Supplement for Improving Comprehension of Measurements Using Concrete Re-expression Strategies

COMPARING REUNITIZATIONS TO EXISTING AUTOMATED SOLUTIONS

The Dictionary of Numbers[1] (DN), The Measure of Things[2] (MT), and Wolfram's Alpha[3] (WA) can present reunitizations as text for some measures. DN and MT represent automated reunitization algorithms that rely on hand-curated databases, both of which took their creators (independent designers) considerable time and effort, even years, to build [2,3].

We compare our reunitization tool against these tools for a set of 60 input measurements (15 measurements for each of the four measures), spanning 8 orders of magnitude and the halfway points between them from 0.001 to 10,000.

We examined the first three results returned by each tool, considering a total of 180 reunitizations per tool. We assessed coverage (e.g., how many input measurements a tool was able to generate re-expressions, how many unique objects these re-expressions use), the familiarity of the objects used in re-expressions, and the magnitude of the multipliers used in the re-expressions. We summarize the results of this analysis below. The complete results from our reunitization tool can be found in the file **strategy_results.xlsx**. The complete results from DN, MT, and WA, can be found in the file **DN_MT_WA_comparison.xlsx**.

Coverage

DN returns a single result for only 6 out of the 60 inputs (6/180, 6/180 unique objects). MT returns three results for all 60 inputs (180/180; 96/180 unique objects). WA returns three results for 41 of the 60 inputs, two results for 7 of the 60 inputs, one result for 9 of the 60 inputs, and 0 results for 3 of the 60 inputs (146/180; 77/180 unique objects).

In contrast, our reunitization tool returns three results for 60 inputs (180/180; 84/180 unique objects). Only MT also returns as many re-expressions. MT results include slightly more unique objects than our results (12 more unique objects) across the set of inputs.

Familiarity

Three of the six objects returned by DN to re-express the input measurement are of questionable familiarity (*Mass equivalent of the energy that is called 1 megaton of TNT equivalent; weight of an adult elephant; length of longest blue whale measured, the largest animal*).

Many of the objects used in re-expressions returned by MT and WA are also of questionable familiarity. MT presents, for example, multiples of the weights of a *Blue Whale's tongue*, *a Tyrannasaurus Rex*, *a reindeer*, *a cubic meter of snow*, *a human brain*, *hippopotamus*, and *an elephant*.

WA presents, for example, *volume of one mole of ideal gas at STP*, *height of Burj Khalafa*, *length of the Hindenburg Zeppelin*, *amoeba proteus bacterium length*, *length of Noah's Ark, average ground level of the Maldives above sea level, height of Nelson's column (including statue), highest measured ocean wave during a tsunami.*

---

[1] https://www.dictionaryofnumbers.com/

[2] http://www.bluebulbprojects.com/measureofthings/

[3] https://www.wolframalpha.com/

Our tool occasionally returns a multiple of a synset that some users may not find familiar (e.g., *a light-emitting diode*, or *LED* may seem unfamiliar to some users). Overall, however, our tool clearly outperforms all three other tools for object familiarity by using mostly common everyday objects.

Multiplier Magnitude

DN only returns reunitizations where the multiplier is 1 (6/6 results). MT returns 79/180 (44%) reunitizations with multipliers less than 1, 4/180 (2%) reunitizations with multipliers over 10, and the remaining 97/180 (54%) reunitizations with multipliers between 1 and 10. WA returns 87/146 (60%) reunitizations with multipliers less than 1, 2/146 (1.4%) reunitizations with multipliers over 10, and the remaining 57/180 (32%) reunitizations with multipliers between 1 and 10.

Our tool outperforms all three other tools for returning reunitizations with multipliers in a range that is known to be easily understood by people based on number sense research. Our tool returns 35/180 (19%) reunitizations with multipliers less than 1, 10/180 (5.6%) reunitizations with multipliers over 10, and the remaining 135/180 (75%) reunitizations with multipliers between 1 and 10.

REFERENCES

1. Glen Chiachieri (creator of *The Dictionary of Numbers*). Personal communication. (2014).
2. Jonathon Clase (creator of *The Measure of Things*). Personal communication. (2017).