

EdWordle: Consistency-preserving Word Cloud Editing

(Supplemental Material)

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Abstract—This supplemental material provides additional information about the three studies presented in the paper “EdWordle: Consistency-preserving Word Cloud Editing”. First, we provide additional results of quantitative evaluation (*study 1*), in terms of comparisons on compactness (computed by convex hull method), distortion, and uniform area utilization. For the lab study (*study 2*), we provide additional details for the tasks of user study, as well as screenshots of all errors made by users during the study. For the case studies with designers/writers (*study 3*), we provide additional descriptions of the designers’ backgrounds, designing rationales, and resulting layouts.

1 ADDITIONAL RESULTS OF QUANTITATIVE COMPARISON (STUDY 1)

In this section, we add some more results to the quantitative comparison in our paper:

Figure 1(a) shows results for the parameter *Compactness* computed by the convex hull method, which are very similar to those computed by the bounding box method as shown in the paper. After applying EdWordle to the layout, the compactness improved substantially in these word clouds. In Figure 1(b), we see that all word cloud layouts created by EdWordle are almost equal to the input layouts in terms of *Distortion*. This is another aspect of how well the desired similarities are realized, or in other words, how well the neighborhood relations are preserved. Figure 1(a) and (b) suggest that EdWordle is able to further improve given semantic word clouds, by making them more compact while at the same time preserving the neighborhoods.

Figure 1(c) demonstrates that the output layouts created by EdWordle achieve almost the same level of *Uniform Area Utilization* as the input layouts. As we can see, Edwordle keeps the uniformity of the layouts quite well. Since this aspect is not our concern in the paper, we simply display the result here and leave it for further discussion.

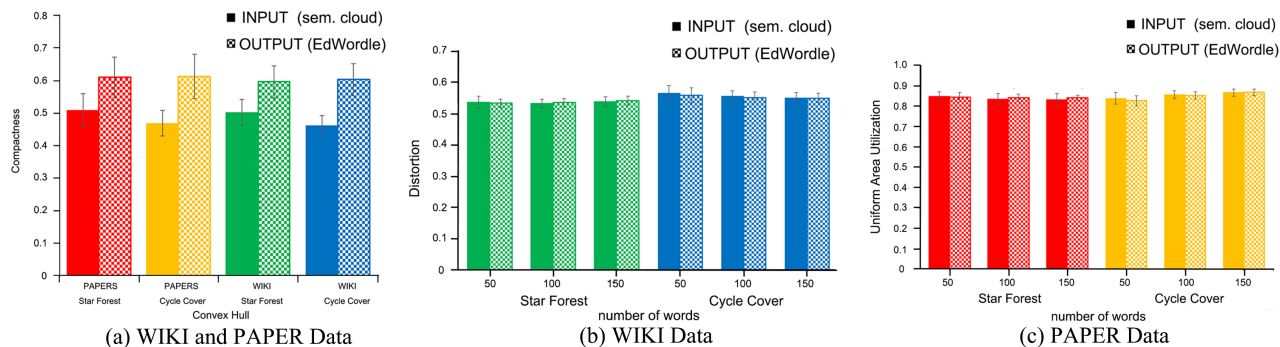


Fig. 1. (a) Mean and standard deviation of *Compactness* computed by the convex hull method (higher is better) (b) Mean and standard deviation of *Distortion* for word clouds of various size (higher is better) (c) Mean and standard deviation of *Uniform Area Utilization* for word clouds of various size (higher is better)

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2 ADDITIONAL DETAILS ON THE CONTROLLED USER STUDY (STUDY 2)

This section includes the following additional information on Study 2: (1) additional data of the 16 participants, (2) the training participants received on how to use EdWordle and ManiWordle; (3) the task descriptions including task introduction and an additional screenshots of how the tasks were shown to participants; and 4) more details on the results, including screenshots of all the errors that have been made in the study.

2.1 Additional Participant Information

We recruited 16 participants (8 male, 8 female), most of them are computer science students from the local university. The age ranged from 20 to 29 years (median age 22). See Table 1. All participants reported normal or corrected-to-normal vision, and had no color vision deficiencies. None of them had prior experience with word cloud generating tools.

Table 1. User Study Participants' Information

No	Sex	Age	Education	Major	Job	Color Blindness(Y/N)
1	Female	22	Undergraduate	CS	Students	N
2	Male	24	PhD	CS	Students	N
3	Male	21	Undergraduate	Physics	Students	N
4	Male	20	Undergraduate	CS	Students	N
5	Male	29	PhD	CS	Students	N
6	Male	29	PhD	CS	Students	N
7	Female	23	Master	CS	Students	N
8	Male	22	Master	CS	Students	N
9	Male	24	Master	CS	Students	N
10	Female	22	Undergraduate	CS	Students	N
11	Female	21	Undergraduate	CS	Students	N
12	Female	21	Undergraduate	CS	Students	N
13	Female	24	Master	CS	Students	N
14	Female	22	Undergraduate	CS	Students	N
15	Female	21	Undergraduate	CS	Students	N
16	Male	21	Undergraduate	CS	Students	N

2.2 Training

EdWordle: The familiarization with EdWordle is accomplished by asking users to read the instructions in Tables 2, 3, 4 and practice them. Our goal was to introduce the full set of features to them, before then informed them that only a subset of features (moving and rotating) were used in the actual study. In detail, we first asked them to learn how to select words from a given word cloud by using the mouse, see Table 2. Then, we instructed the participants to manipulate words with the operations listed in Table 2, and finally we explained the additional button functions listed in Table 4 for further editing words. We spent around half an hour in instructing and demonstrating these editing operations step-by-step. The study did not start until the user was able to freely edit wordles with these operations.

Table 2. Selection ways

Selection ways	How to do
Selection	Left click(mouse)
Multi-select	CTRL+Left click
Rectangle selection	Left click-and-dragging

Table 3. How to do

Operations	How to do
Move	Left click-and-dragging on the selected word
Rotate	Right click-and-dragging at the corner of the selected word SHIFT
Rotate certain angles	Right click-and-dragging for rotating with certain angles(15/30/45 degree, etc.)
Resize	Scroll the mouse wheel
Delete	Click the Button Delete, or key Delete
Change color or font	Use the submenu at the lower right of the canvas
Remove force	Hold the key Z when editing

Table 4. Button functions

Buttons	Function
Undo, Redo	/
ReWordle	Use this function when there is too much empty space in the layout
Re-Layout	Randomly initialize the word cloud layout
WordsList	Remove, or change the color/font of the words in the list
AddWord	Add a word with a given weight between 0 to 1
ForceOn/ForceOff	Switch on/off the forces in the system

ManiWordle: For the familiarization with ManiWordle, we provided the teaching video of ManiWordle and let users practice.

2.3 Task Description

2.3.1 Introduction of Tasks

Task 1 Please finish these requests using both tools:

1. put word x on top of word y;
2. put x on left of y;
3. put x on top of y and rotate them to a certain angle.

where the corresponding words are highlighted using the same color as the requirements.

Task 2 The words of the same color should be grouped together. Please put the displaced words to their right group. The gray words are background. You don't need to worry about their positions.

2.3.2 Examples

Figure 2 provides two additional examples of how the tasks were shown to users in the study. Figure 2(a) is an abstract spatial way to illustrate Task 1. On the one hand, this approach allows users to easily infer the target position. On the other hand, it is still abstract enough to avoid that users focus on superficial details, such as how close words are or what are their relative positions. For Figure 2(a), the user needs to put the word *survey* on top of the word *tag*, put the word *people* on left of *design*, and put *used* on top of *visual* and furthermore rotate the word clockwise for a small angle. The words to be edited are emphasized using a color box. The color of boxes equals to the color of the task in the layout of the top of the figure. In this way, we sought to avoid introducing a bias that might stem from the user's time to search for target words in the layout.

Figure 2(b) is another example of Task 2. The goal of this task is grouping words of the same color together. So users need to move the word *medal* to the orange group, move *skating* to the red group, move *combination* to the green group and *competation* to the yellow group. The grey words are background words that do not belong to any of the semantic groups, so we ignore their positions.

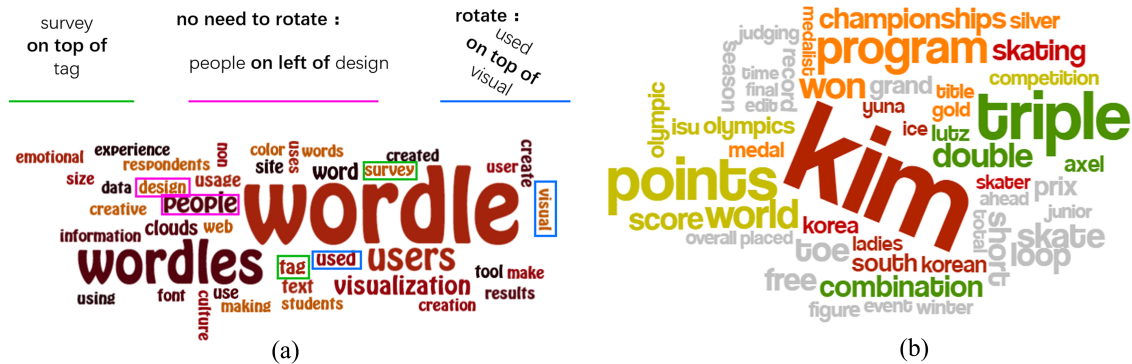


Fig. 2. (a) Example picture for Task 1. (b) Example picture for Task 2.

2.4 Results Analysis

The results of our quantitative measures are summarized in Figure 3. For *time*, *clicks*, and *distance*, lower values are better, for *compactness*, higher values are better. The results are consistent with the trends we initially predicted with our hypotheses. All three efficiency measures, (a) *time*, (b) *clicks*, and (c) *distance* show a clear and strong effect of EdWordle being more efficient than ManiWordle.

For detailed results, please see Table 5 and Table 6.

Table 5. User Study Participants' Result Data (Task 1)

No	Time		Distance		Clicks		Compactness		Errors	
	EdWordle	ManiWordle	EdWordle	ManiWordle	EdWordle	ManiWordle	EdWordle	ManiWordle	EdWordle	ManiWordle
1	0:26	0:42	874.73	2332.57	5	8	0.3241	0.3599	0	0
2	0:38	0:54	1196.48	2452.61	7	14	0.3054	0.2642	0	1
3	0:33	1:52	1402.25	4648.06	9	42	0.3351	0.201	0	2
4	0:57	1:24	1241.37	2302.55	9	10	0.2792	0.3451	1	1
5	0:39	1:06	1563.57	3192.59	8	16	0.3846	0.3158	0	0
6	1:28	1:44	2162.88	3402.06	22	21	0.3133	0.2525	0	1
7	0:46	1:13	1461.68	3472.87	6	8	0.3296	0.3138	0	1
8	0:41	1:06	2812.63	1722.24	10	18	0.2727	0.2543	0	0
9	0:59	0:34	1663.14	1270.68	10	12	0.3271	0.2892	1	0
10	0:42	1:07	1070.77	2920.74	6	17	0.3219	0.3043	0	1
11	0:50	1:19	1124.62	3144.59	12	18	0.3028	0.3185	0	2
12	0:55	0:55	1269.36	2564.18	8	17	0.344	0.3473	0	1
13	0:44	1:41	2631.43	3389.49	9	21	0.2301	0.2792	0	0
14	0:31	0:58	1081.34	4070.70	8	16	0.3351	0.3292	0	1
15	0:44	1:26	1294.64	3272.35	7	17	0.3388	0.2408	0	0
16	0:49	1:15	1117.40	3649.37	8	11	0.3388	0.2996	0	0

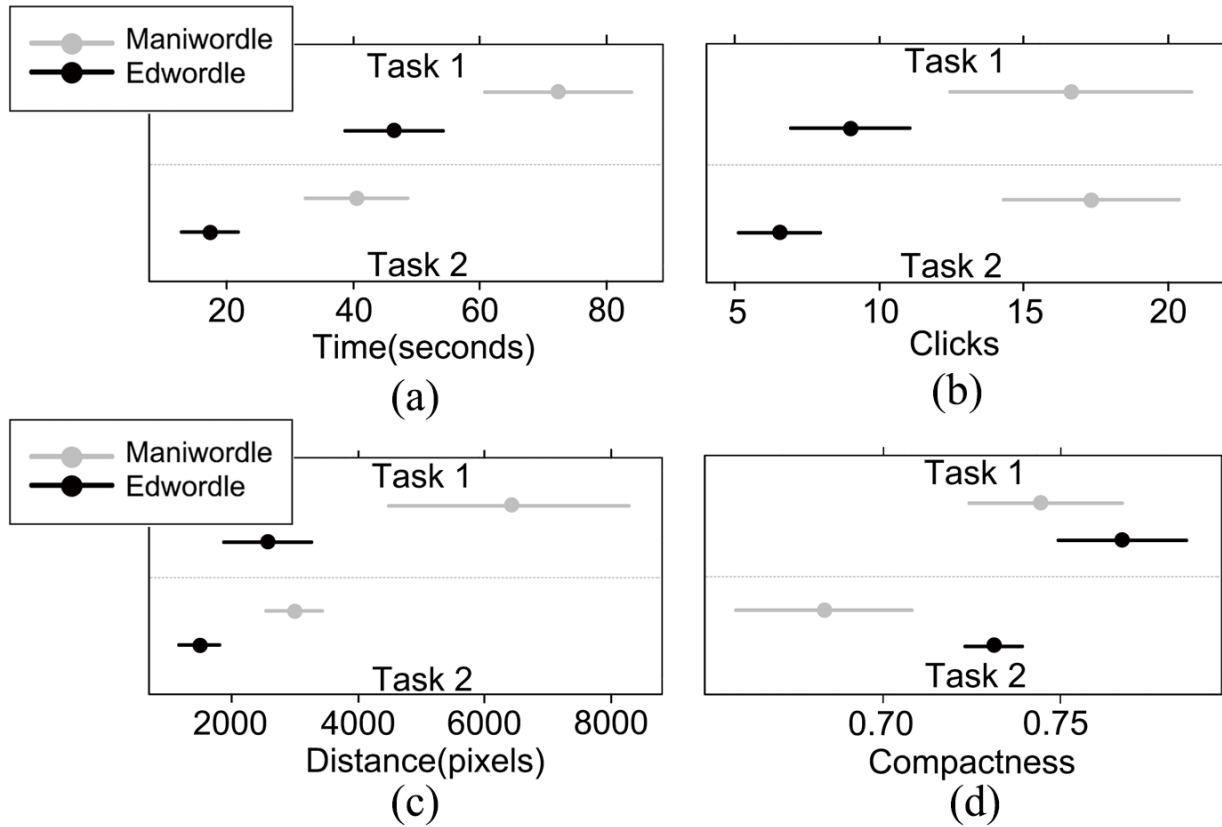


Fig. 3. Mean values and errors as 95% CIs of (a) time, (b) clicks, (c) distance, and (d) compactness. For (a)-(c), lower values are better; for (d) higher values are better

Table 6. User Study Participants' Result Data (Task 2)

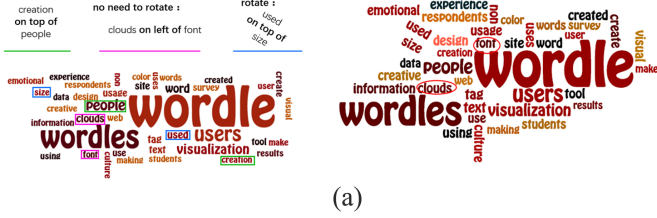
No	Time		Distance		Clicks		Compactness	
	EdWordle	ManiWordle	EdWordle	ManiWordle	EdWordle	ManiWordle	EdWordle	ManiWordle
1	0:13	0:53	1668.68	16005.38	6	26	0.2601	0.173
2	0:15	0:46	2112.59	5389.43	8	27	0.2826	0.2573
3	0:14	0:23	2080.56	3330.40	6	14	0.2762	0.2428
4	0:15	0:20	3639.57	5534.71	4	5	0.2814	0.2274
5	0:19	0:46	2472.80	5849.20	8	23	0.2894	0.2153
6	0:37	1:16	3640.53	5156.79	14	22	0.2945	0.3033
7	0:09	0:29	1679.37	3244.53	6	18	0.3008	0.3054
8	0:14	0:38	1990.40	3599.41	5	16	0.2772	0.2878
9	0:10	0:31	1654.02	3904.36	5	19	0.2962	0.2845
10	0:15	0:46	1640.21	7974.17	4	21	0.2887	0.2088
11	0:21	0:43	2521.27	5257.92	9	17	0.2678	0.1645
12	0:15	0:46	1736.21	12556.27	4	16	0.2939	0.1757
13	0:37	0:40	3711.04	5210.49	10	12	0.2643	0.2659
14	0:11	0:26	6743.05	5729.18	5	15	0.2923	0.2093
15	0:20	1:02	1906.53	9695.75	6	16	0.2452	0.187
16	0:11	0:23	2084.02	3999.72	5	10	0.293	0.23

2.4.1 Pictures of all errors made during user study

In this section, we provide screenshots of all errors that were made by participants during the study. All these mistakes occurred in Task 1 and no mistakes were done in Task 2, because it was very easy for the users to check the correctness of created colored groups. In EdWordle, 16 users made two errors in total. See Figure 4.

In ManiWordle, 10 errors occurred, as shown in Figure 5. Some users even made more than one mistake using ManiWordle. It is easy to understand why users made so many mistakes with ManiWordle. When moving and rotating words in ManiWordle, other words are replaced to completely new positions in the layout, often without the user noticing such global changes. Some carefully designed word positions then might be damaged. Sometimes users also simply moved the wrong words. Because the unpredictable relocation strategy of words in ManiWordle, sometimes it was hard for participants to recognize words and remember their position. These drawbacks are well handled in EdWordle, which hence led to less errors.

Error: clouds on left of font



Error: culture on left of people

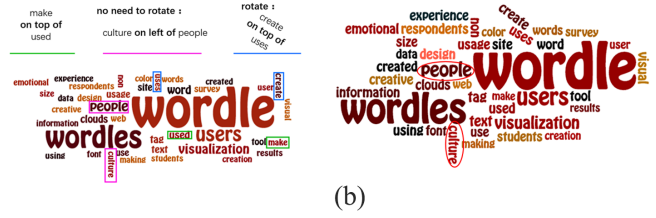
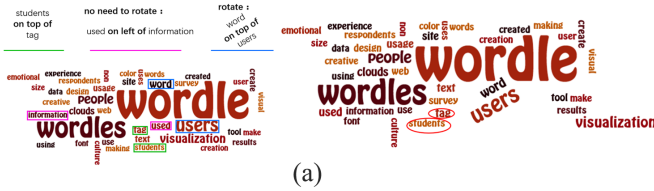
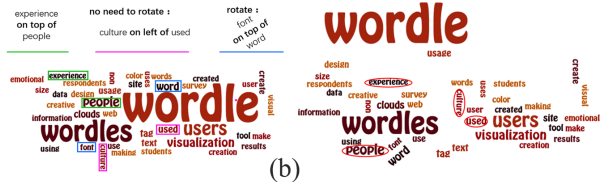


Fig. 4. Errors made in EdWordle. (a) by the 4th user. (b) by the 9th user.

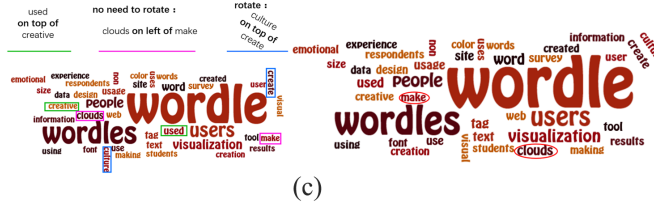
Error: students on top of tag



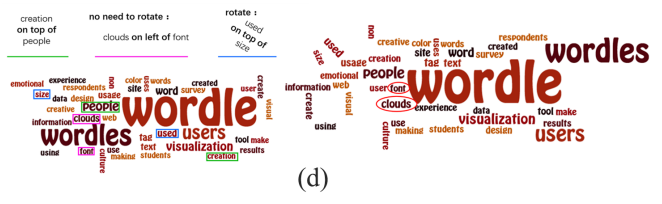
Error: experience on top of people, culture on left of used



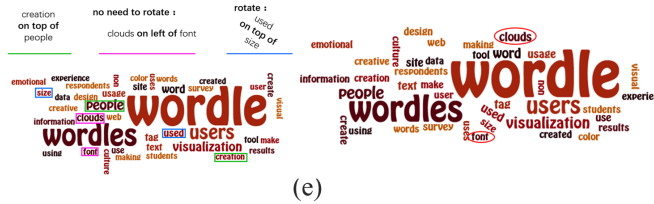
Error: clouds on left of make



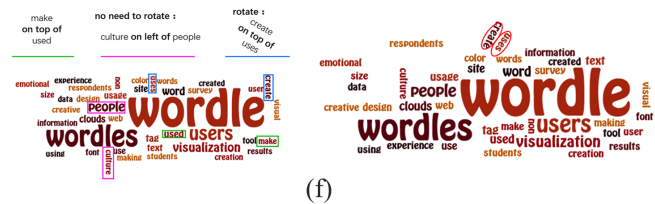
Error: clouds on left of font



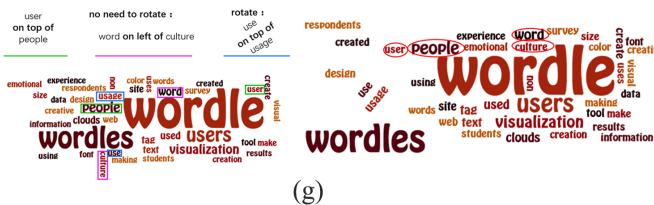
Error: clouds on left of font



Error: create on top of uses



Error: word on left of culture, user on top of people



Error: use on top of clouds

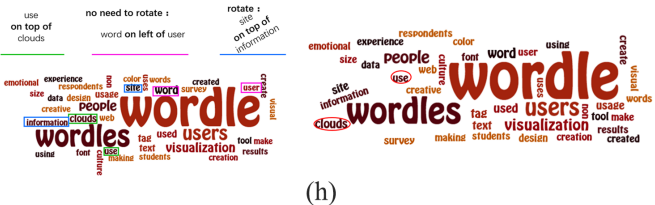


Fig. 5. Errors made in ManiWordle. (a) by the 2nd user. (b) by the 3rd user. This user made 2 mistakes. (c) by the 4th user. (d) by the 6th user. (e) by the 7th user. (f) by the 10th user. (g) by the 11th user. This user made 2 mistakes. (h) by the 12th user.

2.5 Questionnaire and short interview

2.5.1 Questions

Questionnaire: Each user was asked to give subjective ratings on ManiWordle and EdWordle. The questionnaire includes 6 questions. See Table 7.

Table 7. Subjective Responses to Six Questions(Average Ratings)

Questions	ManiWordle	EdWordle
Q1: It was easy to learn this visualization.	6	6.41
Q2: It was easy to use this visualization.	4.94	6.18
Q3: I liked to use this visualization.	4.56	6.09
Q4: It was fun to use this visualization.	5.12	5.74
Q5: I felt creative while using this visualization.	5.12	5.53
Q6: Overall, I am satisfied with the result layout.	4.69	6.08

Interview: In the short interview, the questions are more specific than those in the questionnaire. We hoped to improve our program according to the interview results. First, we asked users to explain what lead them to gave the previous rating. Then we collect their comments on operation design and system interface to raise the usability of our system. There were mainly two questions: Do you think the operations by mouse and keyboard in EdWordle are easy to do? How do you like our interface?

2.5.2 Detailed Results

The results are shown in Table 7, they indicate that EdWordle was consistently better rated than ManiWordle by our participants. Especially questions related to usability (Q2 & Q3) and to the generated results (Q6) give clear evidence that EdWordle subjectively outperforms ManiWordle. Detailed scores are in Table 8.

Table 8. User Study Participants' Result Data (Question Rate)

No	EdWordle						ManiWordle					
	Q1	Q2	Q3	Q4	Q5	Q6	Q1	Q2	Q3	Q4	Q5	Q6
1	7	6	5	4	5	5	7	3	2	4	5	2
2	7	7	7	7	7	6	7	5	6	7	5	5
3	7	7	7	7	7	7	5	6	6	6	7	5
4	6	7	6	6	6	6	6	4	4	6	5	6
5	6	6	6	6	5	6	6	6	5	4	6	5
6	6	6	6	5	5	6	4	2	3	5	5	6
7	7	6	6	6.5	6	6	6.5	5	4	5	4	3
8	7	7	7	7	5	7	7	5	5	5	5	4
9	6	6	6	6	6	6	4	4	4	3	4	3
10	6	6	6	6	6	6	6	6	5	6	6	5
11	7	4	7	5	5	6	7	7	3	5	5	3
12	6	6	6	5	5	7	6	4	5	6	5	5
13	6	7	5	5	6	7	6	6	5	5	6	7
14	6	5	5	4	4	5	6	5	4	4	4	5
15	6	6	6	6	6	6	6	5	5	4	5	5
16	7	7	6.5	7	5	6.3	6.5	6	6.5	7	5	6.7
Average	6.41	6.18	6.09	5.74	5.53	6.08	6	4.94	4.56	5.12	5.12	4.69

3 ADDITIONAL DETAILS OF THE 10 CASE STUDIES WITH DESIGNERS/WRITERS (STUDY 3)

For each case study, we list the article source, give a brief description of the participants background, provide a description of their workflow and design rationales, and show screenshots of the resulting Wordle layouts.

A piece of BBC News

- *Article source:*
<http://www.english-listening.com/printthread.php?tid=32925>
- *Designer background:* female, graduate student from School of Political Science and Public Administration, major in International Affairs. She used to be the head of school news department and is good at writing.
- *Description:* Figure 6(a) contains abundant semantic meanings. The words related to the same issue were shown in the same color, as well as spatially grouped together. The article is made up of five news pieces: (1) America support Israeli-Palestinian solution. (2) The administration of President Trump is fine-tuned and he had published travel ban. (3) Marine Le Pen, who is a presidential candidate of France, was alleged false pretenses and was under investigation. (4) 70 people were killed in Pakistan because of a suicide attack. (5) 50 people in Baghdad died of a car bomb carried out by IS.

Scientists need YOU to help make a solar eclipse movie

- *Article source:*
<http://www.csmonitor.com/Science/2017/0221/Scientists-need-YOU-to-help-make-a-solar-eclipse-movie>

- *Designer background:* male, undergraduate, majors in software engineering. He works in the news department of a student union and is also good at photography.
- *Description:* In Figure 6(b), the designer thought the central word of the article is “eclipse”. He put that word in the center and placed some typical words of the article around it. The placement of the other words is at random. Actually he said he would like to put words with the same characteristics together (for example, adjective group, noun group, verb group, etc.) but he did not stick to this goal as he felt not fluent enough in English. He designed the shape of this layout very carefully. He said he preferred the square layout and he deliberately chose cold colors for this scientific article. He did not use the default color scheme but designed the color combination by himself. He also inspired us to implement snapping to 45 degrees as a feature of our system.

Mossberg: I just deleted half my iPhone apps, you should too

- *Article source:*
<http://www.theverge.com/2016/7/20/12231176/walt-mossberg-delete-your-unnecessary-apps>
- *Designer background:* male, undergraduate, majors in Literature and Journalism. He is an editor of a network media and thus is good at writing.
- *Description:* The wordle in Figure 6(c) tells us about deleting half of our iPhone apps. The shape is designed into the brand logo of Apple. The leaf of the apple is a sentence: “delete and you will thank me later”. There are also other semantic groups in the layout: app store, 2 million apps, delete 54 percent of the apps and gain back 24 percent more free space, etc.

YouTube: Obama addresses school kids

- *Article source:*
<https://www.youtube.com/watch?v=47c6z2mrTEM>
- *Designer background:* male, undergraduate, major in software engineering. He works in the advertisement department of his college. Good at graphic design.
- *Description:* The four corner parts of the whole layout in Figure 7(a) are four paragraphs of Obama’s speech. And the central part which looks like a bar is formed by the words that appear throughout the whole speech. The designer wanted to show the structure of the speech via this layout. He used a default color scheme.

Apple launches red iPhone 7 and video app

- *Article source:*
<http://www.bbc.com/news/technology-39343218>
- *Designer background:* female, undergraduate from Software Engineering, interested in writing and technology. She is a reporter of news media.
- *Description:* In Figure 7(b) shows that Apple launched the red iPhone 7. We can obtain plenty information from this wordle. The word “Red” here has two meanings: one is the color of the new iPhone, the other one is the name of a public service organization which aids HIV patients. The Apple company has developed a ten years partnership with this organization, and this launch is the celebration of this event. At the same time, Apple has also launched a new app called Clips, which is quite similar to Snapchat. From the right bottom corner of the layout, we can see that the purpose of Apple is to build a “social good branding”

Psychology and Learning

- *Article source:*
This is an interview transcript that the designer provided directly.
- *Designer background:* female, undergraduate, major in software engineering. Good at sketching and painting. She works in the drawing group of a network media.
- *Description:* Figure 7(c) tells how psychology affects our learning process. Semantic groups: feel stronger, English learning, improve studying, bored, struggle (the negative words are grouped together on the left bottom corner of the layout). For shape, this designer preferred a circular layout.

I have a dream

- *Article source:*
<http://www.americanrhetoric.com/speeches/mlkihaveadream.htm>
- *Designer background:* female, undergraduate, a photographer of school media. She is good at graphic design.
- *Description:* In the center of Figure 8(a) there is a sentence: “All men are created equal”. Other words do not have a specific semantic meaning. The shape is also not special, instead the designer tried to make the layout into a rectangle. She used a default color scheme.

Barack Obama’s Inaugural Address

- *Article source:*
<https://obamawhitehouse.archives.gov/blog/2009/01/21/president-barack-obamas-inaugural-address>
- *Designer background:* male, Ph.D. student of Computer Science and Technology, interested in Information Visualization. He is good at computer graphics design and web design.
- *Description:* The wordle in Figure 8(b) summarizes the Inaugural Address of Barack Obama on January 20th, 2009. The sentence that appeared most frequently in his speech was: “Yes, we can”. So the designer opted to make this the central message of the word cloud as well. There are also some other semantic parts in this wordle: “I will be your president”, “This is your victory”, “We as a people will get there”, “Ann Nixon Cooper”, “United States”, and “by the people”.

Athens democracy reforms

- *Article source:*
<http://www.doc88.com/p-0641514163937.html>
- *Designer background:* female, undergraduate student of Software Engineering. She is interested in English writing as well as web design.
- *Description:* See Figure 8(c). The Wordle is mainly about democracy reforms that happened in ancient Athens. The red-colored groups of words tell us the main idea. The pink groups contain detailed reform solutions. The yellow groups tells the leader of this reform: Solon and Cleisthenes, and how they modified the original system. The blue words illustrate the results or effects of this reform. The designer intentionally used gradient color, which makes the cloud much more pretty in her opinion.

S. Korean prosecutors to seek arrest warrant for ex-president Park



Fig. 8. (a) I have a dream. (b) Barack Obama's Inaugural Address. (c) Athens democracy reforms. (d) South Korean prosecutors to seek arrest warrant for ex-president Park.