Comments on 8 Puzzle

From the data displayed above, various conclusions can be drawn on the performance of each of the 3 heuristics, h1(Misplaced Tile), h2(Manhattan Distance), and h3(Linear Conflict).
A quick glance at the 3 tables shows that h3 outperforms both h2 and h1, and h2 outperforms h1. Here are the details of each heuristic;

h1:

This is the least optimal search compared to the other 2 heuristics, it doesn't factor in the distance from the tile to the goal and only counts how many tiles are misplaced. This leads for a very suboptimal performance causing more nodes to be expanded in order to find the solution, making it inefficient compared to the other heuristics.

h2:

This heuristic is more optimal than h1, the reason for that is that this heuristic factors in the distance from each tile to its goal position,
leading for a more accurate heuristic than just counting misplaced tiles, creating less nodes than h1, making it more efficient and optimal

h3:

This heuristic is the most optimal of the 3. The reason for this is that it utilises the Manhattan Distance as well as applying a penalty for tiles that are in the right column or row but simply out of order. It is the most informed heuristic out of the 3 and finds the solution path with the least number of nodes, making it the most efficient and optimal The heuristics ordered in ranking of how informed they are is as follows h3>h2>h1. This ranking also accurately depicts the performance level of each heuristic, fewer nodes explored = more efficient heuristic = goal reached more efficiently

Comments on 15 Puzzle

Misplaced Tiles (h1):

- This heuristic is the least informed among the three, and it only counts tiles that are out of their goal positions.
- Since it doesn’t consider the actual distance each tile needs to move, it tends to

generate higher node expansions compared to h2 and h3.

- While h1 still guarantees a solution with the minimum number of moves due to the A* algorithm's properties, it typically requires significantly more node expansions, leading to slower and less efficient searches.

Manhattan Distance (h2):

- h2, which computes the total Manhattan distance of tiles from their goal positions, is more informed than h1.
- Since it reflects both the position and distance of each tile to its target, h2 results in more selective and effective expansions.
- In most cases, h2 explores fewer nodes than h1, and its paths are generally optimal. This makes it a more efficient choice over h1 for the 15-puzzle.

Linear Conflict (h3):

- h3 combines h2 with an analysis of linear conflicts (where two tiles in the same row or column block each other), making it the most informed heuristic.
- By adding a penalty for these conflicts, h3 reduces the need for additional expansions in such cases, further refining the efficiency of node expansions.
- As a result, h3 generally outperforms h1 and h2 in cases with significant linear conflicts, exploring the fewest nodes among the three while maintaining the minimum solution path length.

Comments on 24 Puzzle

Heuristic h1, which counts tiles that are misplaced, typically performs the least well. It requires more nodes to be expanded and more steps to find solutions. This is probably because it only gives a rough estimate of how close the goal is and not enough to effectively guide the search.

The efficiency of the Manhattan distance heuristic (h2) is significantly higher than that of h1. On average, It requires fewer steps and nodes to be extended. It improves the efficiency of the A*

algorithm by giving a more direct indicator of the distance to the goal state by taking into account the minimal number of movements needed for each tile.

The Manhattan distance is improved by Heuristic h3, the linear conflict heuristic, which adds penalties for tiles in opposing locations. This greatly improves search performance by promoting the settlement of local disputes. Because of this, h3 often has the fewest node expansions and steps, proving its advantage in directing the A* search in fewer movements toward the best answers.