ShapeWordle: Tailoring Wordles using Shape-aware Archimedean Spirals

(Supplemental Material)

Yunhai Wang, Xiaowei Chu, Kaiyi Zhang, Chen Bao, Xiaotong Li, Jian Zhang,
Chi-Wing Fu, Christophe Hurter, Bongshin Lee, and Oliver Deussen

◆

1 CURVATURE RADIUS COMPUTATION

For a given scalar field φ, the curvature radius R along the isoline of φ at point (x, y) can be estimated by using the Hessian matrix [1]:

$$\kappa(x, y) = \mathbf{T}^\mathsf{T} \mathbf{H} \mathbf{T} / |\mathbf{G}| \, , \tag{1}$$

where $\mathbf{G}$ is the gradient vector field of φ and $\mathbf{H}$ is the Hessian matrix:

$$\mathbf{H} = \begin{pmatrix} \frac{\partial^2 \varphi}{\partial x^2} & \frac{\partial^2 \varphi}{\partial x \partial y} \\ \frac{\partial^2 \varphi}{\partial y \partial x} & \frac{\partial^2 \varphi}{\partial y^2} \end{pmatrix} \, .$$

Once κ is available, we can readily compute the curvature radius R, which is the reciprocal of κ.

2 ADDITIONAL CASE STUDIES

In this section, we list the remaining 25 case study results, which are not included in the paper, and for each layout, we offer a brief introduction.

Fig. 1. The logos of Microsoft Windows, Apple Inc., IOS, and Android.

- *Y. Wang, X. Chu, K. Zhang, C. Bao, and X. Li are with Shandong University. Email: {cloudseawang, cuxiaoxie, sdukaiyi, baochen95, xiaotonglig}@gmail.com.*
- *J. Zhang is with CNIC, CAS. E-mail: zhangjian@sccas.cn.*
- *C.-W. Fu is with the Chinese University of Hong Kong. E-mail: cwfu@cse.cuhk.edu.hk.*
- *C. Hurter is with ENAC, France. E-mail: christophe.hurter@enac.fr.*
- *B. Lee is with Microsoft Research. E-mail: bongshin@microsoft.com.*
- *O. Deussen is with Konstanz University, Germany and Shenzhen VisuCA Key Lab, SIAT, China. E-mail: oliver.deussen@uni-konstanz.de.*
- *Y. Wang and X. Chu are joint first authors.*

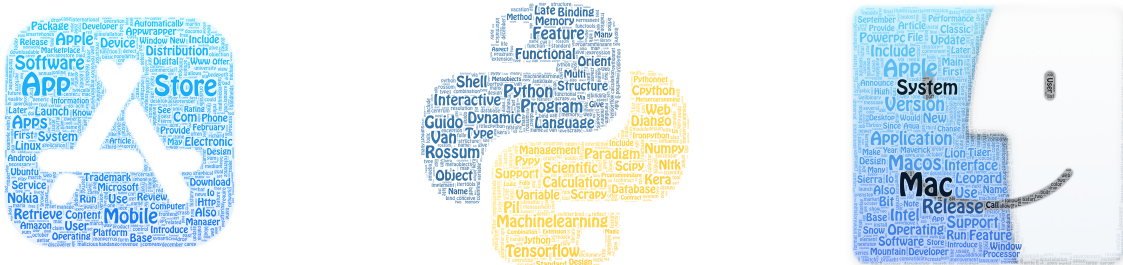Fig. 2. The logos of Google Inc., Google Play, and Firefox.

Fig. 3. The logos of Apple App Store, Python, and Finder.

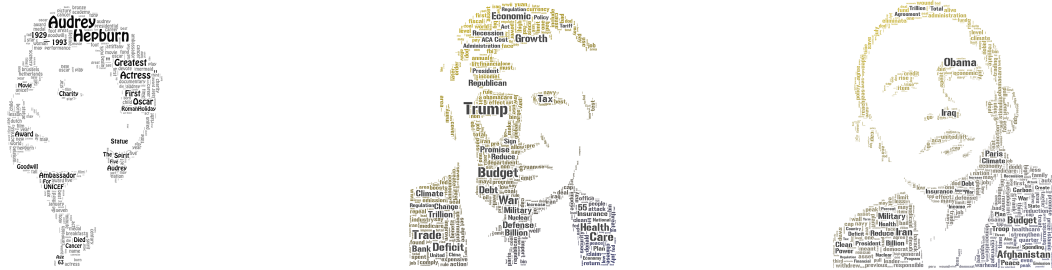Fig. 4. The silhouettes of a girl, Captain America, and Iron Man.

Fig. 5. The silhouettes of Audrey Hepburn, Donald Trump, and Barack Obama.

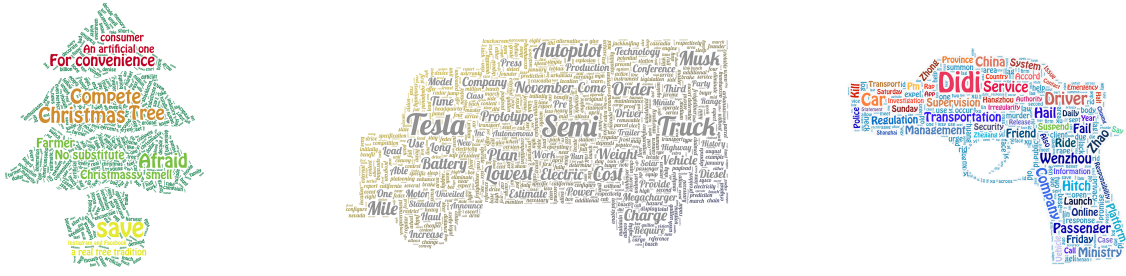Fig. 6. The silhouette of Donald Trump, the logos of Linkin Park, and Tesla.

Fig. 7. The shapes of a Christmas tree, a truck, and a gun.

Fig. 8. The shapes of some animals: squirrel, rabbit, panda, and pigeon.

3 CASES FOR TEMPORAL SHAPE WORDLE

The temporal wordle of human life cycle is partially shown in the paper due to limited space. Here, we show the complete version of this case. We also create another example of temporal shape wordle using another data source in the Morphable Word Clouds paper [2]. This case is about the life cycle of a frog.

(a)

(b)
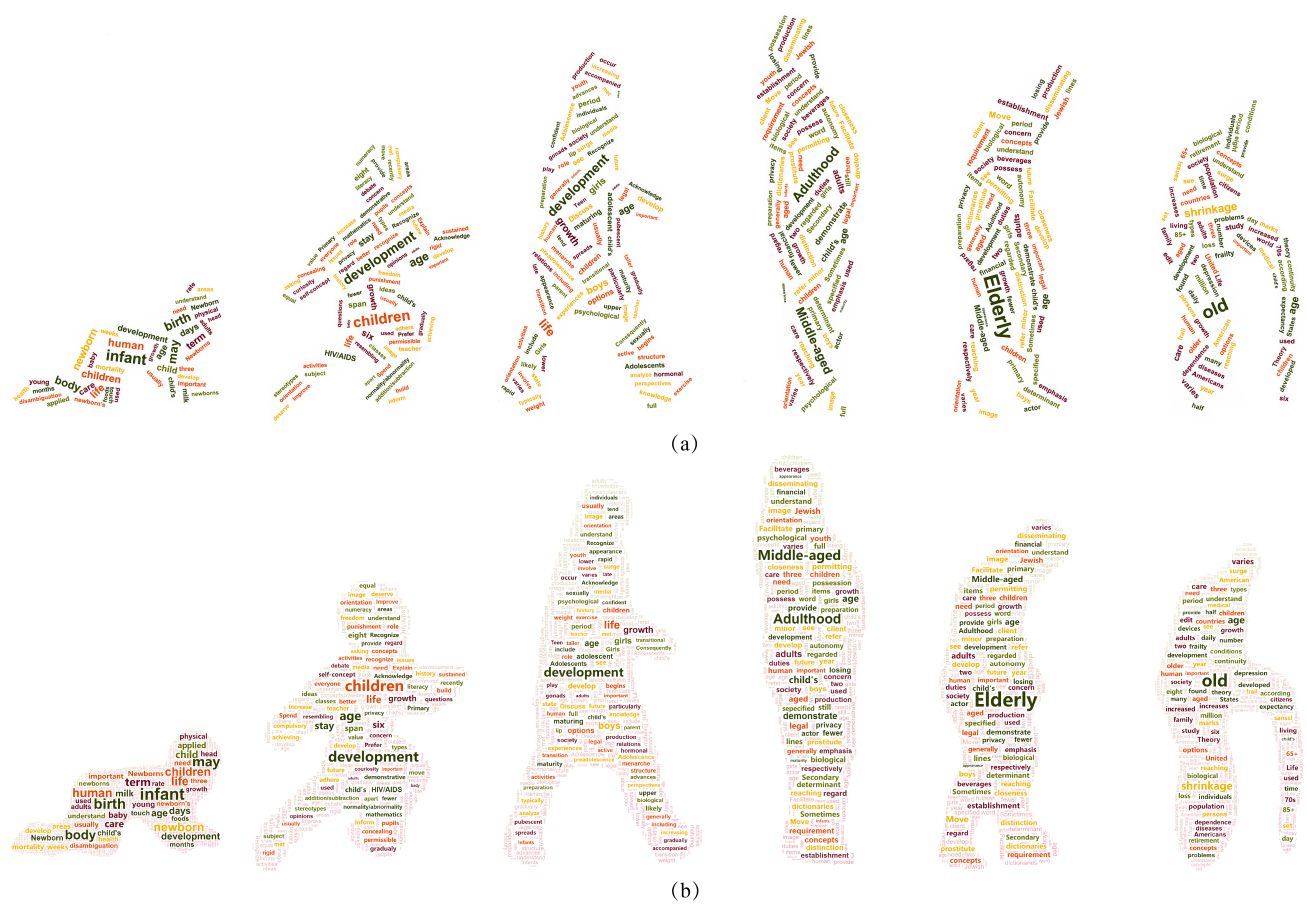
Fig. 9. A comparison between temporal shape wordles generated by (a) Morphable word clouds and by (b) our algorithm. This picture illustrates the stage of human life cycle.
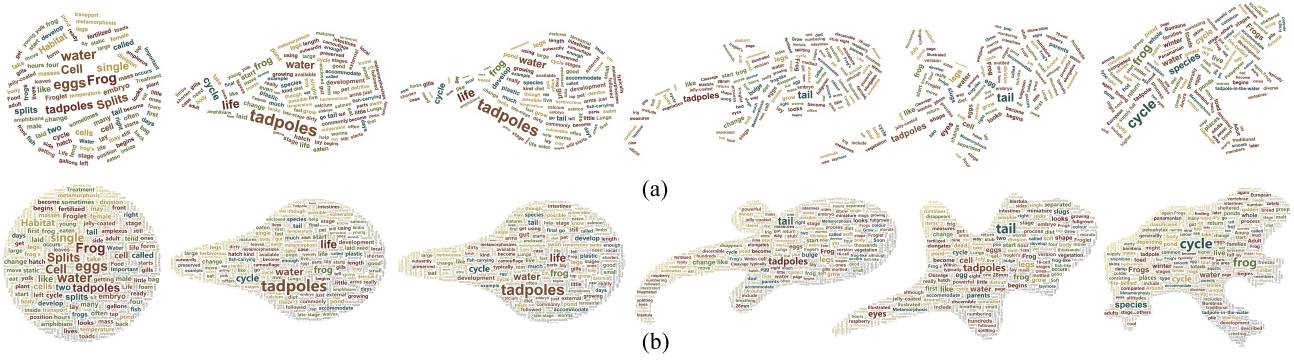
Fig. 10. A comparison between temporal shape wordles generated by (a) Morphable word clouds and by (b) our algorithm. This picture illustrates the stage of frog life cycle.

4 COMPARISON WITH TAGXEDO

Tagxedo [3] is an online tool, which appears to be able to generate shaped word clouds. In this section, we show two examples of Tagxedo results to compare our ShapeWordle with Tagxedo. The generated Tagxedo layouts were created by using the Christmas tree shape and the Flower shape in the paper, and by filling the shapes with the corresponding text. We set the number of words in each layout as 60, following what we presented in main paper. Then, we found that Tagxedo, by default, omits some of the keywords due to the limited space. For example, in Fig. 11(a) below, the word "Day" is missing. And Fig. 12(a) is even worse, where "Asteraceae", "families", and "includes" are all omitted. While Tagxedo offers a slider for users to adjust the number of words in the layout. But since it simply follows a standard circular spiral to layout words, large amount of areas in the shapes are not filled; see the bottom part of the trunk in Christmas tree (Fig. 11(b)) and the leftmost and rightmost parts in Fig. 12(b). Hence, the layouts generated by Tagxedo are not really shape-aware (as compared to WordArt and our method); thus, we decided to compare with WordArt but not with Tagxedo in the quantitative evaluation presented in main paper.
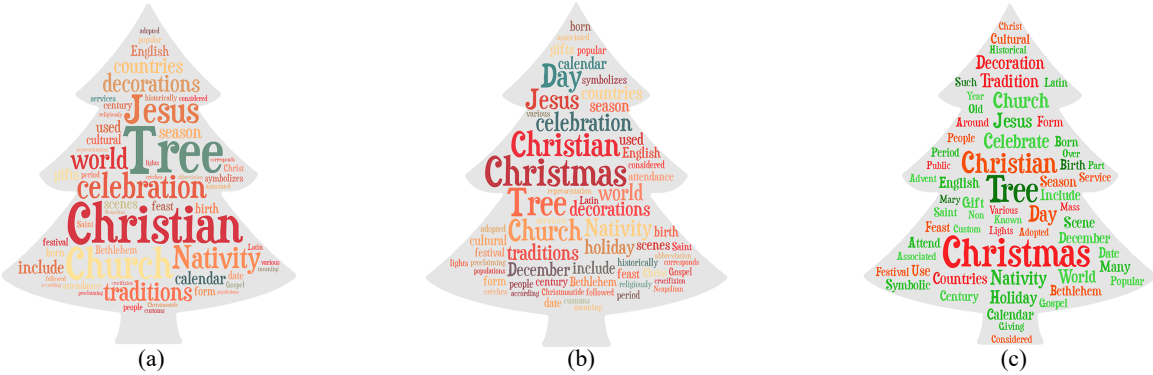
Fig. 11. (a) The default result of Tagxedo. Note that 4 out of the 60 words are missing, for example, "Day"; (b) the adjusted result of Tagxedo with all the 60 keywords but the bottom part of the tree is clearly missed in the filling; and (c) the result of our ShapeWordle.
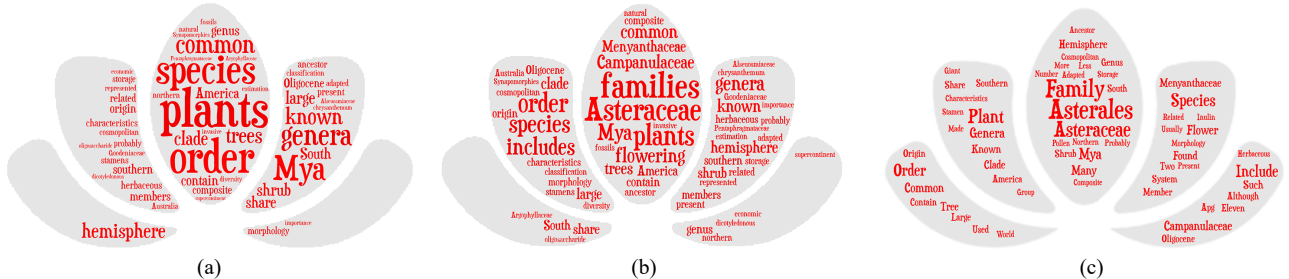
Fig. 12. (a) The default result of Tagxedo. Note that 7 out of the 60 words are missing, including even the very big word "Asteraceae"; (b) the adjusted result of Tagxedo with all the 60 keywords but the leftmost and rightmost parts in the shape are clearly not filled, demonstrating the incapability of Tagxedo to generate shape-aware results; and (c) the result of our ShapeWordle.

5 ADDITIONAL INFORMATION OF QUANTITATIVE COMPARISON

In this section, we provide the layouts used in the quantitative study and the complete results of the three metrics: *Layout Coverage* (**LC**), *Layout Uniformity* (**LU**), and *Shape Similarity* (**SS**).

Each row presents one shape in our dataset. In each of the figures shown on subsequent pages, the first column shows the results produced by our ShapeWordle, and the second column shows the result produced by WordArt. Each of these layouts contains 60 words. We used these two

layouts for the calculations and comparison of the three metrics and the results are shown under the corresponding figures. The third column shows the final result produced by Shape Wordle, after filling the less important words, whereas the fourth column shows the corresponding final result produced by WordArt.

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.2, LU−87, SS−1675

LC−0.18, LU−99, SS−2026

LC−0.21, LU−80, SS−1888

LC−0.2, LU−84, SS−2109

LC−0.17, LU−119, SS−1017

LC−0.17, LU−152, SS−1437

LC−0.23, LU−76, SS−964

LC−0.12, LU−178, SS−1810

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC-0.21, LU-74, SS-805

LC-0.2, LU-79, SS-864

LC-0.23, LU-73, SS-973

LC-0.11, LU-161, SS-2678
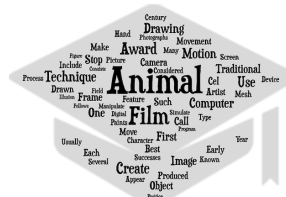
LC-0.18, LU-93, SS-8295

LC-0.2, LU-89, SS-7680

LC-0.17, LU-135, SS-4175

LC-0.16, LU-168, SS-3935

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
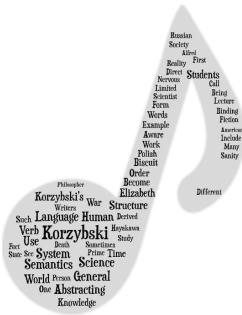
LC−0.2, LU−100, SS−1233   LC−0.2, LU−88, SS−1028

LC−0.18, LU−74, SS−1290   LC−0.19, LU−90, SS−5480

LC−0.21, LU−81, SS−1027   LC−0.23, LU−78, SS−905

LC−0.15, LU−64, SS−1660   LC−0.15, LU−66, SS−6146

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.21, LU−73, SS−789
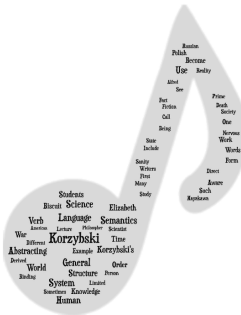
LC−0.14, LU−96, SS−1159
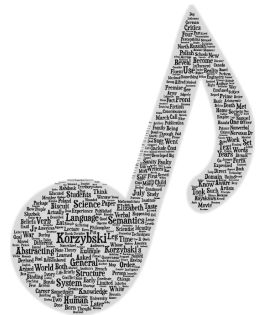
LC−0.21, LU−91, SS−1027

LC−0.2, LU−90, SS−1238
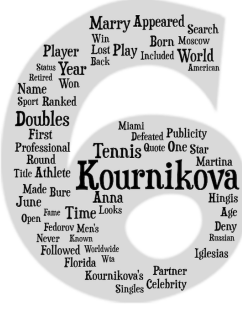
LC−0.21, LU−83, SS−1032
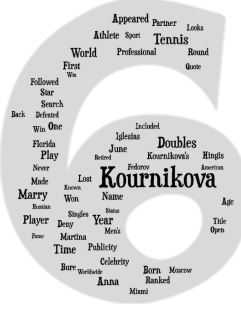
LC−0.12, LU−180, SS−2319

LC−0.18, LU−53, SS−3994

LC−0.2, LU−49, SS−3996

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.22, LU−92, SS−945   LC−0.14, LU−159, SS−1897

LC−0.19, LU−90, SS−1091   LC−0.18, LU−83, SS−1159

LC−0.23, LU−87, SS−1787   LC−0.15, LU−155, SS−6617
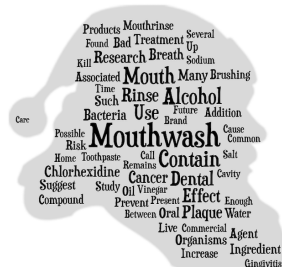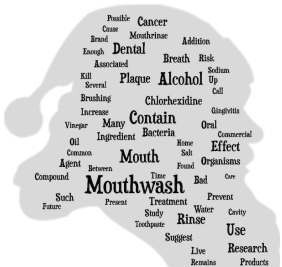
LC−0.16, LU−74, SS−1170   LC−0.16, LU−85, SS−1515
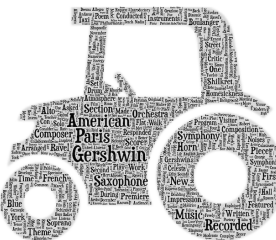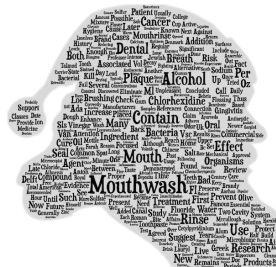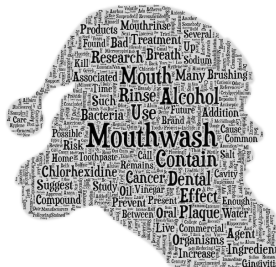
ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
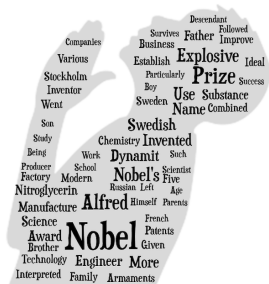
LC−0.2, LU−54, SS−4118   LC−0.14, LU−78, SS−5835
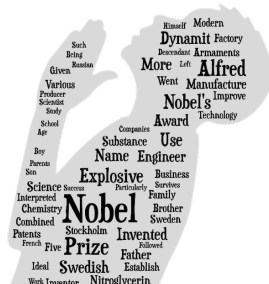
LC−0.22, LU−51, SS−947   LC−0.22, LU−84, SS−1626
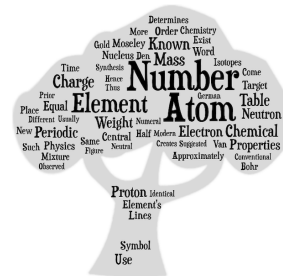
LC−0.21, LU−93, SS−728   LC−0.23, LU−80, SS−928
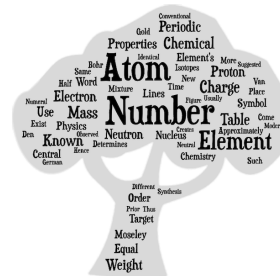
LC−0.24, LU−62, SS−1680   LC−0.23, LU−67, SS−1523

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.13, LU−110, SS−3304   LC−0.12, LU−134, SS−4776

LC−0.25, LU−43, SS−817   LC−0.25, LU−49, SS−702

LC−0.23, LU−79, SS−1563   LC−0.23, LU−73, SS−1511

LC−0.22, LU−53, SS−721   LC−0.19, LU−78, SS−1015

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
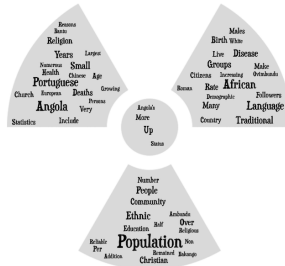
LC−0.2, LU−56, SS−811   LC−0.15, LU−101, SS−1043
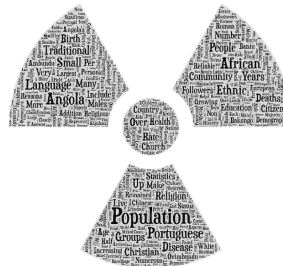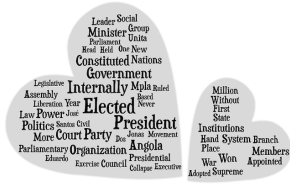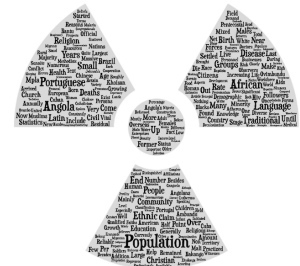
LC−0.22, LU−75, SS−927   LC−0.21, LU−87, SS−1117
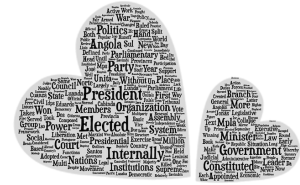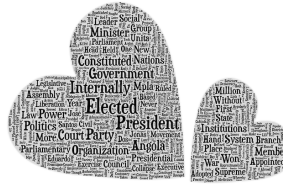
LC−0.16, LU−83, SS−1398   LC−0.15, LU−99, SS−1458
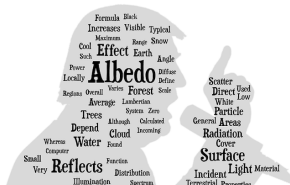
LC−0.19, LU−78, SS−1470   LC−0.24, LU−56, SS−1416
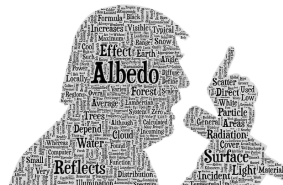
ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
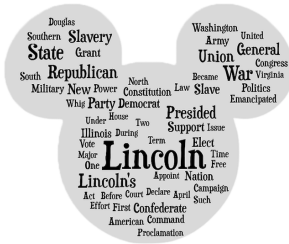
LC−0.2, LU−41, SS−744　　　　LC−0.25, LU−37, SS−494

LC−0.2, LU−27, SS−1577　　　　LC−0.24, LU−30, SS−1473

LC−0.2, LU−64, SS−2342　　　　LC−0.22, LU−51, SS−2219

LC−0.19, LU−74, SS−1148　　　　LC−0.17, LU−103, SS−1683

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.19, LU−105, SS−1547
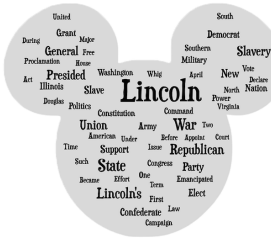
LC−0.14, LU−158, SS−1740
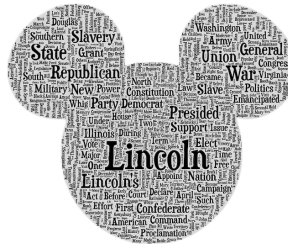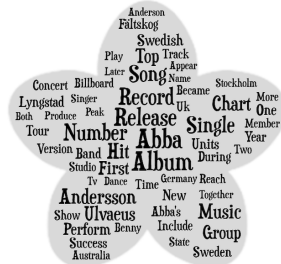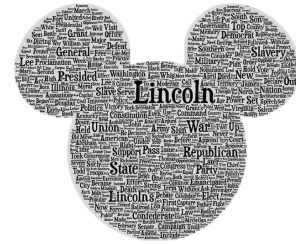
LC−0.25, LU−56, SS−547

LC−0.23, LU−80, SS−994

LC−0.17, LU−87, SS−1465

LC−0.1, LU−151, SS−1538

LC−0.16, LU−115, SS−1717

LC−0.08, LU−196, SS−2484
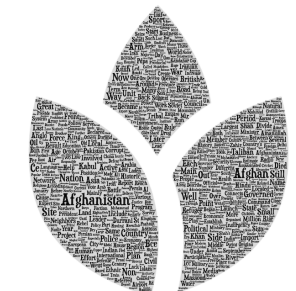
ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.2, LU−81, SS−1657   LC−0.16, LU−112, SS−2128
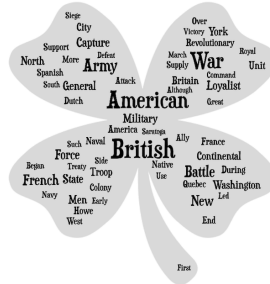
LC−0.19, LU−60, SS−1561   LC−0.15, LU−75, SS−2319

LC−0.23, LU−49, SS−1317   LC−0.11, LU−123, SS−2116
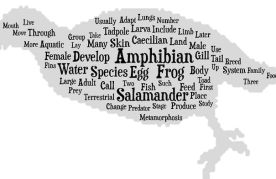
LC−0.23, LU−45, SS−9066   LC−0.09, LU−129, SS−10051
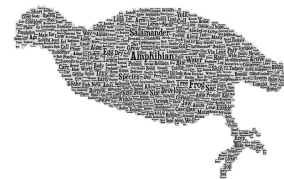
ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC-0.21, LU-62, SS-3776

LC-0.16, LU-81, SS-3499

LC-0.21, LU-54, SS-1432

LC-0.1, LU-121, SS-4963

LC-0.19, LU-68, SS-2658

LC-0.15, LU-76, SS-2691

LC-0.19, LU-122, SS-1541

LC-0.16, LU-143, SS-1610

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.18, LU−152, SS−1448

LC−0.11, LU−261, SS−2312
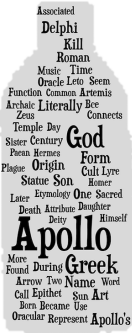
LC−0.24, LU−124, SS−1537

LC−0.12, LU−251, SS−2521
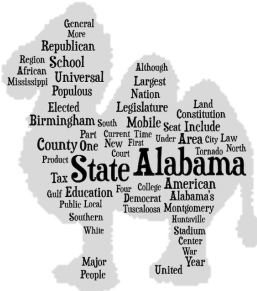
LC−0.23, LU−64, SS−3473

LC−0.14, LU−123, SS−4911

LC−0.22, LU−53, SS−647
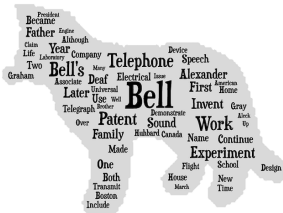
LC−0.22, LU−58, SS−687

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.2, LU−78, SS−3758

LC−0.1, LU−141, SS−7516

LC−0.21, LU−45, SS−3768

LC−0.25, LU−46, SS−3944
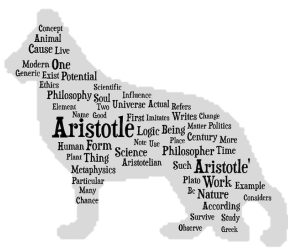
LC−0.22, LU−56, SS−3522
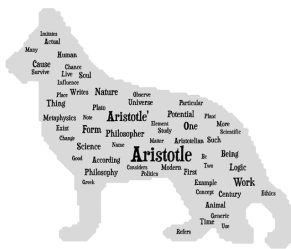
LC−0.14, LU−100, SS−5100
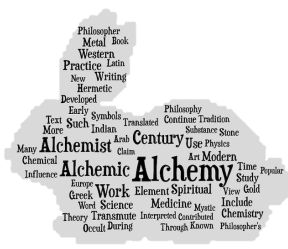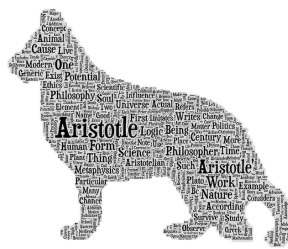
LC−0.23, LU−68, SS−974

LC−0.12, LU−151, SS−1821

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.2, LU−68, SS−5334
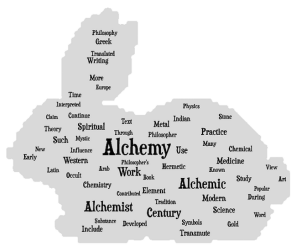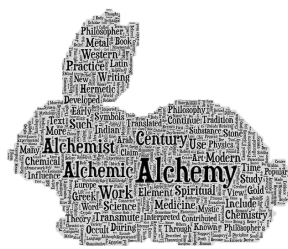
LC−0.14, LU−95, SS−8688
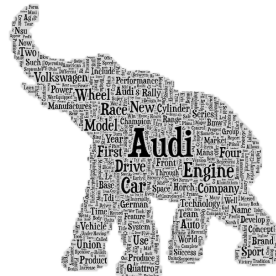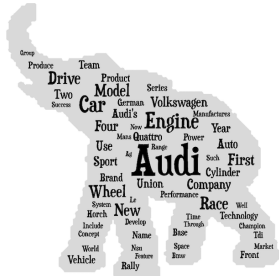
LC−0.2, LU−62, SS−871

LC−0.2, LU−62, SS−1941

LC−0.23, LU−51, SS−848

LC−0.14, LU−103, SS−1487

LC−0.23, LU−66, SS−431
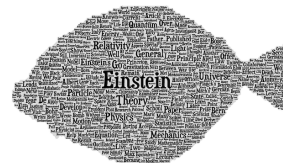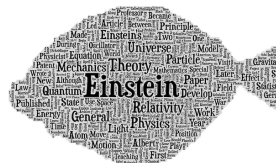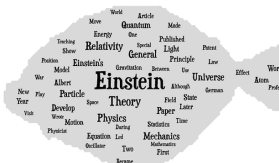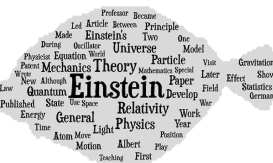
LC−0.14, LU−147, SS−1335

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.2, LU−53, SS−1212   LC−0.15, LU−74, SS−1991

LC−0.2, LU−106, SS−608   LC−0.24, LU−80, SS−684
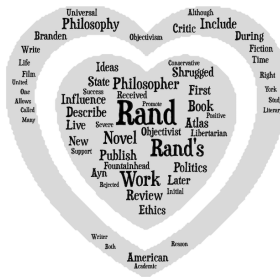
LC−0.16, LU−98, SS−2773   LC−0.18, LU−107, SS−4462
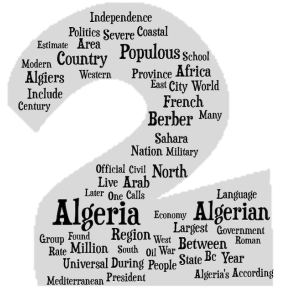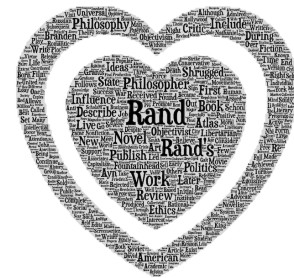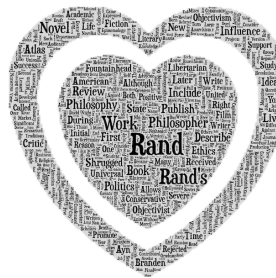
LC−0.22, LU−81, SS−871   LC−0.12, LU−164, SS−1811

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
LC−0.22, LU−82, SS−949	LC−0.11, LU−164, SS−1629		
LC−0.21, LU−79, SS−3380	LC−0.14, LU−131, SS−5153		
LC−0.23, LU−57, SS−1114	LC−0.15, LU−96, SS−1703		
LC−0.23, LU−77, SS−5819	LC−0.07, LU−315, SS−11385		
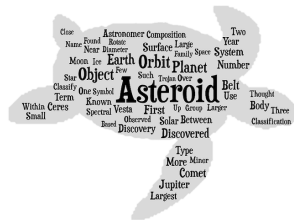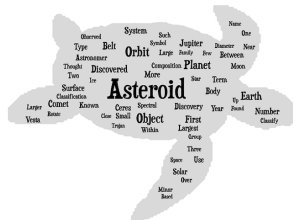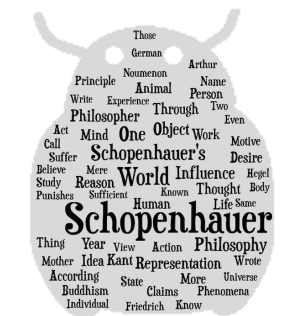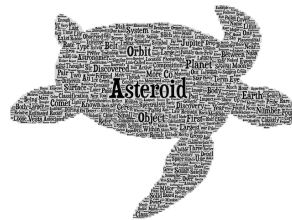
ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
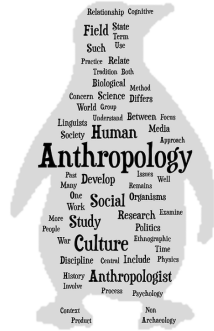
LC−0.19, LU−92, SS−5039
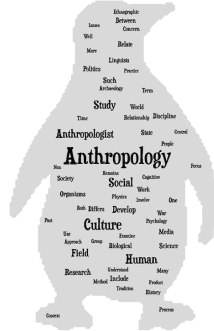
LC−0.1, LU−193, SS−6318
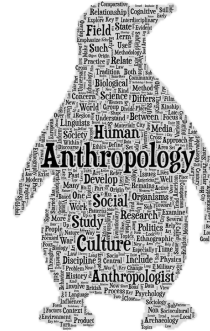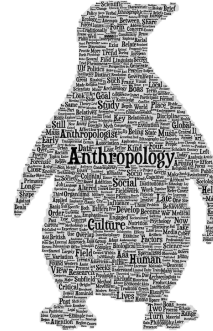
LC−0.23, LU−45, SS−710

LC−0.18, LU−61, SS−861
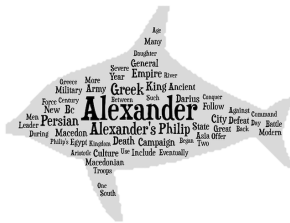
LC−0.24, LU−41, SS−1250

LC−0.12, LU−108, SS−4081

LC−0.23, LU−54, SS−937
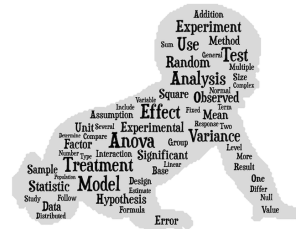
LC−0.25, LU−46, SS−831

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
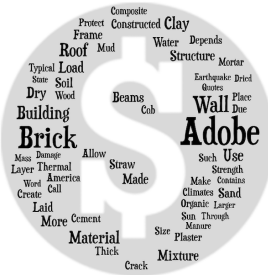
LC−0.18, LU−97, SS−1011

LC−0.16, LU−108, SS−1152

LC−0.22, LU−84, SS−1534

LC−0.16, LU−114, SS−6159

LC−0.17, LU−84, SS−921

LC−0.11, LU−131, SS−1722

LC−0.23, LU−99, SS−946

LC−0.22, LU−83, SS−895
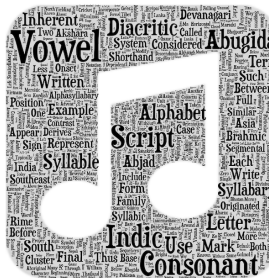
ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
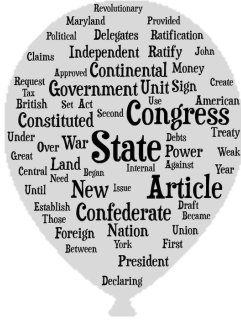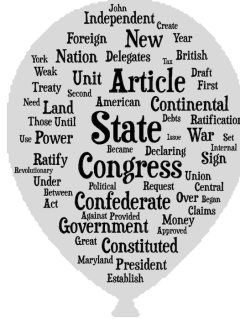
LC−0.24, LU−71, SS−1286

LC−0.24, LU−77, SS−2007

LC−0.18, LU−98, SS−765

LC−0.19, LU−77, SS−862
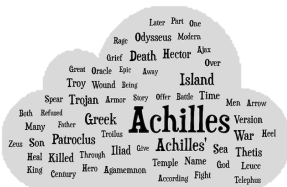
LC−0.15, LU−139, SS−1875

LC−0.12, LU−190, SS−1988

LC−0.21, LU−71, SS−1373

LC−0.15, LU−104, SS−1487

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
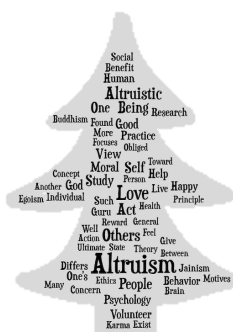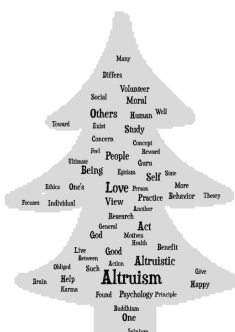
LC−0.22, LU−65, SS−1163   LC−0.12, LU−121, SS−1539

LC−0.22, LU−52, SS−1620   LC−0.15, LU−82, SS−1775
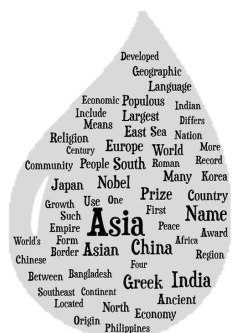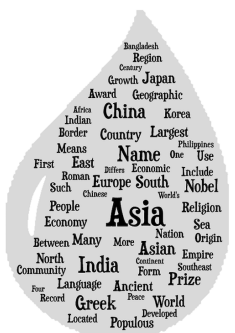
LC−0.21, LU−95, SS−1390   LC−0.2, LU−95, SS−1890
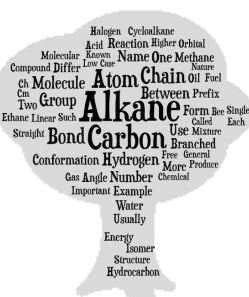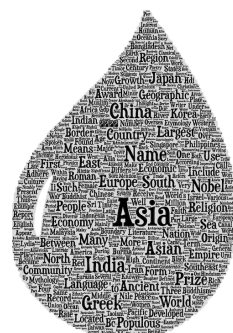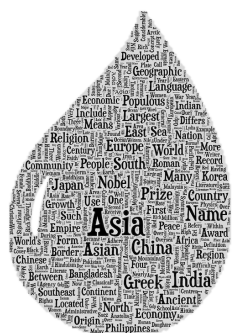
LC−0.25, LU−68, SS−1772   LC−0.18, LU−98, SS−1624

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.19, LU−57, SS−3402

LC−0.2, LU−68, SS−3514

LC−0.17, LU−125, SS−1475

LC−0.16, LU−137, SS−1521

LC−0.2, LU−78, SS−8624

LC−0.15, LU−96, SS−9122

LC−0.17, LU−161, SS−938

LC−0.19, LU−73, SS−725

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.13, LU−159, SS−1742

LC−0.12, LU−129, SS−1183

LC−0.21, LU−87, SS−1063

LC−0.14, LU−150, SS−1186

LC−0.22, LU−61, SS−1449

LC−0.19, LU−82, SS−1784

LC−0.23, LU−43, SS−841

LC−0.25, LU−57, SS−1803

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.22, LU−41, SS−679   LC−0.17, LU−53, SS−1027

LC−0.17, LU−94, SS−1699   LC−0.16, LU−88, SS−1505

LC−0.22, LU−64, SS−1337   LC−0.21, LU−87, SS−1814

LC−0.22, LU−95, SS−8851   LC−0.16, LU−135, SS−9141

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.22, LU−73, SS−804   LC−0.21, LU−71, SS−817

LC−0.22, LU−45, SS−4106   LC−0.17, LU−69, SS−4398

LC−0.2, LU−76, SS−6691   LC−0.14, LU−98, SS−10781

LC−0.2, LU−46, SS−539   LC−0.19, LU−49, SS−978

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.2, LU−67, SS−1036

LC−0.14, LU−116, SS−1948

LC−0.22, LU−53, SS−503

LC−0.17, LU−106, SS−1126

LC−0.2, LU−94, SS−1090
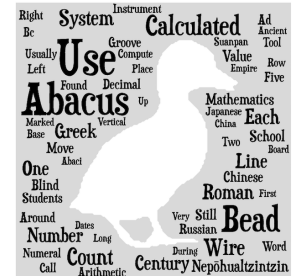
LC−0.22, LU−88, SS−2571
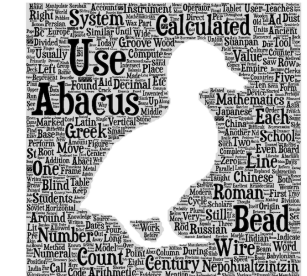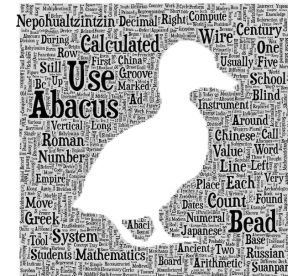
LC−0.22, LU−85, SS−915
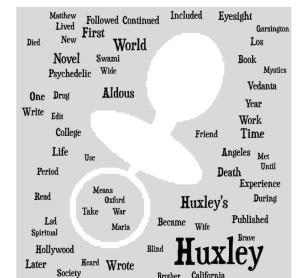
LC−0.11, LU−199, SS−2026
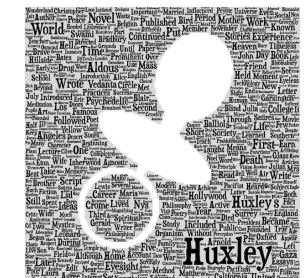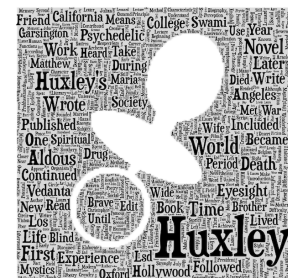
ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
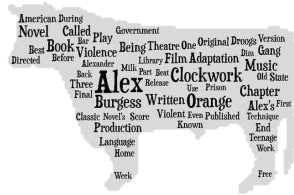
LC−0.23, LU−55, SS−3068
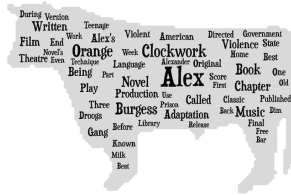
LC−0.2, LU−73, SS−5260
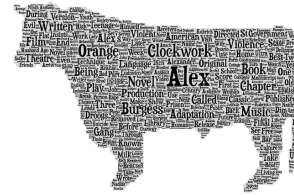
LC−0.2, LU−56, SS−922

LC−0.17, LU−68, SS−894
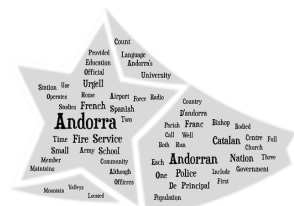
LC−0.14, LU−87, SS−1324
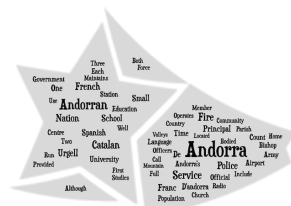
LC−0.15, LU−95, SS−3162

LC−0.21, LU−84, SS−894

LC−0.2, LU−89, SS−1241

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.22, LU−50, SS−617   LC−0.23, LU−47, SS−593

LC−0.2, LU−79, SS−1283   LC−0.2, LU−73, SS−1640

LC−0.2, LU−82, SS−1073   LC−0.21, LU−76, SS−1031

LC−0.23, LU−51, SS−617   LC−0.23, LU−73, SS−885

ShapeWordle (60 words) **WordArt (60 words)** **ShapeWordle (final result)** **WordArt (final result)**

LC−0.21, LU−96, SS−549   LC−0.25, LU−88, SS−888

LC−0.2, LU−117, SS−899   LC−0.13, LU−171, SS−1423
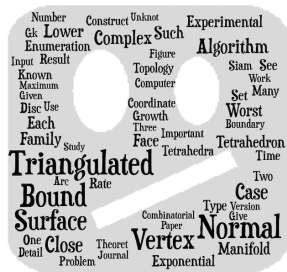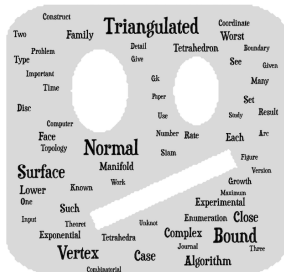
LC−0.21, LU−93, SS−967   LC−0.1, LU−225, SS−1754

LC−0.18, LU−109, SS−962   LC−0.16, LU−101, SS−815

ShapeWordle (60 words) **WordArt (60 words)** **ShapeWordle (final result)** **WordArt (final result)**

LC−0.2, LU−118, SS−1249   LC−0.1, LU−251, SS−1908
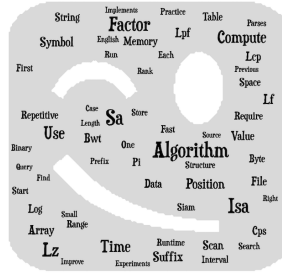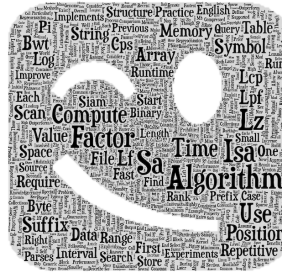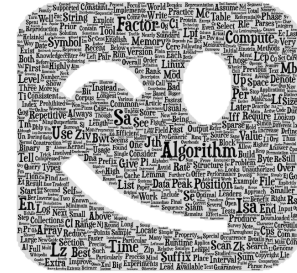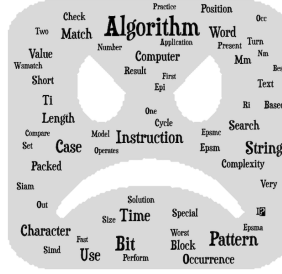
LC−0.2, LU−122, SS−1065   LC−0.11, LU−206, SS−1705
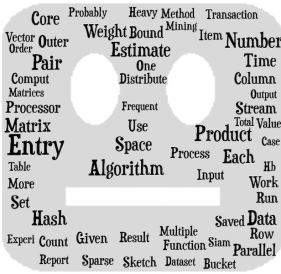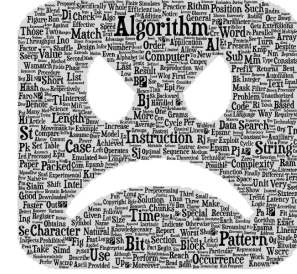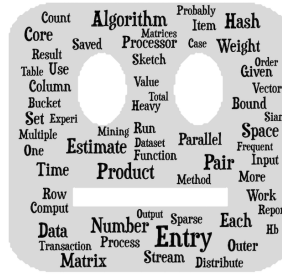
LC−0.18, LU−161, SS−938   LC−0.18, LU−127, SS−1078
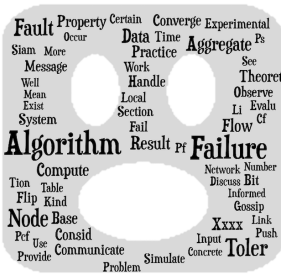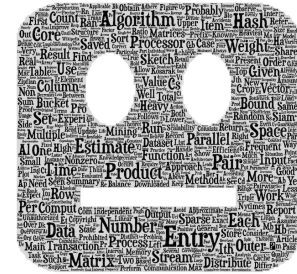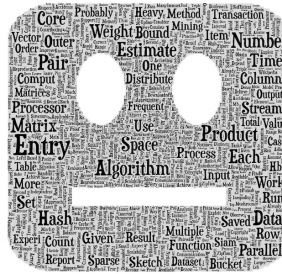
LC−0.19, LU−103, SS−1013   LC−0.1, LU−221, SS−1543

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.23, LU−73, SS−2242

LC−0.2, LU−84, SS−3047

LC−0.23, LU−75, SS−3846

LC−0.14, LU−121, SS−3589

LC−0.2, LU−65, SS−11808

LC−0.23, LU−59, SS−10576

LC−0.22, LU−56, SS−769

LC−0.17, LU−77, SS−873

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.19, LU−51, SS−7019

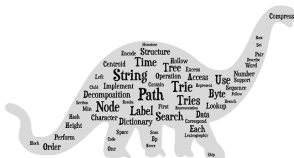LC−0.2, LU−58, SS−7031
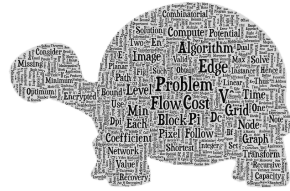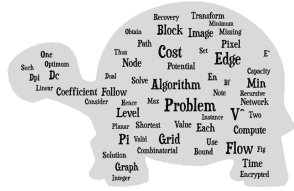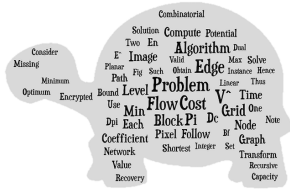
LC−0.17, LU−109, SS−1335

LC−0.15, LU−137, SS−1481
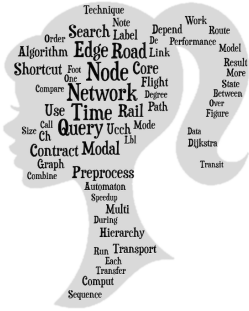

LC−0.2, LU−73, SS−2721

LC−0.16, LU−83, SS−3018
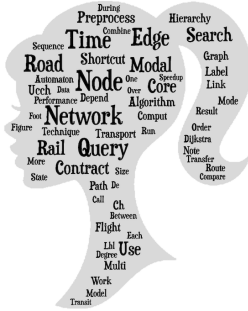

LC−0.18, LU−57, SS−2039

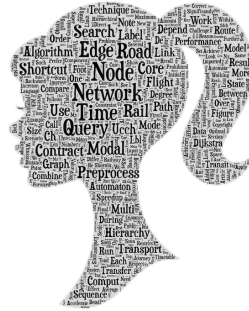LC−0.2, LU−52, SS−2038

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.21, LU−97, SS−3948

LC−0.19, LU−91, SS−3147

LC−0.23, LU−39, SS−5903

LC−0.25, LU−49, SS−6642

LC−0.24, LU−56, SS−695

LC−0.2, LU−69, SS−763

LC−0.24, LU−58, SS−788

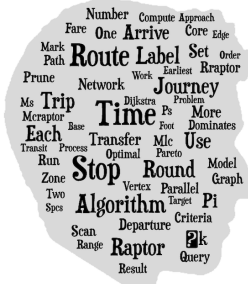LC−0.25, LU−56, SS−694

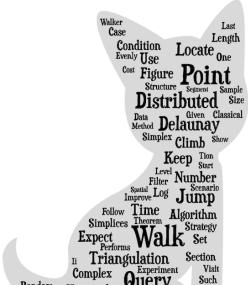| ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

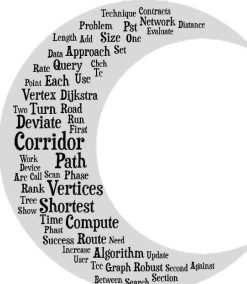LC−0.21, LU−76, SS−1505   LC−0.22, LU−69, SS−1281
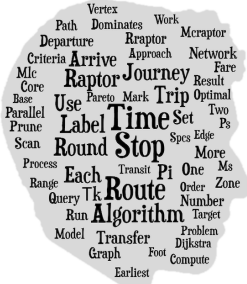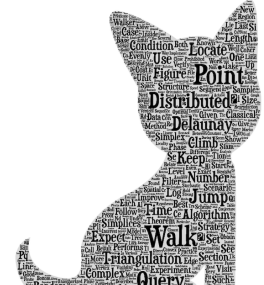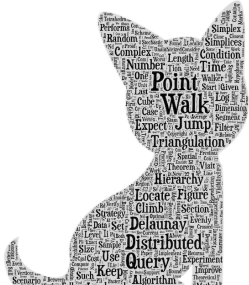

LC−0.24, LU−71, SS−613   LC−0.22, LU−85, SS−1055
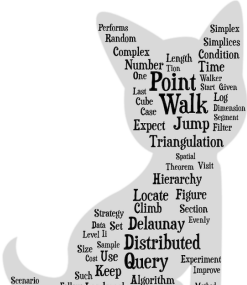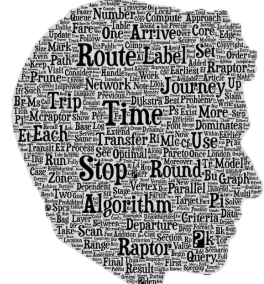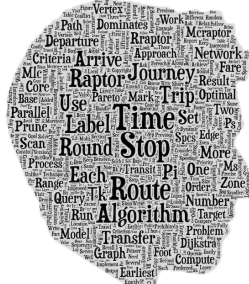
LC−0.22, LU−61, SS−928   LC−0.25, LU−47, SS−1164

LC−0.22, LU−60, SS−2177   LC−0.15, LU−89, SS−2358

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**
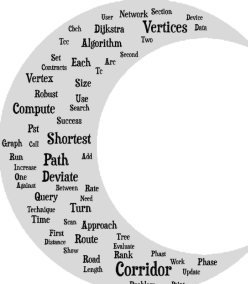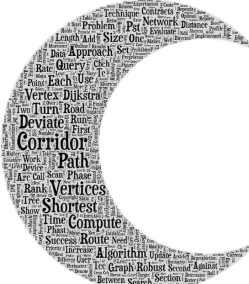
LC−0.19, LU−126, SS−3647   LC−0.13, LU−149, SS−3815

LC−0.22, LU−47, SS−1805   LC−0.23, LU−53, SS−2255
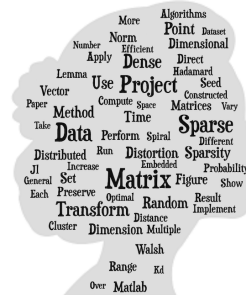
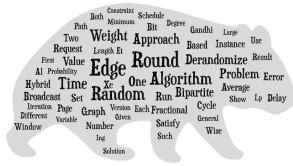LC−0.24, LU−92, SS−1604   LC−0.2, LU−97, SS−1494

LC−0.14, LU−111, SS−1284   LC−0.12, LU−130, SS−1550
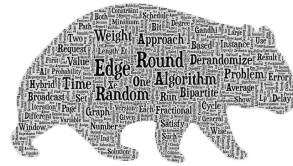
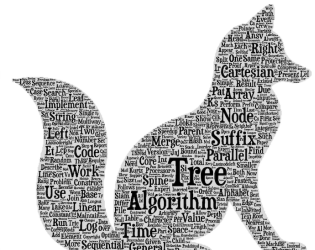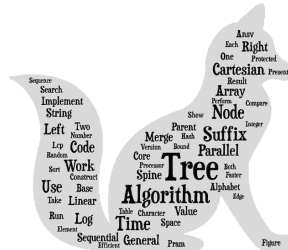| ShapeWordle (60 words) | WordArt (60 words) | ShapeWordle (final result) | WordArt (final result) |

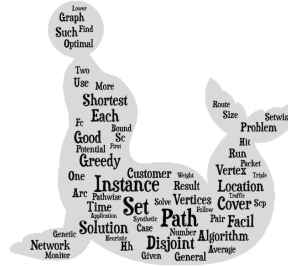LC−0.2, LU−73, SS−1909   LC−0.23, LU−72, SS−1981

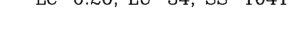LC−0.21, LU−65, SS−886   LC−0.21, LU−66, SS−846

LC−0.21, LU−64, SS−889   LC−0.23, LU−50, SS−563

LC−0.21, LU−52, SS−926   LC−0.26, LU−34, SS−1041

ShapeWordle (60 words)	**WordArt (60 words)**	**ShapeWordle (final result)**	**WordArt (final result)**

LC−0.22, LU−47, SS−838

LC−0.24, LU−49, SS−1009

LC−0.19, LU−89, SS−1221

LC−0.17, LU−86, SS−1351

LC−0.21, LU−45, SS−9737

LC−0.25, LU−49, SS−10045

LC−0.19, LU−74, SS−8111

LC−0.2, LU−73, SS−8810

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)

LC−0.2, LU−73, SS−1326

LC−0.23, LU−57, SS−3525

LC−0.2, LU−67, SS−1285

LC−0.22, LU−52, SS−1437
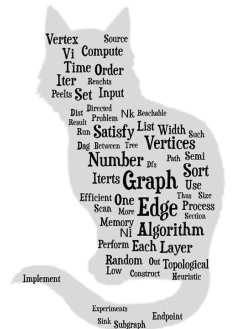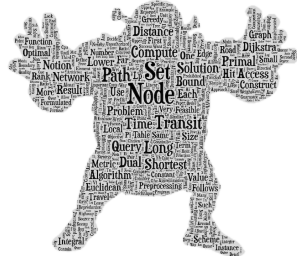
LC−0.22, LU−80, SS−978

LC−0.19, LU−81, SS−1116

LC−0.22, LU−89, SS−1705

LC−0.17, LU−131, SS−3289

ShapeWordle (60 words)	WordArt (60 words)	ShapeWordle (final result)	WordArt (final result)
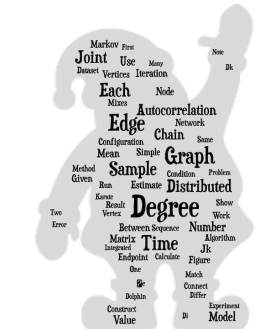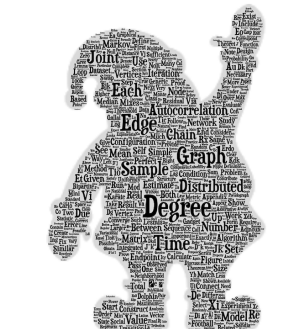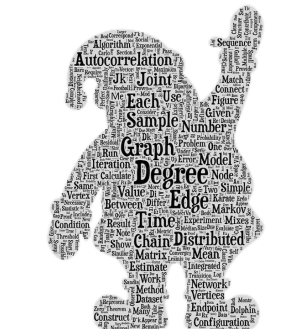
LC−0.19, LU−103, SS−1790   LC−0.11, LU−160, SS−1972

LC−0.24, LU−85, SS−1257   LC−0.14, LU−163, SS−1948

LC−0.2, LU−55, SS−7975   LC−0.16, LU−66, SS−8894

LC−0.21, LU−70, SS−834   LC−0.19, LU−80, SS−837

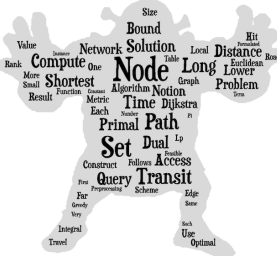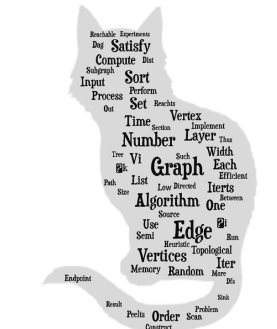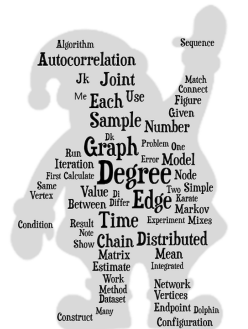**ShapeWordle (60 words)** **WordArt (60 words)** **ShapeWordle (final result)** **WordArt (final result)**
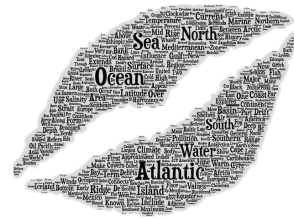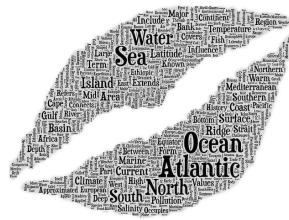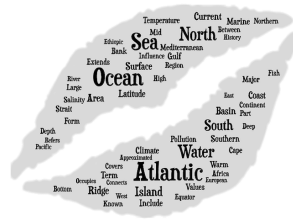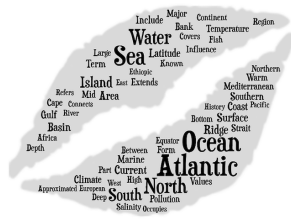

LC−0.2, LU−78, SS−1589   LC−0.16, LU−100, SS−2333

REFERENCES

[1] K. Binmore and J. Davies. *Calculus: concepts and methods*. Cambridge University Press, 2002.

[2] M.-T. Chi, S.-S. Lin, S.-Y. Chen, C.-H. Lin, and T.-Y. Lee. Morphable word clouds for time-varying text data visualization. *IEEE Trans. Vis. & Comp. Graphics*, 21(12):1415–1426, 2015. doi: 10.1109/TVCG.2015.2440241

[3] H. Leung. Tagxedo website. `http://www.tagxedo.com/`. last visited 06/2017.