

Report of Project 1

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Abstract. In this report, I describe the algorithms underlying a knowledge-based AI agent for solving basic 2 x 2 puzzles in Raven's Progressive Matrices test. A further discussion was made to elucidate the difference between the AI agent behaviors and the ways a human using to solve these problems.

Section I: Provide a narrative of how you approached the project.

In general, there are two ways to solve the basic 2 x 2 puzzles in Raven's Progressive Matrices test. One is to estimate the difference between figure A and B, $\text{delta}(A,B)$, then compare figure C with each candidate figure d and estimate their differences $\text{delta}(C,d)$, followed by measuring the similarity between $\text{delta}(A,B)$ and $\text{delta}(C,d)$ and made a decision. This methodology is called *infer-infer-compare*. The other approach is also gauging the $\text{delta}(A,B)$ first, but then applied the $\text{delta}(A,B)$ to figure C and infer the most possible answer of figure D. This methodology is called *infer-map-apply*¹.

In this project my approach to figure out the basic 2 x 2 puzzles was like a mixture of *infer-infer-compare* and *infer-map-apply*. First of all, the AI agent defines the rules of transforming figure A to B, **rules(A,B)**, and the rules of transforming figure A to C, **rules(A,C)**. Secondly, for each candidate figure d, the AI agent defines the rules of transforming figure B to d, **rules(B,d)**, and the rules of transforming figure C to d, **rules(C,d)**. Finally the AI agent estimates the similarity between **rules(A,B)** and **rules(C,d)**, as well as the similarity of **rules(A,C)** and **rules(B,d)** and generates a score. The candidate figure with the maximum score will be selected as the final solution.

Hi! Welcome to Joyner Document Format (JDF). This document format is an attempt to avoid all the difficulties we encounter when requiring specific word or page counts. By standardizing the page count, we hope to incentivize efficiency with both words and figures. Plus, having a standard format makes every paper feel more professional. This format is also available [as a Google document](#).

Most conferences take this approach, but we find that most conference formats are overkill relative to what we really need for our classes. So, we've created our own format inspired mostly by [Lecture Notes in Computer Science](#).

Grading

Note that we will not be applying explicit document checks on your formatting. Your submission will not be automatically rejected for failure to strictly adhere to this format. Minor issues that no one would notice organically will not be held against you. More significant issues, like incorrect font sizes, incorrect margins, or systematic small errors may be subject to penalties. Alterations that appear to be specifically intended to shorten or extend a paper's apparent length may be subject to harsher penalties.

Text

All text in JDF should be in the Crimson Text font. The Crimson Text font is available via [Google Fonts](#), or [this zip file](#).

The paper title should be in 18 point bold font, centered at the top of the first page. The title may be up to three lines. The author's name and email should be next *unless* you want or were asked to submit anonymously, in which case this should be omitted. For typical assignments, the document title may be as simple as "Assignment 1". More specialized assignments may warrant more unique paper names, like "A Proposal to Create a New Document Format".

Body text in JDF should be 12 points, 1.15 spacing. **Bold**, *italics*, and underline may be used as needed. Hyperlinks may be inserted in the text, as well as superscripts^{like this},

subscripts^{like this}, and footnotes¹. Body text should be 1.15 spaced, with 6 points of line spacing after each paragraph. Paragraphs should not be indented.

Heading 1 and Heading 2

Heading 1 should be bold and in 18 point font. Heading 2 should be bold and in 14 point font. All headings at all levels should have 12pt spacing before the heading and 6pt spacing after the heading.

Heading 3

Heading 3 should be bold and 12 point font. Like the other headings, it should be preceded by 12pt spacing and followed by 6pt spacing.

Heading 4

Use of headings beyond Heading 3 is not recommended. If need be, though, Heading 4 should be bold, italicized, and 12 point font. Like the other headings, it should be preceded by 12pt spacing and followed by 6pt spacing.

Heading 5

Use of headings beyond Heading 3 is not recommended. If need be, though, Heading 5 should be italicized and 12 point font. Like the other headings, it should be preceded by 12pt spacing and followed by 6pt spacing.

Heading 6

Use of headings beyond Heading 3 is not recommended. If need be, though, Heading 6 should 12 point font and otherwise unformatted. Like the other headings, it should be preceded by 12pt spacing and followed by 6pt spacing.

¹ This is a footnote. The footnote should be indicated in the text by a number footnote in superscript format, and the footnote itself should be in 10 point font at the bottom of the corresponding page.

Margins

Margins should be 1.5 inches on all sides. The page number should be included in the top right corner of the page in the margin.

Figures & Tables

You are encouraged to use figures in your submissions. An example of a figure inserted into a paper is below.



Figure 1. The “Cats Playing Scrabble” drawing I commissioned as a birthday present for my wife.

Those are our cats, as well as her childhood dog and fish.

Figures should always be centered on the page, although they may also take up the entire width of the page. They should not, however, exceed the page margins. Figures should always be referenced in the text. Figures may also be equations, diagrams, or other kinds of content.

Figure Captions

Figures captions should be centered underneath the corresponding figure. The label for the figure, e.g. “Figure 1”, should be bolded, and the entire caption should be 10

point font. If need be, you may have one figure caption corresponding to multiple consecutive figures, and use either locational descriptors (e.g. “Top Left”, “Middle”) or labels (e.g. “A”, “B”) to map parts of the caption to parts of the figure.

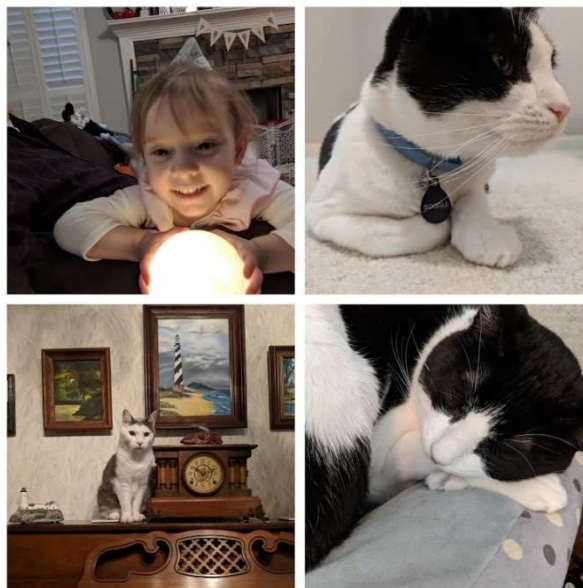


Figure 2. Top left: my daughter Lucy and the moon. Top right: Boggle. Bottom left: Achilles. Bottom right: Artemis.

Table Captions

Table captions should be formatted the same way as figure captions, but they should be placed above the table. The popular mnemonic for this is: figures at the foot, tables at the top. Like figures, tables should not exceed the margins on the page and should be centered on the page. You have freedom to format the table in the way that works best for your data.

Make sure that captions are on the same page as the corresponding figure or table. If a figure or table’s size is such that it cannot fit in the text without leaving considerable blank space on a page or separating the caption from the table or figure, consider rearranging the text. For example, this paragraph was moved before the table below so that the table would not span two pages. You may also place the figure or table and

its caption in a textbox with no outlines and use that to position the figure or table at the top or bottom of a page while the text rearranges around it.

Table 1. A chart of the number of references to various animals and children in this document.

Name (species)	# of References
Boggle (cat)	2
Artemis (cat)	2
Achilles (cat)	2
Lucy (human)	1
Sparky (cat)	1
Snickers (dog)	1
Flower (dog)	1
Feesh (fish)	1

Citations and References

Works should be cited in-line. All works cited in-line should be compiled into a references list at the end of the paper. APA format is preferred for both in-line citations and the reference list.

In-Line Citations

Other articles or sources to which you refer should be cited in-line with the authors' names and the year of publication. The citation should be placed close in the text to the actual claim, not merely at the end of the paragraph. For example: students in the OMSCS program are older and more likely to be employed than students in the on-campus program (Joyner 2017). In the event of multiple authors, list them. For example: research finds sentiment analysis of the text of OMSCS reviews corresponds to student-assigned ratings of the course (Newman & Joyner 2018). You may also cite multiple studies together. For example: several studies have found students in the

online version of an undergraduate CS1 class performed equally with students in a traditional version (Joyner 2018a; Joyner 2018b; Joyner 2019). If you would like to refer to an author in text, you may also do so by including the year (in parentheses) after the author's name in text. If a publication has more than 4 authors, you may list only the first author followed by 'et al'. For example: Joyner et al. (2016) claim that a round of peer review prior to grading may improve graders' efficiency and the quality of feedback given. This applies to parenthetical citations as well, e.g. (Joyner et al. 2016).

Reference List

References should be placed at the end of the paper in a dedicated section. Reference lists should be numbered and organized alphabetically by first author's last name. If multiple papers have the same author(s) and year, you may append a letter to the end of the year to allow differentiated in-line text (e.g. Joyner 2018a and Joyner 2018b in the section above). If multiple papers have the same author(s), list them in chronological order starting with the older paper. APA citation and reference style is preferred, but MLA, Chicago, Harvard, and Vancouver styles are accepted. Only works that are cited in-line should be included in the references section.

For more information on in-line citations and reference sections, we recommend looking at the [Purdue Owl](#) (Purdue Owl 2018). Note that references are *not* counted against the length requirements in any of the listed classes. If the length limit for a particular assignment is 4 pages, then the main text must stop by the end of the fourth page, but the reference list may extend into and past the 5th page.

Additional Components

There are additional components you may need to include in your paper: in-line quotes, block quotes, bulleted lists, numbered lists, and more.

In-Line and Block Quotes

If you would like to quote an outside source, you may do so with quotation marks followed by an in-line citation. If the quote is fewer than three lines, you may quote it in line. It is acceptable to replace pronouns with their target for clarity. For example, “Heavy use of peer grading would compromise [the school’s] reputation” (Joyner 2016). If a quote is more than three lines, you should offset it as its own paragraph with half-inch larger margins on each side. For example:

“Whether or not the grades generated by peers are reliably similar to grades generated by experts is only one factor worth considering, however. Student perception is also an important factor. A recent study indicated that reliance on peer grading is one of the top drivers of high MOOC dropout rates. This problem may be addressed by reintroducing some expert grading where possible” (Joyner 2016)

Bulleted and Numbered Lists

Bulleted and numbered lists half their text indented a half-inch from the left margin, with the bullet or number within that space (the standard format for bullets and margins in Word and Google Docs). For example:

1. This is an item.
2. Note that the left side of the text is aligned, as are the numerals.
3. Notice also that a second line corresponding to the same bullet is also indented at the same level of the previous lines.

Bulleted lists follow the same format:

- Here’s an item.
- Like numbered lists, the second line along a single line in a bulleted list is at the same level of indentation.

Other Content

For other content not covered here, you have reasonable flexibility in determining how it should be used in this format. Generally, nothing should lay outside the margins. You may specify new types of captions if you would like, such as Equations, Diagrams, or other kinds of content.

References

1. Joyner, D. A., Ashby, W., Irish, L., Lam, Y., Langston, J., Lupiani, I., Lustig, M., Pettoruto, P., Sheahen, D., Smiley, A., Bruckman, A., & Goel, A. (2016). Graders as Meta-Reviewers: Simultaneously Scaling and Improving Expert Evaluation for Large Online Classrooms. In *Proceedings of the Third Annual ACM Conference on Learning at Scale*. Edinburgh, Scotland.
2. Joyner, D. A. (2017). Scaling Expert Feedback: Two Case Studies. In *Proceedings of the Fourth Annual ACM Conference on Learning at Scale*. Cambridge, Massachusetts.
3. Joyner, D. A. (2018a). Intelligent Evaluation and Feedback in Support of a Credit-Bearing MOOC. In *Proceedings of the 19th International Conference on Artificial Intelligence in Education*. London, United Kingdom. Springer.
4. Joyner, D. A. (2018b). Toward CS1 at Scale: Building and Testing a MOOC-for-Credit Candidate. In *Proceedings of the Fifth Annual ACM Conference on Learning at Scale*. London, United Kingdom. ACM Press.
5. Joyner, D. A. (2019). Building Purposeful Online Learning: Outcomes from Blending CS1. In Madden, A., Margulieux, L., Kadel, R., & Goel, A. (Eds) *Blended Learning in Practice*. MIT Press.
6. Newman, H. & Joyner, D. A. (2018). Sentiment Analysis of Student Evaluations of Teaching. In *Proceedings of the 19th International Conference on Artificial Intelligence in Education*. London, United Kingdom. Springer.

Appendices

Appendices may be included after the reference list. If you have multiple appendices, you should label the appendix section in general as a level-1 section called Appendices, and each Appendix with a level-2 header with a label and title, e.g. “Appendix A: Interview Transcripts”. If you have only one appendix, you may simply label it as something like “Appendix: Interview Transcripts”.

Appendices do not count against the page limit, but appendices should also not contain any information *required* to answer the question. The body text should be sufficient to answer the question, and the appendices should be included only for you to reference or to give context. Some assignments may also require you to include certain things in the appendices: these will not count against the page limit either.