What is a sandwich?

A data analysis in $\mathbb{R}^{43}$

Vincent Macri David White Matthew Stuart

Group D

June 6, 2018

Abstract

In this paper we set out to examine the sandwich views of students and teachers at William Lyon Mackenzie C.I.

Our study consisted of a survey conducted in person with 140 participants. We asked participants basic demographic information about where they fit into the William Lyon Mackenzie Collegiate Institute community, and examined correlations between sandwich views and demographics.

We propose the creation of a two-dimensional sandwich alignment chart, inspired by two-dimensional political axes. The sandwich alignment chart has a dimension for "sandwich purity", and "sandwich orthodoxy".

We hypothesize that:

1. Sandwich purity and sandwich orthodoxy will be positively correlated.
2. Students in the MaCS or Gifted program are more likely to have a low orthodoxy score.

We believe the first hypothesis to be true because we believe those with a pure definition of a sandwich will also have an orthodoxy definition. We believe the second hypothesis to be true because we believe that students in those programs tend to challenge societal norms more so than most.

Contents

Part I

Introduction

Chapter 1

Purpose

1.1 The failure of the dictionary

We find dictionary definitions to be insufficient, as they are either too restrictive, or too vague.

The Oxford English Dictionary [10] restrictively defines a sandwich as:

> An item of food consisting of two pieces of bread with a filling between them, eaten as a light meal.

Whereas The Free Dictionary [31] more broadly defines a sandwich as:

> a. Two or more slices of bread with a filling such as meat or cheese placed between them.
>
> b. A partly split long or round roll containing a filling.
>
> c. One slice of bread covered with a filling.

Since the Oxford English Dictionary definition requires two pieces of bread, this excludes sub sandwiches, which most would consider a sandwich. This makes the Oxford definition too restrictive.

Also, both definitions fail to adequately define "filling". The Free Dictionary gives meat and cheese as examples, but many people put lettuce and tomato in their sandwiches, neither of which are meat or cheese.

So, dictionary definitions of "sandwich" are insufficient to determine what a sandwich is.

1.2 Legal background

The question of what is a sandwich has been the centre of several legal publications. We believe that these publications have failed to provide a strong definition of what a sandwich is, and they contradict each other.

For tax purposes, the New York State Department of Taxation and Finance [28] says:

> *Sandwiches* include cold and hot sandwiches of every kind that are prepared and ready to be eaten, whether made on bread, on bagels, on rolls, in pitas, in wraps, or otherwise, and regardless of the filling or number of layers. A sandwich can be as simple as a buttered bagel or roll, or as elaborate as a six-foot, toasted submarine sandwich.
>
> Some examples of taxable sandwiches include:
>
> - common sandwiches, such as:
>   - BLTs (bacon, lettuce, and tomato sandwiches);
>   - club sandwiches;
>   - cold cut sandwiches;
>   - grilled cheese sandwiches;
>   - peanut butter and jelly sandwiches
>   - salad-type sandwiches (e.g., chicken, egg, ham, and tuna);
> - bagel sandwiches (served buttered or with spreads, or otherwise as a sandwich);
> - burritos
> - cheese-steak sandwiches;
> - croissant sandwiches;
> - fish fry sandwiches;
> - flatbread sandwiches;

- breakfast sandwiches;
- gyros;
- hamburgers on buns, rolls, etc.;
- heroes, hoagies, torpedoes, grinders, submarines, and other such sandwiches;
- hot dogs and sausages on buns, rolls, etc.;
- melt sandwiches;
- open-faced sandwiches;
- panini sandwiches;
- Reuben sandwiches; and
- wraps and pita sandwiches.

This is a very broad definition, but it is also quite comprehensive and informative. It is important to note that [28] defines burritos as sandwiches. However, other legal cases contradict this definition.

A case in the Commonwealth of Massachusetts Superior Court entitled White City Shopping Center, LP v. PR Restaurants, LLC dba Bread Panera [45] involved two companies in a dispute over whether or not burritos are sandwiches. In this case, the court ruled that burritos are not sandwiches. This contradicts the definition in New York State tax law. So, we can clearly see that there is no legal consensus on this matter.

Furthermore, the legal scholar Marjorie Florestal argues that the decision of the White City case is rooted in classist and racial views of sandwich cuisine [15]:

> The burrito meets resistance not just because of its class but also because of its race—and the way the two play off each other.

So, we have established that the definition of a sandwich is inconclusive among both the linguist and legal communities [10, 31, 28, 45]. The question is also of importance for better understanding class systems and race in our society [15].

Chapter 2

Terminology and notation

As this paper is dealing with sandwich mathematics, which is a developing field, we will define the terms we have coined in this chapter.

Food question A food question is any question asked about sandwiches or their ingredients. We asked 43 food questions as a part of this study. Participants answered each question on a 0 to 10 scale. We purposely started the scale at 0 so as to make 5 exactly in the middle of the range of possible responses.

Demographic question A demographic question is any of the non-food questions asked in our survey. These questions asked about participants demographics, in order to examine any correlations between demographics and sandwich views.

Chapter 3

Methodology

3.1 Survey type

We conducted our survey as mix of a stratified, voluntary, and random sample. We surveyed roughly 10% of the William Lyon Mackenzie population. With a sample size this large, most bias should be eliminated.

Unfortunately, we failed to collect a perfectly stratified sample. However, an analysis of the data shows that to be inconsequential.

We made manual changes to categorical to correct for similar, blank, and inappropriate responses. As part of this, we grouped ethnicity into the following 11 categories: Caucasian, Chinese, East Asian, Filipino, Jewish, Korean, Middle Eastern, Mixed, Other, South Asian, and Vietnamese.

Demographic questions

For demographic information, we asked participants for their grade (with teacher as an option), favourite subjects, and ethnic background. We asked students for their academic stream, and teachers for their department.

Since the number of teachers surveyed was small, we do not do any analysis on teachers departments, and instead treat them as a separate grade and academic stream. We also do not analyze the data on favourite subjects since it is very noisy.

Food questions

We asked respondents 43 questions related to sandwiches and their ingredients. We use all of this data.

Chapter 4

Metrics

4.1 Axes metrics

We have two metrics used in our calculations: purity and orthodoxy.

Purity is how pure a respondent's definition of a sandwich is. The less things a respondent considers a sandwich, the greater their purity score will be. Similarly, the more things a respondent considers a sandwich, the lower their purity score will be.

Orthodoxy is a measure of how much a respondent differs from the mean set of responses. The less a respondent's answers differ from the mean set of answers, the greater their orthodoxy score will be. Similarly, the more a respondent's answers differ from the mean set of answers, the lower their orthodoxy score will be.

Both purity and orthodoxy are bound in the range $[-1, 1]$.

We describe the general scoring system in subsection 4.1.1. This scoring system is used to calculate the purity metric described in subsection 4.1.2 on the next page and the orthodoxy metric described in subsection 4.1.3 on page 9.

4.1.1 Scoring

While participants answered each food question on a 0 to 10 scale, it is more convenient to perform calculations using a -5 to 5 scale. We converted responses from the 0 to 10 scale to the -5 to 5 scale by subtracting each response from 5.

Formally, for each response to a food question, we calculate the score for the response by the passing the response through the sandwich spectrum function, defined in 1 on the next page.

Definition 1 (Sandwich spectrum function)**.** The sandwich spectrum function is defined as:

$$s : \{x \in \mathbb{R} \mid 0 \leq x \leq 10\} \to \{x \in \mathbb{R} \mid -5 \leq x \leq 5\} \text{ by } s(x) = 5 - x \quad (4.1)$$

Due to the format of our survey, all responses are integers, and are mapped to another integer by the sandwich spectrum function. Although, in principle, the sandwich spectrum function works for real numbers as well.

We can create a table for s:

x	0	1	2	3	4	5	6	7	8	9	10
$s(x)$	5	4	3	2	1	0	-1	-2	-3	-4	-5

One will note that this gives responses that were originally high a lower score. This is intentional. Subsection 4.1.2 will show it to be useful for calculating the purity metric, and subsection 4.1.3 on the next page will show it to be irrelevant for calculating the orthodoxy metric.

4.1.2 Purity

The purity score for a respondent is defined as the sum of a respondent's scores divided by the maximum possible score.

The maximum score for a question is 5, and there are 43 food questions. This means that the maximum possible score is $43 \times 5 = 215$.
Definition 2 (Sadwich purity function)**.** For a given response with a set of 43 food answers, A, we define the sandwich purity function as:

$$p : \mathbb{R}^{43} \to \mathbb{R} \text{ by } p(A) = \frac{\sum_{i=1}^{43} A_i}{215} \quad (4.2)$$

This definition illustrates why we subtract each response from 5 to get the score. The sandwich spectrum function will assign higher purity values for lower responses. Since a lower response to a question implies a more pure definition of a sandwich, 1 is a valid metric.

4.1.3 Orthodoxy

To calculate orthodoxy for each respondent, we take the score for each question as a dimension of a vector, which creates a vector in 43-dimensional Euclidean space.

We also calculate the mean response for each question, and create an additional $\mathbb{R}^{43}$ vector from that. This vector is referred to as the mean vector, and denoted as $\vec{m}$.

The orthodoxy score for a respondent is defined as the cosine similarity between the respondent's $\mathbb{R}^{43}$ vector and $\vec{m}$.

Definition 3 (Mean vector)**.** To calculate the value of the mean vector, $\vec{m}$:

Let $A \in \mathbb{R}^{43}$ be the set of response vectors. Then, $n(A)$ is the cardinality of the set A.

Then:

$$\vec{m} = \frac{\sum_{i=1}^{n(A)} A_i}{n(A)} \tag{4.3}$$

Definition 4 (Sandwich orthodoxy function)**.** To calculate the orthodoxy score for a respondent:

Let $\vec{r}$ be a vector in $\mathbb{R}^{43}$ defined as having its each of its components equal to the score for each food question.

$$o : \mathbb{R}^{43} \to \mathbb{R} \text{ by } o(\vec{r}) = \frac{\vec{r} \cdot \vec{m}}{\|\vec{r}\|\|\vec{m}\|} \tag{4.4}$$

Since we are calculating orthodoxy as the cosine of the angle between two vectors, it is useful to have some vector components be negative, as that allows respondents to have a negative orthodoxy score if they answer opposite to the mean response. It does not matter what direction the vectors are in, as we are only looking at the angle between them. This means that the sandwich spectrum function could have been defined as subtracting 5 instead of subtracting from 5 for the purposes of the orthodoxy function. Since both definitions would have worked for orthodoxy, we stick with 1 on the previous page for the sake of consistency with the purity metric.

Part II

Results Summary

Chapter 5

Results summary

5.1 Data with outliers

Table 5.1: The results of all respondents with outliers included. Teachers had their stream set to "Teacher".

#	Purity	Orthodoxy	Grade	Background	Stream
1	−0.26047	0.78743	Grade 12	Mixed	Gifted
2	0.04186	0.90389	Grade 12	Filipino	Academic
3	−0.70233	0.415	Grade 11	Chinese	MaCS
4	−0.66512	0.46478	Grade 11	Caucasian	MaCS
5	0.04651	0.87398	Grade 12	Chinese	MaCS
6	0.12558	0.76755	Grade 12	East Asian	MaCS
7	−0.29767	0.04865	Grade 12	Chinese	MaCS
8	−0.16279	0.89784	Grade 12	Jewish	MaCS
9	−0.17674	0.62968	Grade 12	Middle Eastern	Academic
10	−0.50233	0.67579	Grade 12	Filipino	MaCS
11	−0.05581	0.92452	Grade 12	Mixed	MaCS
12	0.18605	0.83489	Teacher	Jewish	Teacher
13	0.13488	0.8108	Grade 12	Middle Eastern	Gifted
14	−0.67442	0.3936	Grade 12	South Asian	MaCS
15	0.11628	0.78018	Grade 12	Chinese	MaCS
16	0.12093	0.83977	Grade 11	Korean	MaCS
17	−0.55814	0.54878	Grade 11	Chinese	MaCS
18	−0.44186	0.6077	Grade 11	Chinese	MaCS
19	0.13023	0.82374	Grade 12	East Asian	MaCS
20	−0.25581	0.79897	Grade 12	Chinese	MaCS
21	−0.11628	0.85328	Grade 12	Vietnamese	Academic
22	−0.03256	0.90503	Grade 12	Jewish	Academic
23	−0.03256	0.81788	Grade 12	South Asian	Academic
24	−0.2	0.72832	Grade 11	Vietnamese	Other

25	0.15814	0.8595	Grade 12	Filipino	Academic
26	−0.09767	0.75217	Grade 12	Jewish	Gifted
27	0.13953	0.8086	Teacher	Other	Teacher
28	0.22791	0.62137	Grade 12	Chinese	MaCS
29	−0.28837	0.84233	Grade 12	East Asian	MaCS
30	−0.2093	0.89615	Grade 12	Caucasian	MaCS
31	0.08372	0.8059	Grade 12	Jewish	MaCS
32	−0.42791	0.72797	Grade 12	Chinese	MaCS
33	−0.14419	0.87928	Grade 12	Caucasian	MaCS
34	0.09302	0.82863	Grade 12	Vietnamese	MaCS
35	−0.58605	0.56467	Grade 11	Caucasian	MaCS
36	−0.02791	0.79334	Grade 12	South Asian	MaCS
37	0.00465	0.85846	Teacher	Other	Teacher
38	−0.16279	0.69499	Grade 12	Caucasian	MaCS
39	−0.06047	0.91415	Grade 12	Caucasian	MaCS
40	−0.24186	0.76056	Grade 12	Jewish	MaCS
41	−0.53023	0.54403	Grade 11	Other	MaCS
42	−0.06047	0.77035	Grade 12	South Asian	Applied
43	0.08837	0.67952	Grade 12	Mixed	Academic
44	0.05116	0.87279	Grade 12	Filipino	Academic
45	−0.14419	0.64695	Grade 9	Caucasian	Academic
46	−0.24186	0.64867	Grade 12	Caucasian	Academic
47	−0.13953	0.73419	Grade 9	East Asian	Academic
48	0.27907	0.80968	Grade 12	Jewish	Academic
49	−0.04651	0.81095	Grade 12	Jewish	Academic
50	−0.30698	0.67331	Grade 12	East Asian	Academic
51	0.21395	0.30716	Grade 12	Caucasian	Academic
52	−0.8	0.23213	Grade 12	Caucasian	Academic
53	0.38605	0.46599	Grade 12	Vietnamese	Academic
54	0.25581	0.52316	Grade 12	Other	Other
55	−0.14419	0.77929	Grade 9	Jewish	Academic
56	0.17674	0.82393	Grade 12	Mixed	Academic
57	0.24651	0.75861	Grade 12	Caucasian	Applied
58	0.40465	0.56366	Grade 12	Mixed	Academic
59	0.17674	0.13833	Grade 11	Other	Academic
60	−0.29767	0.78865	Teacher	Caucasian	Teacher
61	−0.01395	0.5918	Grade 11	Other	Applied
62	−0.04651	0.44875	Grade 12	Korean	Academic

63	0.00465	0.79811	Grade 12	Filipino	Academic
64	−0.66512	−0.13785	Grade 12	Korean	Gifted
65	−0.15349	0.52585	Grade 12	Filipino	Academic
66	−0.0093	0.86197	Grade 12	Caucasian	Academic
67	−0.07907	0.55806	Grade 12	South Asian	MaCS
68	−0.57674	0.52544	Grade 11	Caucasian	Academic
69	0.10698	0.49637	Grade 12	Jewish	Academic
70	−0.04186	0.84955	Grade 12	Caucasian	Gifted
71	−0.81395	0.29688	Grade 12	Chinese	MaCS
72	0.07907	0.77065	Grade 12	Caucasian	Gifted
73	0.25116	0.81689	Grade 11	Korean	MaCS
74	0.22791	0.79962	Grade 11	South Asian	MaCS
75	−0.03721	0.83146	Grade 12	East Asian	Gifted
76	0.12558	0.81047	Grade 11	Other	Academic
77	−0.24651	0.87283	Grade 11	Caucasian	MaCS
78	−0.4186	0.52009	Grade 11	Jewish	Gifted
79	−0.42791	0.52045	Grade 11	Other	Gifted
80	−0.37209	0.44516	Grade 11	Vietnamese	Gifted
81	−0.01395	−0.20124	Grade 11	Caucasian	Other
82	0.33023	0.38251	Grade 9	Other	Other
83	0.16279	0.01988	Grade 9	Caucasian	Other
84	0.26047	0.801	Grade 9	Mixed	MaCS
85	0.07907	0.63674	Grade 12	Middle Eastern	Academic
86	−0.17209	0.72197	Grade 12	Other	Academic
87	0.09767	0.66355	Grade 12	Chinese	Academic
88	−0.0186	0.83655	Teacher	Other	Teacher
89	−0.12558	0.83448	Grade 11	Caucasian	Applied
90	0.08837	0.76628	Grade 10	Other	Academic
91	0.10698	0.70924	Grade 9	Mixed	Academic
92	−0.17674	0.82363	Grade 11	Mixed	MaCS
93	−0.33488	0.66008	Grade 11	Chinese	MaCS
94	−0.51163	0.54699	Grade 11	Mixed	MaCS
95	−0.23721	0.82223	Grade 12	East Asian	Academic
96	0.03256	0.87361	Grade 9	South Asian	MaCS
97	−0.05581	0.82581	Grade 12	Caucasian	Academic
98	0.39535	0.61396	Grade 10	Jewish	MaCS
99	0.15349	0.833	Grade 10	Caucasian	MaCS
100	0.33488	0.75085	Grade 11	Korean	Gifted

101	0.04186	0.84494	Grade 11	South Asian	Gifted
102	0.03721	0.88977	Grade 12	Jewish	MaCS
103	−0.03721	−0.03783	Grade 11	Filipino	Academic
104	−0.28372	0.82859	Grade 11	Mixed	Academic
105	0.17674	0.85856	Grade 12	Other	Academic
106	0.15814	0.70685	Grade 12	Middle Eastern	Academic
107	0.04186	0.812	Grade 12	Caucasian	Academic
108	−0.22791	0.6251	Grade 10	Middle Eastern	MaCS
109	0.0093	0.8927	Grade 9	East Asian	MaCS
110	0.23721	0.79064	Grade 9	Jewish	MaCS
111	0.85581	−0.02167	Grade 11	South Asian	Academic
112	−0.25581	0.88868	Grade 12	Chinese	MaCS
113	0.14419	0.33265	Grade 11	Other	MaCS
114	0.27442	0.74374	Grade 9	Other	MaCS
115	−0.33488	0.65545	Other	Other	Other
116	−0.34419	0.80198	Grade 10	Jewish	MaCS
117	0.13023	0.8297	Grade 11	Mixed	MaCS
118	−0.53488	0.63103	Grade 9	Chinese	Gifted
119	0.4	0.62724	Grade 11	Middle Eastern	Academic
120	0.14884	0.22078	Grade 12	Caucasian	MaCS
121	−0.17209	0.83039	Grade 10	Mixed	MaCS
122	0.32093	0.77196	Grade 12	Filipino	Academic
123	−0.04186	0.81574	Grade 10	East Asian	MaCS
124	0.2093	0.79373	Grade 12	Other	MaCS
125	−0.06047	0.404	Grade 9	Other	MaCS
126	0.21395	0.80349	Grade 11	Caucasian	MaCS
127	−0.01395	0.81005	Grade 12	Mixed	MaCS
128	−0.0186	0.89398	Grade 10	South Asian	MaCS
129	0.25581	0.4521	Grade 10	Korean	MaCS
130	0.23256	0.31299	Grade 10	South Asian	MaCS
131	0.1907	0.825	Grade 11	Other	Academic
132	0.4093	0.7017	Grade 10	Filipino	Academic
133	−0.16279	0.73321	Grade 9	East Asian	Gifted
134	0.11163	0.72394	Grade 11	Caucasian	MaCS
135	−0.03721	0.77001	Grade 12	Other	Other
136	−0.07442	0.85982	Grade 10	Korean	Gifted
137	0.26047	0.83633	Grade 11	Caucasian	MaCS
138	0.44651	0.56466	Grade 11	South Asian	MaCS

139	0.22791	0.56602	Grade 11	Vietnamese	Gifted
140	0.0186	0.78616	Grade 12	South Asian	MaCS

5.2 Data without outliers

See chapter 6 on page 21 for an explanation of how we identified and removed outliers. The numbers given for removed outliers match with those in table 5.1 on page 11.

Table 5.2: The results of all respondents with outliers removed. Teachers had their stream set to "Teacher".

#	Purity	Orthodoxy	Grade	Background	Stream
1	−0.26047	0.78815	Grade 12	Mixed	Gifted
2	0.04186	0.90326	Grade 12	Filipino	Academic
3	−0.70233	0.42266	Grade 11	Chinese	MaCS
4	−0.66512	0.47168	Grade 11	Caucasian	MaCS
5	0.04651	0.8733	Grade 12	Chinese	MaCS
6	0.12558	0.76728	Grade 12	East Asian	MaCS
7	−0.29767	0.0506	Grade 12	Chinese	MaCS
8	−0.16279	0.89988	Grade 12	Jewish	MaCS
9	−0.17674	0.63362	Grade 12	Middle Eastern	Academic
10	−0.50233	0.68039	Grade 12	Filipino	MaCS
11	−0.05581	0.92441	Grade 12	Mixed	MaCS
12	0.18605	0.83312	Teacher	Jewish	Teacher
13	0.13488	0.81043	Grade 12	Middle Eastern	Gifted
14	−0.67442	0.39959	Grade 12	South Asian	MaCS
15	0.11628	0.77803	Grade 12	Chinese	MaCS
16	0.12093	0.83883	Grade 11	Korean	MaCS
17	−0.55814	0.55405	Grade 11	Chinese	MaCS
18	−0.44186	0.61217	Grade 11	Chinese	MaCS
19	0.13023	0.82177	Grade 12	East Asian	MaCS
20	−0.25581	0.80138	Grade 12	Chinese	MaCS
21	−0.11628	0.85365	Grade 12	Vietnamese	Academic
22	−0.03256	0.90589	Grade 12	Jewish	Academic
23	−0.03256	0.81831	Grade 12	South Asian	Academic
24	−0.2	0.72945	Grade 11	Vietnamese	Other

25	0.15814	0.85655	Grade 12	Filipino	Academic
26	−0.09767	0.75429	Grade 12	Jewish	Gifted
27	0.13953	0.80702	Teacher	Other	Teacher
28	0.22791	0.61649	Grade 12	Chinese	MaCS
29	−0.28837	0.84506	Grade 12	East Asian	MaCS
30	−0.2093	0.89862	Grade 12	Caucasian	MaCS
31	0.08372	0.80452	Grade 12	Jewish	MaCS
32	−0.42791	0.73191	Grade 12	Chinese	MaCS
33	−0.14419	0.87949	Grade 12	Caucasian	MaCS
34	0.09302	0.8266	Grade 12	Vietnamese	MaCS
35	−0.58605	0.56963	Grade 11	Caucasian	MaCS
36	−0.02791	0.79424	Grade 12	South Asian	MaCS
37	0.00465	0.85834	Teacher	Other	Teacher
38	−0.16279	0.69682	Grade 12	Caucasian	MaCS
39	−0.06047	0.91568	Grade 12	Caucasian	MaCS
40	−0.24186	0.76238	Grade 12	Jewish	MaCS
41	−0.53023	0.55032	Grade 11	Other	MaCS
42	−0.06047	0.76982	Grade 12	South Asian	Applied
43	0.08837	0.67731	Grade 12	Mixed	Academic
44	0.05116	0.87281	Grade 12	Filipino	Academic
45	−0.14419	0.6505	Grade 9	Caucasian	Academic
46	−0.24186	0.64962	Grade 12	Caucasian	Academic
47	−0.13953	0.73656	Grade 9	East Asian	Academic
48	0.27907	0.8067	Grade 12	Jewish	Academic
49	−0.04651	0.81201	Grade 12	Jewish	Academic
50	−0.30698	0.6755	Grade 12	East Asian	Academic
51	0.21395	0.3018	Grade 12	Caucasian	Academic
52	−0.8	0.24014	Grade 12	Caucasian	Academic
53	0.38605	0.45965	Grade 12	Vietnamese	Academic
54	0.25581	0.52025	Grade 12	Other	Other
55	−0.14419	0.77982	Grade 9	Jewish	Academic
56	0.17674	0.8213	Grade 12	Mixed	Academic
57	0.24651	0.75488	Grade 12	Caucasian	Applied
58	0.40465	0.55973	Grade 12	Mixed	Academic
59	0.17674	0.13431	Grade 11	Other	Academic
60	−0.29767	0.79173	Teacher	Caucasian	Teacher
61	−0.01395	0.59031	Grade 11	Other	Applied
62	−0.04651	0.44906	Grade 12	Korean	Academic

63	0.00465	0.79806	Grade 12	Filipino	Academic
64	−0.66512	−0.12974	Grade 12	Korean	Gifted
65	−0.15349	0.53067	Grade 12	Filipino	Academic
66	−0.0093	0.86244	Grade 12	Caucasian	Academic
67	−0.07907	0.55812	Grade 12	South Asian	MaCS
68	−0.57674	0.53104	Grade 11	Caucasian	Academic
69	0.10698	0.49374	Grade 12	Jewish	Academic
70	−0.04186	0.85092	Grade 12	Caucasian	Gifted
71	−0.81395	0.30472	Grade 12	Chinese	MaCS
72	0.07907	0.76819	Grade 12	Caucasian	Gifted
73	0.25116	0.81383	Grade 11	Korean	MaCS
74	0.22791	0.79754	Grade 11	South Asian	MaCS
75	−0.03721	0.83171	Grade 12	East Asian	Gifted
76	0.12558	0.80812	Grade 11	Other	Academic
77	−0.24651	0.87637	Grade 11	Caucasian	MaCS
78	−0.4186	0.5233	Grade 11	Jewish	Gifted
79	−0.42791	0.52325	Grade 11	Other	Gifted
80	−0.37209	0.44752	Grade 11	Vietnamese	Gifted
81	0.33023	0.37562	Grade 9	Other	Other
82	0.16279	0.01816	Grade 9	Caucasian	Other
83	0.26047	0.79635	Grade 9	Mixed	MaCS
84	0.07907	0.63522	Grade 12	Middle Eastern	Academic
85	−0.17209	0.72342	Grade 12	Other	Academic
86	0.09767	0.66397	Grade 12	Chinese	Academic
87	−0.0186	0.83643	Teacher	Other	Teacher
88	−0.12558	0.83503	Grade 11	Caucasian	Applied
89	0.08837	0.76433	Grade 10	Other	Academic
90	0.10698	0.7068	Grade 9	Mixed	Academic
91	−0.17674	0.82482	Grade 11	Mixed	MaCS
92	−0.33488	0.66197	Grade 11	Chinese	MaCS
93	−0.51163	0.55082	Grade 11	Mixed	MaCS
94	−0.23721	0.82381	Grade 12	East Asian	Academic
95	0.03256	0.87259	Grade 9	South Asian	MaCS
96	−0.05581	0.82647	Grade 12	Caucasian	Academic
97	0.39535	0.60729	Grade 10	Jewish	MaCS
98	0.15349	0.83218	Grade 10	Caucasian	MaCS
99	0.33488	0.74636	Grade 11	Korean	Gifted
100	0.04186	0.84329	Grade 11	South Asian	Gifted

101	0.03721	0.88879	Grade 12	Jewish	MaCS
102	−0.03721	−0.03835	Grade 11	Filipino	Academic
103	−0.28372	0.83128	Grade 11	Mixed	Academic
104	0.17674	0.85693	Grade 12	Other	Academic
105	0.15814	0.70517	Grade 12	Middle Eastern	Academic
106	0.04186	0.81177	Grade 12	Caucasian	Academic
107	−0.22791	0.62601	Grade 10	Middle Eastern	MaCS
108	0.0093	0.89322	Grade 9	East Asian	MaCS
109	0.23721	0.78687	Grade 9	Jewish	MaCS
110	−0.25581	0.89106	Grade 12	Chinese	MaCS
111	0.14419	0.33119	Grade 11	Other	MaCS
112	0.27442	0.74006	Grade 9	Other	MaCS
113	−0.33488	0.65934	Other	Other	Other
114	−0.34419	0.8054	Grade 10	Jewish	MaCS
115	0.13023	0.8282	Grade 11	Mixed	MaCS
116	−0.53488	0.63568	Grade 9	Chinese	Gifted
117	0.4	0.62004	Grade 11	Middle Eastern	Academic
118	0.14884	0.21818	Grade 12	Caucasian	MaCS
119	−0.17209	0.83282	Grade 10	Mixed	MaCS
120	0.32093	0.76796	Grade 12	Filipino	Academic
121	−0.04186	0.81481	Grade 10	East Asian	MaCS
122	0.2093	0.79192	Grade 12	Other	MaCS
123	−0.06047	0.40232	Grade 9	Other	MaCS
124	0.21395	0.80023	Grade 11	Caucasian	MaCS
125	−0.01395	0.81109	Grade 12	Mixed	MaCS
126	−0.0186	0.89308	Grade 10	South Asian	MaCS
127	0.25581	0.44946	Grade 10	Korean	MaCS
128	0.23256	0.30747	Grade 10	South Asian	MaCS
129	0.1907	0.82166	Grade 11	Other	Academic
130	0.4093	0.69627	Grade 10	Filipino	Academic
131	−0.16279	0.73301	Grade 9	East Asian	Gifted
132	0.11163	0.72323	Grade 11	Caucasian	MaCS
133	−0.03721	0.76895	Grade 12	Other	Other
134	−0.07442	0.86083	Grade 10	Korean	Gifted
135	0.26047	0.83348	Grade 11	Caucasian	MaCS
136	0.44651	0.55779	Grade 11	South Asian	MaCS
137	0.22791	0.56078	Grade 11	Vietnamese	Gifted
138	0.0186	0.78707	Grade 12	South Asian	MaCS

5.3 Summary with outliers

Table 5.3: A summary of all respondents with outliers included.

Purity	Orthodoxy
Min. : −0.81395	Min. : −0.2012
1st Qu.: −0.20233	1st Qu.: 0.5657
Median : −0.01628	Median : 0.7688
Mean : −0.04259	Mean : 0.6758
3rd Qu.: 0.15000	3rd Qu.: 0.8265
Max. : 0.85581	Max. : 0.9245

5.4 Summary without outliers

Table 5.4: A summary of all respondents with outliers removed.

Purity	Orthodoxy
Min. : −0.81395	Min. : −0.1297
1st Qu.: −0.20697	1st Qu.: 0.5946
Median : −0.01860	Median : 0.7681
Mean : −0.04931	Mean : 0.6872
3rd Qu.: 0.14768	3rd Qu.: 0.8266
Max. : 0.44651	Max. : 0.9244

Part III

Analysis

Chapter 6

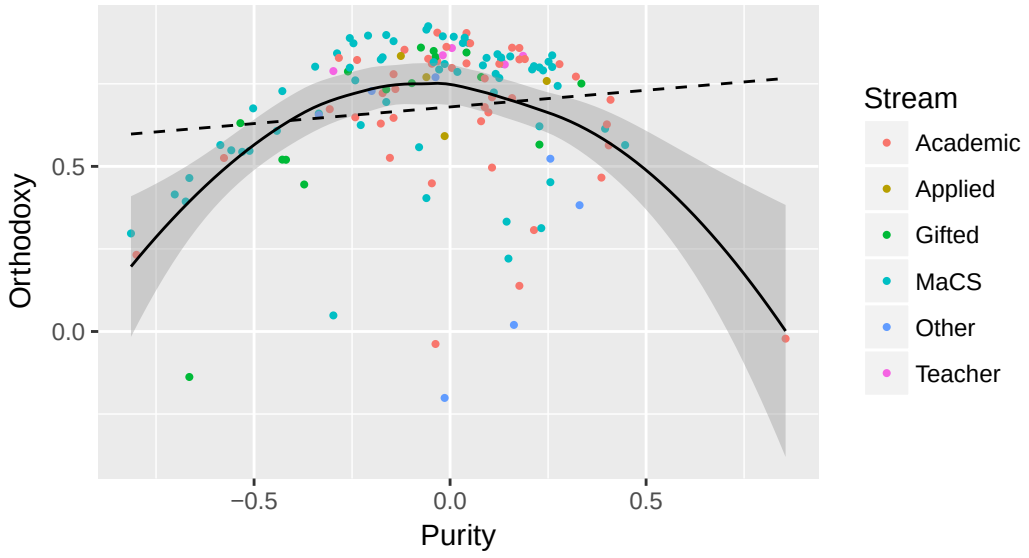
Outliers

We begin our analysis by plotting the purity vs orthodoxy and performing both a linear and locally weighted regression analysis in figure 6.1.

The solid curve is the result of the locally weighted regression analysis, and the shaded area is the 95% confidence interval for that analysis. The dashed line is the result of the linear regression.

6.1 With outliers

Figure 6.1: A plot of purity vs orthodoxy with data points coloured based on stream.

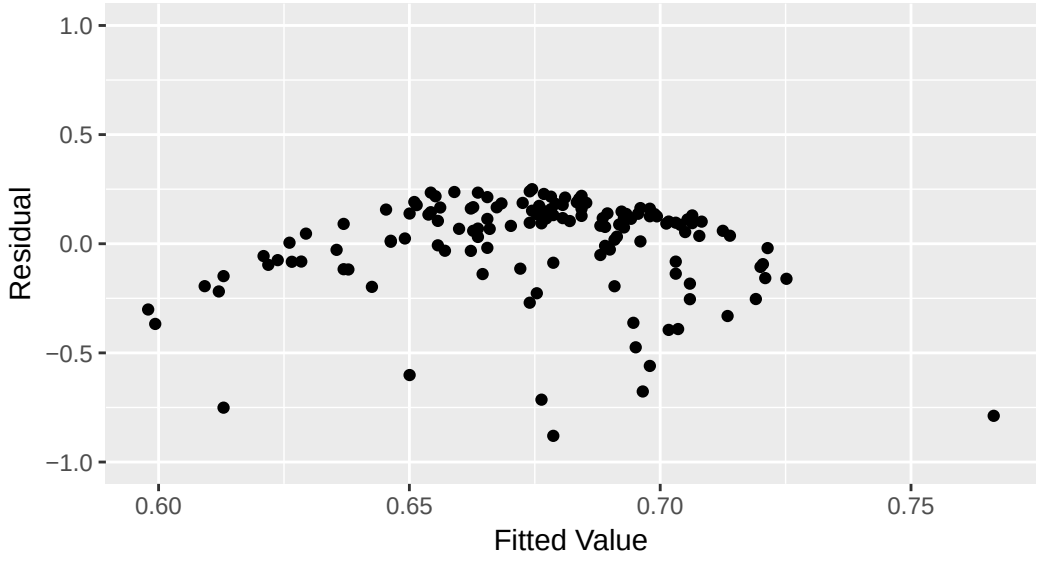


The linear regression has a positive slope, which proves the first hypothesis that purity and orthodoxy are positively correlated.

6.2 Identifying outliers

From the locally weighted regression analysis, it is clear that some points are extremely deviate. We next create residual plots using the linear model in figure 6.2.

Figure 6.2: A residual plot using the linear regression analysis method.



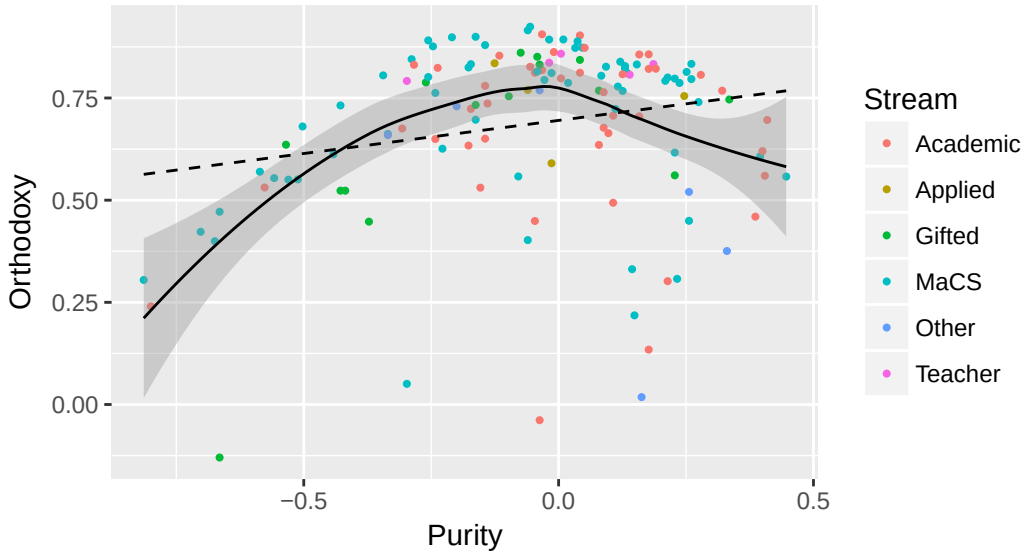
We will eliminate any points with an absolute residual exceeding a certain value.

For the linear analysis, we exclude any points with an absolute residual above 0.76. These are respondents #81, and #111. We will continue the rest of the analysis as if they did not do the survey at all.

6.3 Outliers removed

We once again plot orthodoxy vs purity by stream in figure 6.3, this time with the outliers removed.

Figure 6.3: A plot of purity vs orthodoxy with data points coloured based on stream. Outliers have been removed.



Here, the solid curve is the result of the locally weighted regression analysis, and the shaded area is the 95% confidence interval for that analysis. The dashed line is the result of the linear regression.

From this, we can clearly see that the two outliers removed were significantly effecting the correlation, especially for the locally weighted regression analysis.

Part IV

Appendices

Appendix A

Questions

A.1 Sandwich Survey

What defines a sandwich?

A.2 Demographic Information

We need to study correlations and demographics.

A.2.1 What grade are you in?

Respondents were asked to select only one option.

○ Grade 9 ○ Grade 10 ○ Grade 11 ○ Grade 12 ○ Teacher

A.2.2 What is/are your favourite subjects?

Answer based on what department teaches the subject at Mackenzie.
Respondents were asked to check all that apply.

☐ Arts	☐ Business	☐ Computer Science and Technology
☐ Co-op and Leadership	☐ English	☐ Languages
☐ Library	☐ Math	☐ Physical Education
☐ Science	☐ Social Sciences	☐ Special Education
☐ Other: _____		

A.2.3 What is your ethnic background?

Respondents were asked to provide a free response.

A.3 Student Questions

Questions in this section were asked only of respondents who identified as being in grade 9, 10, 11, or 12. It was not asked of respondents who identified as a teacher.

A.3.1 What is your academic stream?

Select whatever option you most closely identify with.
Respondents were asked to select only one option.

○ Applied ○ Academic ○ MaCS ○ Gifted ○ Other: _____

A.4 Teacher Questions

Questions in this section were asked only of respondents who identified as being a teacher. It was not asked of respondents who identified as being in grade 9, 10, 11, or 12.

A.4.1 What departments do you work in at Mackenzie?

Answer based on what department teaches the subject at Mackenzie.
Respondents were asked to check all that apply.

- ☐ Arts
- ☐ Business
- ☐ Computer Science and Technology
- ☐ Co-op and Leadership
- ☐ English
- ☐ Languages
- ☐ Library
- ☐ Math
- ☐ Physical Education
- ☐ Science
- ☐ Social Sciences
- ☐ Special Education
- ☐ Student Services
- ☐ Other: _____

A.5 Sandwich Questions

For each of the following, answer on a scale from 0 to 10, where 0 is not at all a sandwich, and 10 is definitely a sandwich.

A.5.1 Ham between two slices of bread

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○	○	○	○	○	○	○	○	○	○	○
0	1	2	3	4	5	6	7	8	9	10

Image from [14].

A.5.2 Bacon, lettuce, and tomato between two slices of bread

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○	○	○	○	○	○	○	○	○	○	○
0	1	2	3	4	5	6	7	8	9	10

Image from [36].

A.5.3 Grilled cheese

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○	○	○	○	○	○	○	○	○	○	○
0	1	2	3	4	5	6	7	8	9	10

Image from [4].

A.5.4 Panini

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○	○	○	○	○	○	○	○	○	○	○
0	1	2	3	4	5	6	7	8	9	10

Image from [41].

A.5.5 Sub

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image cropped from [9].

A.5.6 Hamburger

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [6].

A.5.7 Hotdog

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [38].

A.5.8 Ice cream between two cookies

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [8].

A.5.9 Burrito

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [43].

A.5.10 Taco

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [7].

A.5.11 Calzone

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [22].

A.5.12 Quesadilla

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [18].

A.5.13 Open-faced sandwich

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [34].

A.5.14 Pizza

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [35].

A.5.15 Two slices of pizza, face down, on top of each other

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [44].

A.5.16 Slice of bread between two more slices of bread

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [30].

A.5.17 Oreo cookie

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [13].

A.5.18 Ritz cracker

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [24].

A.5.19 Sushi burrito

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [17].

A.5.20 Nigiri sushi

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [46].

A.5.21 Slice of cheese

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image cropped from [27].

A.5.22 Salad with croutons

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [16].

A.5.23 Brick between two slices of bread

Respondents were asked to select only one option, with 0 being "Not at all a sandwich" and 10 being "Definitely a sandwich".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image created in GIMP using [47] and [25].

A.6 Ingredient Questions

For each of the following, answer on a scale from 0 to 10, where 0 is not at all a sandwich ingredient, and 10 is definitely a sandwich ingredient.

A.6.1 Cold cuts

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [37].

A.6.2 Tomato

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [1].

A.6.3 Cheese

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image cropped from [27].

A.6.4 Lettuce

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [48].

A.6.5 Mayonnaise

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [19].

A.6.6 Mustard

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [2].

A.6.7 Ketchup

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [42].

A.6.8 Carrot

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [20].

A.6.9 Peanut butter

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [32].

A.6.10 Jelly

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [39].

A.6.11 Olives

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [5].

A.6.12 Fish

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [26].

A.6.13 Egg

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image cropped from [29].

A.6.14 Fruit

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [40].

A.6.15 Chicken foot

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [23].

A.6.16 Rice

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [12].

A.6.17 Potato

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [11].

A.6.18 Soup

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [33].

A.6.19 Pasta

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

0 1 2 3 4 5 6 7 8 9 10

Image from [3].

A.6.20 Grass

Respondents were asked to select only one option, with 0 being "Not at all a sandwich ingredient" and 10 being "Definitely a sandwich ingredient".

○	○	○	○	○	○	○	○	○	○	○
0	1	2	3	4	5	6	7	8	9	10

Image from [21].

Appendix B

Source Code

B.1 Functions.R

```
1 # Calculate the cosine similarity between two vectors.
2 cosineSimilarity <- function(a, b) {
3         return (sum(a * b) / (sqrt(sum(a^2)) * sqrt(sum(b^2))
    ))
4 }
```

B.2 Calculate.R

```
1 # This is a program to calculate the orthodoxy and purity
    scores on the sandwich spectrum for all respondents.
2
3 source("Functions.R")
4
5 # Define the constants for what columns data is in inside the
     CSV file.
6 GRADE_COLUMN <- 1 # What column the grade data is in.
7 SUBJECTS_COLUMN <- 2 # What column the favourite subjects
    data is in.
8 BACKGROUND_COLUMN <- 3 # What column the ethnic background
    data is in.
9 STREAM_COLUMN <- 4 # What column the stream data is in.
10 QUESTIONS_START <- 6 # What column the food questions start
    at.
11 QUESTIONS_END <- 48 # What column the food questions end at.
12 lockBinding("GRADE_COLUMN", globalenv())
13 lockBinding("SUBJECTS_COLUMN", globalenv())
14 lockBinding("BACKGROUND_COLUMN", globalenv())
15 lockBinding("STREAM_COLUMN", globalenv())
16 lockBinding("QUESTIONS_START", globalenv())
17 lockBinding("QUESTIONS_END", globalenv())
18
```

```
19 respondents <- read.csv("NoOutliers.csv") # Read in the CSV.
20 NUM_RESPONDENTS <- nrow(respondents)
21 lockBinding("NUM_RESPONDENTS", globalenv())
22
23 foodResponses <- as.matrix(respondents)[,QUESTIONS_START:
       QUESTIONS_END] # Convert responses to a matrix.
24 foodResponses <- apply(foodResponses, 1, as.numeric) # Make
       the matrix numeric.
25 foodResponses <- 5 - foodResponses
26
27 NUM_QUESTIONS <- nrow(foodResponses) # The number of sandwich
        questions.
28 lockBinding("NUM_QUESTIONS", globalenv())
29
30 totalResponse <- numeric(NUM_QUESTIONS)
31 averageResponse <- numeric(NUM_QUESTIONS)
32
33 # Sum up the total score for each question by respondent.
34 for (i in 1 : NUM_RESPONDENTS) {
35         totalResponse <- totalResponse + (foodResponses[,i])
36 }
37 averageResponse <- totalResponse / NUM_RESPONDENTS # Divide
       by the number of respondents to find the mean.
38
39 orthodoxyScores <- numeric(NUM_RESPONDENTS)
40 purityScores <- numeric(NUM_RESPONDENTS)
41
42 for (i in 1 : NUM_RESPONDENTS) {
43         orthodoxyScores[i] <- cosineSimilarity(foodResponses
       [,i], averageResponse)
44         purityScores[i] <- sum(foodResponses[,i])
45 }
46 purityScores <- purityScores / (5 * NUM_QUESTIONS)
47
48 # Put data into frame.
49 data <- data.frame(purity = purityScores, orthodoxy =
       orthodoxyScores, grade = respondents[,GRADE_COLUMN],
       subjects = respondents[,SUBJECTS_COLUMN], background =
       respondents[,BACKGROUND_COLUMN], stream = respondents[,
       STREAM_COLUMN])
```

B.3 BoxPlots.R

```
1  # This program creates box plots of the respondents.
2
3  library(ggplot2)
4  source("Calculate.R")
5
6  makeBoxPlot <- function(categoryData, categoryName,
       categoryTitle) {
7          boxPlotData <- data[categoryData %in% names(table(
       categoryData))[table(categoryData) > 1],] # Remove all
       categorical data points only occurring once, as these data
        are not helpful for a box plot.
8
9          # Create the purity plot.
10         dataPlot <- ggplot(boxPlotData, aes_string(x =
       categoryName, y = "purity", fill=categoryName)) # Setup
       the plot.
11         dataPlot <- dataPlot + coord_cartesian(ylim = c(-1,
       1)) # Set the graph limits.
12         dataPlot <- dataPlot + geom_boxplot() # Add the data
       points.
13         dataPlot <- dataPlot + labs(x = categoryTitle, y = "
       Purity") # Give axes proper labels.
14         dataPlot <- dataPlot + theme(legend.position = "none"
       ) # Remove the legend.
15         ggsave(paste(categoryTitle, "Purity.pdf"), plot=
       dataPlot, width=9, height=8)
16
17         # Create the orthodoxy plot.
18         dataPlot <- ggplot(boxPlotData, aes_string(x =
       categoryName, y = "orthodoxy", fill=categoryName)) # Setup
        the plot.
19         dataPlot <- dataPlot + coord_cartesian(ylim = c(-1,
       1)) # Set the graph limits.
20         dataPlot <- dataPlot + geom_boxplot() # Add the data
       points.
21         dataPlot <- dataPlot + labs(x = categoryTitle, y = "
       Orthodoxy") # Give axes proper labels.
22         dataPlot <- dataPlot + theme(legend.position = "none"
       ) # Remove the legend.
23         ggsave(paste(categoryTitle, "Orthodoxy.pdf"), plot=
       dataPlot, width=9, height=8)
24 }
25
```

```
26 makeBoxPlot(data$grade, "grade", "Grade")
27 makeBoxPlot(data$background, "background", "Ethnic Background
       ")
28 makeBoxPlot(data$stream, "stream", "Stream")
29
30 boxPlotData <- data
31
32 # Create the purity plot.
33 dataPlot <- ggplot(boxPlotData, aes(x = 1, y = purity)) #
       Setup the plot.
34 dataPlot <- dataPlot + coord_cartesian(ylim = c(-1, 1)) # Set
        the graph limits.
35 dataPlot <- dataPlot + geom_boxplot() # Add the data points.
36 dataPlot <- dataPlot + labs(x = "All respondents", y = "
       Purity") # Give axes proper labels.
37 dataPlot <- dataPlot + theme(axis.text.x = element_blank(),
       axis.ticks.x = element_blank()) # Remove the x axis.
38 ggsave("PurityBoxPlot.pdf", plot=dataPlot, width=2, height=8)
39
40 # Create the orthodoxy plot.
41 dataPlot <- ggplot(boxPlotData, aes(x = 1, y = orthodoxy)) #
       Setup the plot.
42 dataPlot <- dataPlot + coord_cartesian(ylim = c(-1, 1)) # Set
        the graph limits.
43 dataPlot <- dataPlot + geom_boxplot() # Add the data points.
44 dataPlot <- dataPlot + labs(x = "All respondents", y = "
       Orthodoxy") # Give axes proper labels.
45 dataPlot <- dataPlot + theme(axis.text.x = element_blank(),
       axis.ticks.x = element_blank()) # Remove the x axis.
46 ggsave("OrthodoxyBoxPlot.pdf", plot=dataPlot, width=2, height
       =8)
```

B.4 PurityOrthodoxyPlot.R

```
1 # This is a program to plot orthodoxy vs purity on the
       sandwich spectrum for all respondents.
2
3 library(ggplot2)
4 source("Calculate.R")
5
6 makeScatterPlot <- function(categoryName, categoryTitle) {
7         # Create the plot.
```

```
8         dataPlot <- ggplot(data, aes(purity, orthodoxy)) #
    Setup the plot.
9         #dataPlot <- dataPlot + coord_cartesian(xlim = c(-1,
    1), ylim = c(-1, 1)) # Set the graph limits.
10        dataPlot <- dataPlot + geom_point(aes_string(colour =
     categoryName), size = 0.75) # Add the data points.
11        dataPlot <- dataPlot + geom_smooth(method = loess,
    level = 0.95, colour = "black", size = 0.5) # Add the
    confidence curve.
12        dataPlot <- dataPlot + geom_smooth(method = lm, se =
    FALSE, colour = "black", size = 0.5, linetype="dashed") #
    Add the line of best fit.
13        dataPlot <- dataPlot + labs(x = "Purity", y = "
    Orthodoxy", colour = categoryTitle) # Give axes and legend
     proper labels.
14        ggsave(paste(categoryTitle, "PurityVsOrthodoxy.pdf",
    sep = ""), plot=dataPlot, width=5.5, height=3)
15 }
16
17 makeScatterPlot("stream", "Stream")
18 makeScatterPlot("grade", "Grade")
19 makeScatterPlot("background", "Ethnic Background")
```

B.5 Residuals.R

```
1  # This program creates a residual plot of the respondents.
2
3  library(ggplot2)
4  library(broom)
5
6  source("Calculate.R")
7
8  residualPlotData <- data
9
10 # Create the linear model.
11 mod <- lm(orthodoxy ~ purity, data = residualPlotData)
12 df <- augment(mod)
13 #print(df[which(df$.resid < -0.76),])
14 which(df$.resid < -0.76)
15
16 # Create the residual plot.
17 dataPlot <- ggplot(df, aes(.fitted, .resid)) + geom_point()
```

```
dataPlot <- dataPlot + coord_cartesian(ylim = c(-1, 1)) # Set the graph limits.
dataPlot <- dataPlot + labs(x = "Fitted Value", y = "Residual") # Give axes proper labels.
ggsave("LinearResidualPlot.pdf", plot=dataPlot, width=5.5, height=3)

# Create the loess model.
mod <- loess(orthodoxy ~ purity, data = residualPlotData)
df <- augment(mod)
#print(df[which(df$.resid < -0.8),])
which(df$.resid < -0.80)

# Create the residual plot.
dataPlot <- ggplot(df, aes(.fitted, .resid)) + geom_point()
dataPlot <- dataPlot + coord_cartesian(ylim = c(-1, 1)) # Set the graph limits.
dataPlot <- dataPlot + labs(x = "Fitted Value", y = "Residual") # Give axes proper labels.
ggsave("LoessResidualPlot.pdf", plot=dataPlot, width=5.5, height=3)
```

B.6 Levels.R

```
# Output the levels for certain columns of interest in the input.

# Define the constants for what columns data is in inside the CSV file.
GRADE_COLUMN <- 1 # What column the grade data is in.
SUBJECTS_COLUMN <- 2 # What column the favourite subjects data is in.
BACKGROUND_COLUMN <- 3 # What column the ethnic background data is in.
STREAM_COLUMN <- 4 # What column the stream data is in.
QUESTIONS_START <- 6 # What column the food questions start at.
QUESTIONS_END <- 48 # What column the food questions end at.
lockBinding("GRADE_COLUMN", globalenv())
lockBinding("SUBJECTS_COLUMN", globalenv())
lockBinding("BACKGROUND_COLUMN", globalenv())
lockBinding("STREAM_COLUMN", globalenv())
```

```
lockBinding("QUESTIONS_START", globalenv())
lockBinding("QUESTIONS_END", globalenv())

respondents <- read.csv("CleanedData.csv") # Read in the CSV.

print(paste(nrow(respondents), "respondents"))

summary(respondents[,GRADE_COLUMN])
print(paste(length(levels(respondents[,GRADE_COLUMN])), "
    grades"))

#summary(respondents[,SUBJECTS_COLUMN])
#print(paste(length(levels(respondents[,SUBJECTS_COLUMN])), "
    subjects."))

summary(respondents[,BACKGROUND_COLUMN])
print(paste(length(levels(respondents[,BACKGROUND_COLUMN])),
    "ethnic backgrounds"))

summary(respondents[,STREAM_COLUMN])
print(paste(length(levels(respondents[,STREAM_COLUMN])), "
    streams"))
```

B.7 Tables.R

```
# This program creates a CSV file with the data on each
    respondent's metrics.

source("Calculate.R")

data$purity <- round(data$purity, digits=5)
data$orthodoxy <- round(data$orthodoxy, digits=5)
data <- data[,-4]
write.csv(data, file = "Results.csv")
write.csv(summary(data), file = "Summary.csv")
```

Bibliography

[1] Adityamadhav83. *Sliced Round Tomato at Madhurawada, Visakhapatnam*. Oct. 10, 2012. URL: https://commons.wikimedia.org/wiki/File:Sliced_Round_Tomato_at_Madhurawada.JPG (visited on 2018-05-21).

[2] Aeæ commonswiki. *A squeeze bottle of French's Classic Yellow Mustard*. May 21, 2006. URL: https://commons.wikimedia.org/wiki/File:French%27s_classic_yellow_mustard.jpg (visited on 2018-05-21).

[3] Tim Bartel. *Spaghetti*. Dec. 20, 2004. URL: https://commons.wikimedia.org/wiki/File:Spaghetti.jpg (visited on 2018-05-21).

[4] Mack Male from Edmonton Canada AB. *Grilled Cheese Olympics*. Mar. 14, 2010. URL: https://commons.wikimedia.org/wiki/File:Simple_grilled_cheese.jpg (visited on 2018-05-19).

[5] Renee Comet. *green olives*. 1994. URL: https://commons.wikimedia.org/wiki/File:NCI_2_green_olives.jpg (visited on 2018-05-21).

[6] Renee Comet. *Hamburger*. 1994. URL: https://commons.wikimedia.org/wiki/File:Cheeseburger_(2).jpg (visited on 2018-05-19).

[7] Renee Comet. *Hard-shell taco with meat, cheese, lettuce, tomatoes, and onions*. 1994. URL: https://commons.wikimedia.org/wiki/File:NCI_Visuals_Food_Taco.jpg (visited on 2018-05-19).

[8] Renee Comet. *Ice Cream Sandwich*. 1994. URL: https://commons.wikimedia.org/wiki/File:Ice_cream_sandwich_(1).jpg (visited on 2018-05-19).

[9] Crisco 1492. *A Subway pizza sub in Hong Kong (near the Grand Kowloon)*. Aug. 10, 2013. URL: https://commons.wikimedia.org/wiki/File:Subway_Pizza_Sub,_Hong_Kong.JPG (visited on 2018-05-19).

[10] *Definition of sandwich in English by Oxford Dictionaries*. In: *Oxford Dictionaries — English*. Oxford University Press. URL: https://en.oxforddictionaries.com/definition/sandwich (visited on 2018-06-03).

[11] Doudoulolita. *3 potatoes*. Mar. 21, 2012. URL: https://commons.wikimedia.org/wiki/File:Pommes_de_terre.png (visited on 2018-05-21).

[12] Earth100. *The four, main, common forms of consumed rice*. Nov. 16, 2012. URL: https://commons.wikimedia.org/wiki/File:White,_Brown,_Red_%26_Wild_rice.jpg (visited on 2018-05-21).

[13] Evan-Amos. *Two Double Stuf Oreos, by Nabisco. Bought in a New York supermarket*. Mar. 31, 2017. URL: https://commons.wikimedia.org/wiki/File:Nabisco-Double-Stuf-Oreos.jpg (visited on 2018-05-20).

[14] Fancy steve. *A plain ham sandwich*. Nov. 11, 2011. URL: https://commons.wikimedia.org/wiki/File:Ham_sandwich.jpg (visited on 2018-05-19).

[15] Marjorie Florestal. "Is a Burrito a Sandwich? Exploring Race, Class, and Culture in Contracts". In: *Michigan Journal of Race and Law* 14.1 (2008). URL: https://repository.law.umich.edu/mjrl/vol14/iss1/1.

[16] jeffreyw. *Romaine lettuce salad*. Jan. 28, 2011. URL: https://commons.wikimedia.org/wiki/File:Romaine_lettuce_salad.jpg (visited on 2018-05-19).

[17] jen. *sushirrito*. July 9, 2013. URL: https://commons.wikimedia.org/wiki/File:Sushirrito_(9310623804).jpg (visited on 2018-05-21).

[18] Jennifer. *Lamb quesadillas made with leftover grilled lamb, cheddar cheese, red onion, and peppers from the garden*. Feb. 7, 2005. URL: https://commons.wikimedia.org/wiki/File:Lamb_quesadilla.jpg (visited on 2018-05-20).

[19] Joey 424. *mayonaise on da hot afternoon [sic]*. June 1, 1933. URL: https://commons.wikimedia.org/wiki/File:Jorgedamayo.jpg (visited on 2018-05-21).

[20] Kander. *Carrots on display at local greengrocer*. Oct. 27, 2007. URL: https://commons.wikimedia.org/wiki/File:Carrots.JPG (visited on 2018-05-21).

[21] Ubaid kareem. *Beauty of grass*. Oct. 28, 2013. URL: https://commons.wikimedia.org/wiki/File:Beauty_of_grass.jpg (visited on 2018-05-21).

[22] Kobako. *Calzone*. Aug. 7, 2013. URL: https://commons.wikimedia.org/wiki/File:Calzone04.jpg (visited on 2018-05-20).

[23] Krista. *A chicken foot*. Dec. 24, 2007. URL: https://commons.wikimedia.org/wiki/File:A_chicken_foot.jpg (visited on 2018-05-21).

[24] Lance. *Lance Gluten Free Sandwich Crackers*. URL: https://images-na.ssl-images-amazon.com/images/I/71bduHPOL9L._SL1500_.jpg (visited on 2018-05-21).

[25] Lowes. *Bennett is brick*. Apr. 16, 2017. URL: https://commons.wikimedia.org/wiki/File:Brick_Bennett.jpg (visited on 2018-05-19).

[26] Tiia Monto. *Cod fillet baked in oven*. Mar. 7, 2018. URL: https://commons.wikimedia.org/wiki/File:Baked_cod_fillet.jpg (visited on 2018-05-21).

[27] Tiia Monto. *Emmental cheese slices*. Mar. 26, 2016. URL: https://commons.wikimedia.org/wiki/File:Emmental_slices.jpg (visited on 2018-05-21).

[28] New York State Derpartment of Taxation and Finance. *Tax Bulletin ST-835 (TB-ST-835)*. Department of Taxation and Finance. Apr. 13, 2011. URL: https://www.tax.ny.gov/pubs_and_bulls/tg_bulletins/st/sandwiches.htm (visited on 2018-06-03).

[29] Porsche997SBS. *A picture of an egg being fried*. Nov. 10, 2006. URL: https://commons.wikimedia.org/wiki/File:Fried_egg,_sunny_side_up_(black_background).PNG (visited on 2018-05-21).

[30] Qwantz. *This is an image of a toast sandwich, shot from the side. Sandwich was made and photographed by me, Ryan. It was okay.* Mar. 26, 2014. URL: https://commons.wikimedia.org/wiki/File:An_image_of_a_toast_sandwich,_shot_from_the_side.jpg (visited on 2018-05-20).

[31] *Sandwich*. In: *The Free Dictionary*. URL: https://www.thefreedictionary.com/sandwich (visited on 2018-06-03).

[32] Susan Slater. *peanut butter*. Aug. 4, 2015. URL: https://commons.wikimedia.org/wiki/File:96_-_IMG_20150804_111725.jpg (visited on 2018-05-21).

[33] Stu Spivack. *Creamed corn soup*. June 14, 2006. URL: https://commons.wikimedia.org/wiki/File:Creamed_corn.jpg (visited on 2018-05-21).

[34] stef yau stef. *tuna, guacamole sauce and cherry tomatoes*. Aug. 5, 2007. URL: https://commons.wikimedia.org/wiki/File:Open_faced_tuna_sandwich_with_cherry_tomato_and_guacamole_spread.jpg (visited on 2018-05-20).

[35] Becky Stern. *Pizza at State of the Fruit meeting*. June 19, 2015. URL: https://commons.wikimedia.org/wiki/File:Pizza_at_State_of_the_Fruit_meeting_(18611225834).jpg (visited on 2018-05-20).

[36] Groves Steven. *A bacon, lettuce and tomato sandwich on toasted bread.* Feb. 14, 2011. URL: https://commons.wikimedia.org/wiki/File:BLT_sandwich_on_toast.jpg (visited on 2018-05-19).

[37] Stilfehler. *Pastrami*. May 8, 2009. URL: https://commons.wikimedia.org/wiki/File:Pastrami.jpg (visited on 2018-05-21).

[38] Evan Swigart. *Hot Dog*. Sept. 8, 2010. URL: https://commons.wikimedia.org/wiki/File:Hotdog_-_Evan_Swigart.jpg (visited on 2018-05-19).

[39] terri_bateman. *blackberry jelly*. July 21, 2014. URL: https://commons.wikimedia.org/wiki/File:Blackberry_jelly_(20248988916).jpg (visited on 2018-05-21).

[40] Tomwsulcer. *Fruit platter*. Mar. 30, 2013. URL: https://commons.wikimedia.org/wiki/File:Fruit_platter_at_a_party_with_kiwi_melons_strawberries_etc.JPG (visited on 2018-05-21).

[41] Tomwsulcer. *Panini sandwich at a restaurant*. Feb. 27, 2013. URL: https://commons.wikimedia.org/wiki/File:Panini_sandwich_in_a_restaurant.JPG (visited on 2018-05-19).

[42] Tt341. *Heinz Organic Ketchup*. Oct. 2, 2016. URL: https://commons.wikimedia.org/wiki/File:Heinz_USDA_Organic_Tomato_Ketchup.jpg (visited on 2018-05-21).

[43] Elliot Volkman. *A basic burrito*. June 24, 2009. URL: https://commons.wikimedia.org/wiki/File:Basic_burrito.jpg (visited on 2018-05-19).

[44] Gabby Wang. *Pizza sandwich*. URL: https://s3.amazonaws.com/spoonuniversi-wpengine/spoonuniversi/wp-content/uploads/sites/71/2015/02/pizza-sandwich-1.jpg (visited on 2018-05-20).

[45] *White City Shopping Center, LP v. PR Restaurants, LLC dba Bread Panera*. URL: https://casetext.com/case/white-city-v-pr-restaurants (visited on 2018-06-03).

[46] www.bluewaikiki.com. *Salmon Nigiri Sushi with chopsticks, 2008*. Sept. 5, 2008. URL: https://commons.wikimedia.org/wiki/File:Salmon_Nigiri_Sushi_with_chopsticks,_2008.jpg (visited on 2018-05-21).

[47] yamada taro. *Slices Of Bread Free Stock Photo - Public Domain Pictures*. URL: https://www.publicdomainpictures.net/en/view-image.

php?image=26198&picture=slices-of-bread (visited on 2018-05-19).

[48] Rainer Zenz. *Romaine lettuce*. 2006. URL: https://commons.wikimedia.org/wiki/File:Romaine.jpg (visited on 2018-05-21).