proposed an abstraction for number of sides, is it resillient to other characteristics of the shape such as fill, or size?

The key point in person-Reasoning was identifying higher level 'easy' characteristics. Our first task will be uncovering which higher level characteristics can be made into computationally simple and broadly useful heuristics, for an AI agent to make efficient determinations to Progressive Matrix problems.

2 AGENT APPROACH

Our objective is to abstract something computationally straight forward to check for, that eliminates the need for over-engineered solutions. We'll consider some of the simplest approaches, and consider how to apply the logic. Efficiency will be considered as well as Generalizability.

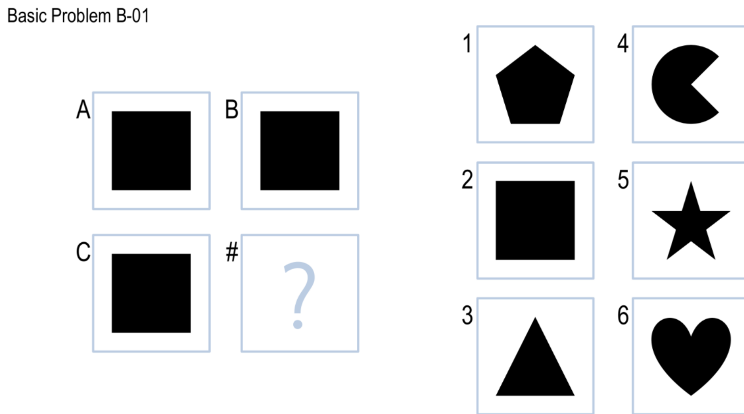

Figure 2—Basic B-01

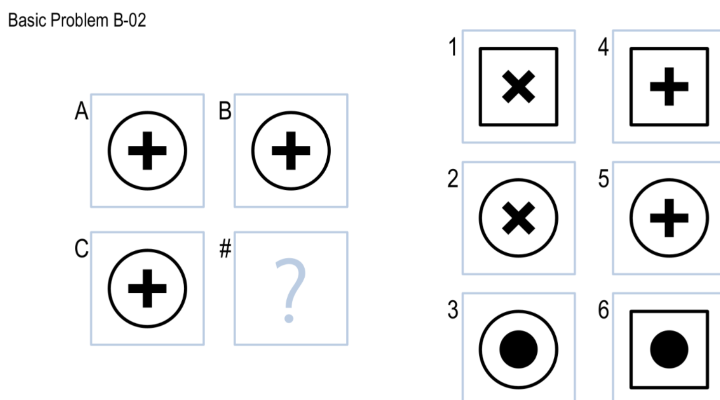

Figure 3—Basic B-02

2.1 When all images are the same

In figures 2 and 3, we see that all four squares will be of the same image. But how would an AI agent know they are the same? In the case this heuristic fails, we still want to be able to work with the images in memory. We will explore if a similarly discriminant deduction occur, and be more generalizable, if we just counted the blackspace.

Counting blackspace can reduce the number of acceptable answers in the case of Figure 4, Basic B-03, where the black space metric reduces the answer bank to answers **1** and **2**, just 2 options (from 6). This means induction using the answer bank can be done more efficiently, if needed.

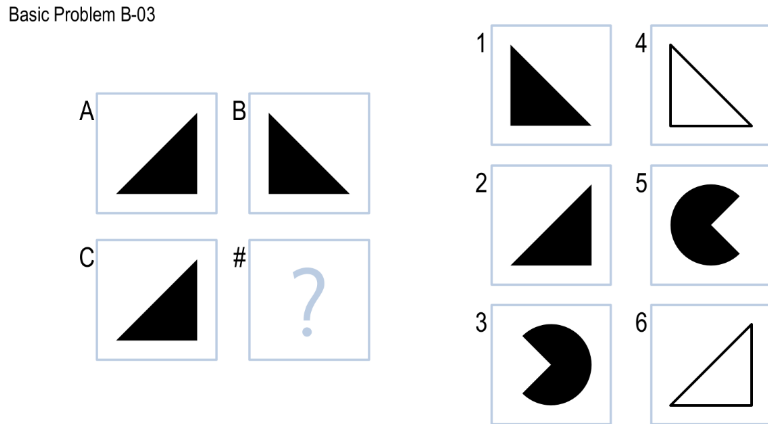

Figure 4—Basic B-03

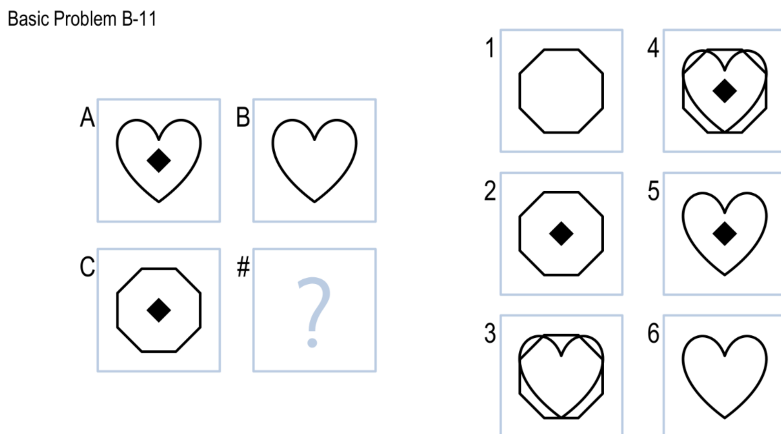

Figure 5—Basic B-11

Measuring blackspace can also be used to solve problems such as Figure 5, or Basic B-11, where a row-wise and column-wise scalar difference in blackspace is a simpler way to discover the answer than identifying shapes, edges, and deriving the semantic network.

2.2 Consistent row-wise and column-wise relationships

Taking blackspace measures a step further, we can also begin finding row-wise or column-wise patterns in differences, proportions, and others.

A rudimentary attempt of finding patterns in differences is implemented in my current iteration of `Agent.py`.

3 AGENT EXPECTATIONS

There are a few expectations of the AI agent, which are that it will use highly discriminant, broadly useful heuristics to choose how to approach the problem, much like a human does.

From there, multiple strategies may be employed, which I suspect will be very focused on visual transformations such as rotation, reflection, addition or subtraction, in varying orders. These orders may be a computationally expensive to discover, and then check against the answer bank.

Through mindful reflection, we can hopefully accomplish the right translation of the task, which will take advantage of the AI Agent's strengths and accommodate its differences from Human Reasoning.

4 CHALLENGES

There are many challenges ahead, but a few most relevant to this week include the following:

The process of discovering patterns in visual transformation procedures in the most efficient way may be difficult to abstract in a computationally efficient way, to an AI Agent.

Identifying shape limits and contours, then comparing them efficiently is an area where I will need to spend time with.

Some of these heuristics may prove to be frail, in which case they may be redesigned to become more robust as I become more acquanted with the problem set.

I expect I will quickly refamiliarize myself with matrix operations such that I can adapt logic applied successfully in 2x2 matrices, to 3x3 matrices.