Building a charging station for electric cars in Moscow

1. Introduction
1.1. Background

Moscow is the major political, economic, cultural, and scientific center of Russia and Eastern Europe, as well as the largest city (both by population and by area) entirely on the European continent. It is a very fast-growing metropolis, but integration of new technologies into society is difficult for some reasons. Mainly, it is because the majority of people prefer to live here and now. They don't tend to look into the future, make investments or seek for future benefits. Let us clarify this point on an economic example. Only 1.5% of the population in the country has brokerage accounts on the Moscow Exchange. This is about 2.2 million people. But only 180 thousand of them are active (1 deal per month) - 0.12% of the country's population. For comparison: according to the results of social surveys in the USA 55% of the population own shares. Nevertheless, new technologies eventually come into play and you have to deal with it. That is why I would like to consider a problem of building an electric car charging station in Moscow.

Here are some statistics. As of January 1, 2017, there were 920 electric vehicles in the Russian Federation. For July 1, 2018, there were 2,530 units. As of January 1, 2019, there were already 3,600 of them. Moreover, sales in 2019 increased three times over the same period of 2018. The government actively supports electric vehicles and motivates people to buy them. For example, recently parking became free for electric vehicles while the owners of gasoline cars pay from 1 to 6 $ per hour. Thus, for a month of parking (if we consider only the working day - 9 hours a day, 22 days a month) you will have to pay from 200$ to 1200$ whereas the average salary in Moscow for 2018 was about 1300$. In addition, the owners of electric cars are exempt from paying transport tax and can use toll roads for free.

1.2. Problem

The benefits of owning an electric vehicle in Russian Federation are obvious. Consequently it is justified to expect a sharp increase in demand for electric cars. I will try to set up some recommendations for building an electric vehicle charging station.

1.3. Interest

Given the interest of the government in the promotion of environmental modes of transport, this study can serve as a guide to action for them. Moreover, this report may be of interest to private entrepreneurs who wish to link their business with new technologies or big companies (such as Tesla) looking forward to gain a foothold in Russia.

2. Data

For this purpose I will use a dataset with coordinates of all existing electric vehicle charging stations in Moscow from Portal of open data of the Government of Moscow (https://data.mos.ru/opendata/7704786030-electric-vehicle-charging-stations) and Foursquare location data. I will try to search for patterns between the location of charging stations and

popular venues nearby. Also I will come up with my own ideas of where to build a new station after studying suitable places and based on personal experience as I am a resident of Moscow myself.

The selected dataset contains location and names of all 34 charging stations in Moscow. Other information is excessive for us.

3. **Exploratory Data Analysis**

Our idea is to use Foursquare location data to get top venues near each of the existing charging stations in Moscow. At our request we receive a dataset that contains names, location and categories of all suitable venues. Here is a folium map with top venues depicted as green markers within walking distance from each station.
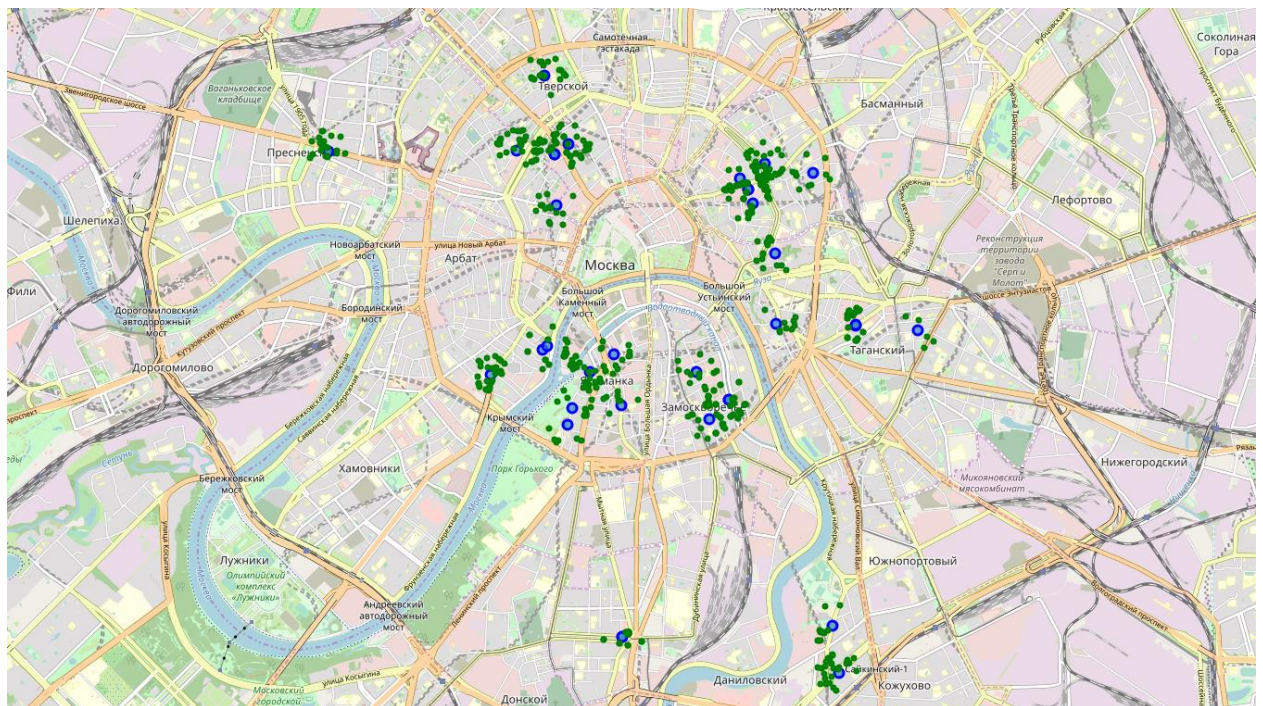
Let us discover which category is the most numerous.

```
items_counts = moscow_venues['Venue Category'].value_counts(normalize=True)
items_counts
```

```
Coffee Shop                                    0.077612
Café                                           0.038806
Restaurant                                     0.034328
Bakery                                         0.028358
Bookstore                                      0.026866
                                                 ...
Residential Building (Apartment / Condo)       0.001493
Deli / Bodega                                  0.001493
Shawarma Place                                 0.001493
Czech Restaurant                               0.001493
Hobby Shop                                      0.001493
Name: Venue Category, Length: 154, dtype: float64
```

It is easy to notice that venues connected with food are at the top of the list. However, it would be wrong to make quick conclusions. To be certain we should conduct a more detailed study. We need to be sure that food venues are more or less evenly distributed to call them the determining factor. Another situation is also possible – there may be other 'rules'. To clarify the situation we will apply k-mean clustering algorithm.

Firstly, we have to prepare our dataset for this procedure. We will add a column named 'Cluster Labels' that will define to which cluster an object belongs and 10 columns containing top 10 venues near each station. After experimenting with the number of clusters, I set their number to five.

ea_en	District_en	Address	Longitude	Latitude	global_id	geoData	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
al`ny`j tivny`j okrug	rajon Zamoskvorech`e	улица Бахрушина, дом 20	37.635950	55.734389	58937156	{type=Point, coordinates=[37.635949800384, 55....]}	2	Hotel	Park	Hookah Bar	Coffee Shop	Caucasian Restaurant	Café	Modern European Restaurant	Gastropub	Playground	Museum
al`ny`j tivny`j okrug	Tverskoj rajon	город Москва, Глинищевский переулок, дом 6	37.609815	55.763042	282292364	{type=Point, coordinates=[37.609815, 55.763042]}	1	Beer Bar	Clothing Store	Bookstore	Hostel	Pedestrian Plaza	Coffee Shop	Pharmacy	Pizza Place	Plaza	Pub
al`ny`j tivny`j okrug	Tverskoj rajon	улица Малая Дмитровка, дом 15	37.605320	55.770210	282292416	{type=Point, coordinates=[37.605319999837, 55....]}	0	Theater	Convenience Store	Fountain	Gaming Cafe	Music Venue	Public Art	Belgian Restaurant	Steakhouse	Bed & Breakfast	Tea Room
al`ny`j tivny`j okrug	Presnenskij rajon	Газетный переулок, дом 1/12	37.607530	55.756691	282292417	{type=Point, coordinates=[37.607530000065, 55....]}	0	Concert Hall	Gym / Fitness Center	Cocktail Bar	Restaurant	Park	Science Museum	Boutique	Spa	Bistro	Coffee Shop
al`ny`j tivny`j okrug	Taganskij rajon	город Москва, Большой Николоворобинский переул...	37.648119	55.751665	282292370	{type=Point, coordinates=[37.648119, 55.751665]}	2	Bakery	Historic Site	Karaoke Bar	Residential Building (Apartment / Condo)	Café	Eastern European Restaurant	Bed & Breakfast	Caucasian Restaurant	Martial Arts Dojo	Spa

To evaluate the results of the procedure let us visualize them. I created another folium map with markers of different colors with each color responsible for one cluster.
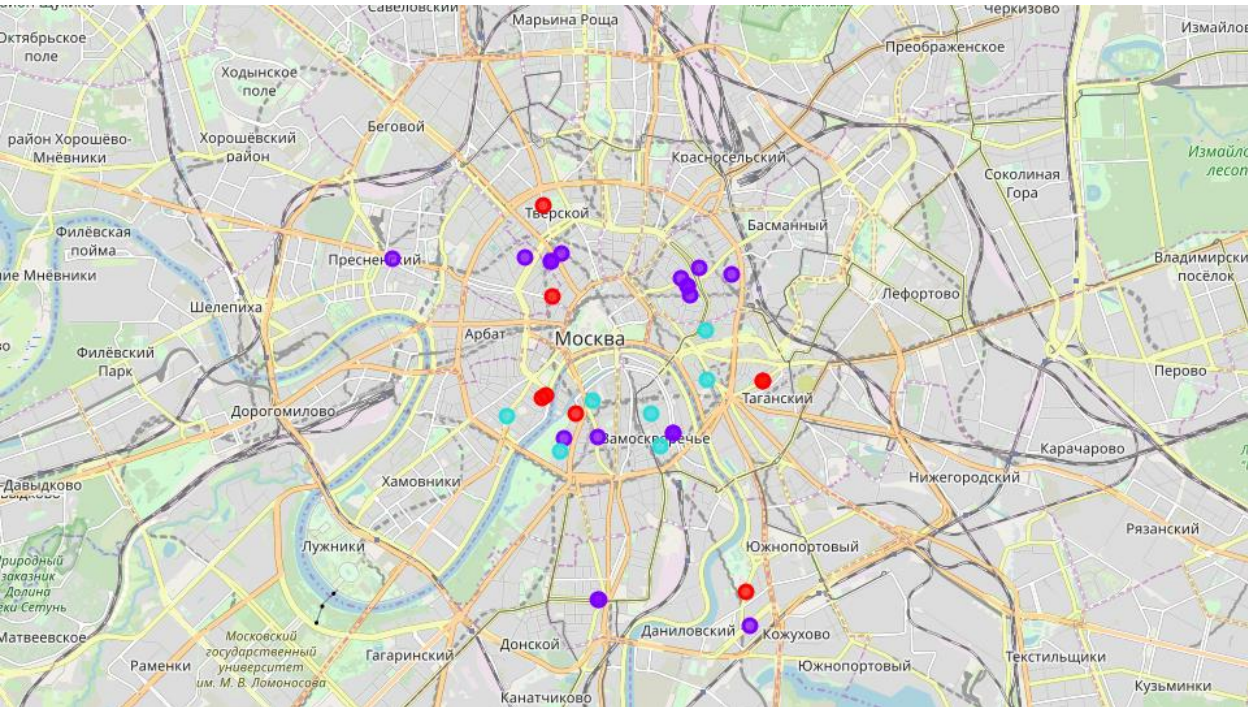
The venues are almost evenly distributed between red, violet and blue clusters. We will need to have a closer look at each cluster to analyze the results.

Here is the first (red) cluster:

	Name_en	Longitude	Latitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
2	ЭЗС улица Малая Дмитровка, дом 15	37.605320	55.770210	0	Theater	Convenience Store	Fountain	Gaming Cafe	Music Venue	Public Art	Belgian Restaurant	Steakhouse	Bed & Breakfast	Tea Room
3	ЭЗС Газетный переулок, дом 1/12	37.607530	55.756691	0	Concert Hall	Gym / Fitness Center	Cocktail Bar	Restaurant	Park	Science Museum	Boutique	Spa	Bistro	Coffee Shop
15	ЭЗС улица Александра Солженицына №1	37.663031	55.744164	0	Coffee Shop	Garden	Theater	Health Food Store	Gastropub	Nightclub	Dance Studio	Restaurant	Sandwich Place	Spa
16	ЭЗС улица Александра Солженицына №2	37.663080	55.744182	0	Coffee Shop	Garden	Theater	Health Food Store	Gastropub	Nightclub	Dance Studio	Restaurant	Sandwich Place	Spa
17	ЭЗС 1-й Голутвинский переулок	37.613719	55.739250	0	Restaurant	Café	Nightclub	Mediterranean Restaurant	Bookstore	Pastry Shop	Concert Hall	Coffee Shop	Cocktail Bar	Pub
27	ЭЗС Восточная улица, дом 11	37.658756	55.712808	0	Dance Studio	Shopping Mall	Restaurant	Business Service	Hookah Bar	Fast Food Restaurant	Baby Store	Blini House	Sporting Goods Shop	Theater
30	ЭЗС 2-й Обыденский переулок, дом 1А	37.604923	55.741622	0	Dance Studio	Art Gallery	Restaurant	Historic Site	French Restaurant	Yoga Studio	Fabric Shop	Food & Drink Shop	Flower Shop	Fast Food Restaurant
31	ЭЗС Курсовой переулок, дом 4	37.605815	55.741978	0	Dance Studio	Restaurant	Coffee Shop	Cocktail Bar	French Restaurant	Boutique	Snack Place	Salon / Barbershop	Chinese Restaurant	Beer Bar

This is a part of the second (violet):

	Name_en	Longitude	Latitude	Cluster	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
7	ЭЗС Леонтьевский переулок, дом 25(2)	37.607197	55.761954	1	Beer Bar	Bookstore	Restaurant	Pizza Place	Salon / Barbershop	Café	Fountain	Caucasian Restaurant	Lebanese Restaurant	Clothing Store
8	ЭЗС улица Большая Бронная, дом 14	37.600217	55.762402	1	Theater	Italian Restaurant	Coffee Shop	Jewelry Store	Toy / Game Store	Men's Store	Road	Restaurant	Cocktail Bar	Playground
9	ЭЗС Мароновский переулок, дом 1/7	37.610525	55.735565	1	Coffee Shop	Supermarket	Sculpture Garden	Vietnamese Restaurant	Park	Gaming Cafe	Salon / Barbershop	Candy Store	Nail Salon	Yoga Studio
10	ЭЗС улица Серпуховский Вал №1	37.619830	55.711677	1	Caucasian Restaurant	Pizza Place	Soup Place	Ice Cream Shop	Indian Restaurant	Health Food Store	Greek Restaurant	Flower Shop	Farmers Market	Falafel Restaurant
11	ЭЗС улица Серпуховский Вал №2	37.619697	55.711679	1	Caucasian Restaurant	Pizza Place	Soup Place	Ice Cream Shop	Indian Restaurant	Health Food Store	Greek Restaurant	Flower Shop	Farmers Market	Falafel Restaurant
12	ЭЗС Автозаводская улица	37.659885	55.707868	1	Arts & Crafts Store	Coffee Shop	Fabric Shop	Beer Store	Mobile Phone Shop	Shawarma Place	Sporting Goods Shop	Pedestrian Plaza	Paper / Office Supplies Store	Pet Store
13	ЭЗС улица Макаренко	37.646220	55.761024	1	Coffee Shop	Restaurant	Bakery	Beer Bar	Performing Arts Venue	Café	Lake	Fountain	Martial Arts Dojo	Mediterranean Restaurant
19	ЭЗС улица Большая Полянка, дом 28	37.619600	55.735781	1	Café	Yoga Studio	Gym / Fitness Center	Bookstore	Coffee Shop	Bakery	Restaurant	Food & Drink Shop	Flower Shop	Fast Food Restaurant
20	ЭЗС улица Красная Пресня, дом 31	37.565319	55.762328	1	Board Shop	Coffee Shop	Yoga Studio	Bath House	Café	Camera Store	Mobile Phone Shop	Boutique	Caucasian Restaurant	Sporting Goods Shop
21	ЭЗС Большой Казенный переулок, дом 6, строение 1	37.655058	55.760040	1	Coffee Shop	Movie Theater	Supermarket	Plaza	Gastropub	Bakery	Health & Beauty Service	Salsa Club	Flower Shop	Fast Food Restaurant
23	ЭЗС Озерковская набережная, дом 44	37.639494	55.736407	1	Hotel	Coffee Shop	Photography Studio	Steakhouse	Caucasian Restaurant	Ramen Restaurant	Restaurant	Modern European Restaurant	Café	Sandwich Place
24	ЭЗС Озерковская набережная, дом 44	37.639507	55.736384	1	Hotel	Coffee Shop	Photography Studio	Steakhouse	Caucasian Restaurant	Ramen Restaurant	Restaurant	Modern European Restaurant	Café	Sandwich Place
25	ЭЗС Колпачный переулок, дом 3, строение 2	37.643166	55.758317	1	Coffee Shop	Bookstore	Cocktail Bar	Café	Plaza	Pizza Place	Castle	Caucasian Restaurant	Nightclub	Belarusian Restaurant
26	ЭЗС Колпачный переулок, дом 3, строение 2	37.643146	55.758297	1	Coffee Shop	Bookstore	Cocktail Bar	Café	Plaza	Pizza Place	Castle	Caucasian Restaurant	Nightclub	Belarusian Restaurant
28	ЭЗС Хохловский переулок, дом 13	37.643998	55.756920	1	Coffee Shop	Café	Arts & Crafts Store	Clothing Store	Photography Studio	Castle	Bookstore	Miscellaneous Shop	Salon / Barbershop	Modern European Restaurant
29	ЭЗС Потаповский переулок, дом 14	37.641554	55.759464	1	Coffee Shop	Cocktail Bar	Bookstore	Belarusian Restaurant	Italian Restaurant	Gastropub	Martial Arts Dojo	Mediterranean Restaurant	Nightclub	Pizza Place

And, finally, these are two remaining clusters (blue and yellow):

	Name_en	Longitude	Latitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	ЭЗС улица Бахрушина, дом 20	37.635950	55.734389	2	Hotel	Park	Hookah Bar	Coffee Shop	Caucasian Restaurant	Café	Modern European Restaurant	Gastropub	Playground	Museum
4	ЭЗС Большой Николоворобинский переулок, дом 7,...	37.648119	55.751665	2	Bakery	Historic Site	Karaoke Bar	Residential Building (Apartment / Condo)	Café	Eastern European Restaurant	Bed & Breakfast	Caucasian Restaurant	Martial Arts Dojo	Spa
5	ЭЗС улица Остоженка, дом 36	37.595418	55.738996	2	Pharmacy	Hotel	Wine Bar	Art Gallery	Burger Joint	Coffee Shop	Italian Restaurant	Café	Salon / Barbershop	Sandwich Place
18	ЭЗС Гончарная улица, дом 20/1, строение 1	37.648308	55.744266	2	Cocktail Bar	Arcade	Vegetarian / Vegan Restaurant	Park	Italian Restaurant	Bakery	Bar	Seafood Restaurant	Museum	Fabric Shop
22	ЭЗС Большая Татарская улица, дом 26	37.633512	55.739334	2	Yoga Studio	Bakery	Dance Studio	Coffee Shop	Clothing Store	Candy Store	Gourmet Shop	Thrift / Vintage Store	Bookstore	Track
32	ЭЗС Старомонетный переулок, дом 11	37.618132	55.741164	2	Art Gallery	Hotel	Irish Pub	Cosmetics Shop	Movie Theater	Salon / Barbershop	Road	Pub	Pool	Middle Eastern Restaurant
33	ЭЗС Якиманский переулок, дом 6	37.609686	55.733764	2	Boxing Gym	Pool	Salon / Barbershop	Nail Salon	Japanese Restaurant	Bridal Shop	Art Gallery	Arts & Crafts Store	Dessert Shop	Farmers Market

```
#Cluster 3
moscow_merged.loc[moscow_merged['Cluster Labels'] == 3, moscow_merged.columns[[1] + list(range(5, moscow_merged.shape[1]))]]
```

	Name_en	Longitude	Latitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
14	ЭЗС Вековая улица	37.674578	55.74364	3	Museum	Gift Shop	Baby Store	Park	Theater	Yoga Studio	Electronics Store	Flower Shop	Fast Food Restaurant	Farmers Market

4. Results

If you take a look at the clusters you might have a thought that venues are distributed randomly between them. That is not exactly so, but this gives us an idea that there is no "monopoly" on charging stations among venue categories. In other words, there is no single rule of where a charging station should be located, but there are several sets of them. Let us discover them all.

No doubt that food venues such as cafes, restaurants and especially coffee shops prevail in the second cluster. Moreover, this cluster is dominant in the number of venues. Thus, food venues were proved to be the main trend.

What about the first cluster? There are still some food venues, but they are not leading anymore. We can find gyms, yoga and dance studios and theaters,

The remaining clusters food venues are present in a small amount. Yet there are lots of hotels, museums and art galleries, beauty salons and parks. The categories are quite diverse here.

There are still a lot of questions to be answered. Why are exactly these categories of venues popular? Which of them do you have to pay attention to? How often do you recharge a car? How much time does it take? We will consider them in the discussion section of this report,

5. Discussion

To start with, we will consider the process of charging of an electric car. But which one? The most popular electric car in Russia (about 70% total) is Nissan Leaf. It seems logical to take this car into account. The second-generation leaf has a 40 kWh battery pack with an EPA-rated range of 243 km (151 miles) on a single charge. Older models can travel up to 172 km (107 miles). Nissan Leaf charge time is strongly dependent on the type of charging station that you use. There are three types of Nissan Leaf charging stations. Charging a car can take you from 30 minutes to 20 hours.

To calculate the exact time of charging you can use a simple formula: divide battery capacity by power of current that can be calculated as current multiplied by voltage. At the charging stations on the unit itself, the current is written and in most cases they are powered by three phases, and then 380 volts should be taken into account. We consider the formula above and subtract 5% from the power of current due to conductor resistance.

It is reasonable to assume that the car will have to be charged twice a week and that optimal time for charging a car is about two hours. That is because drivers do not usually go out with an empty battery and spend about an hour in most of the above venues. Let us calculate the required current at the station: 40kWh/ (0, 95*380V*2h) = 55,4A. For comparison, in a normal the voltage is 220 volts and the wiring and fuses are designed to give a current of 16 amps.

At this point, we have discussed everything about the parameters of the future charging station and customer requirements. The time has come to answer the final question: what place should we choose? In fact, it is incorrect to call any of revealed patterns or tactics wrong. Moreover, if everyone is guided by a single rule, it will soon become a failure. This report gives the reader all necessary information to make a choice himself based on his own interests and guesses.

As I promised at the beginning of the report, I will share one idea coming from my personal observations. If I had a problem, described in the study, I would choose to build a station near a place named "Depot". Just check how many venues are there. It seems that "Depot" owners wanted to create something like a gastronomic Disneyland and literally built an entire city inside the city: the cluster opened on the site of the tram depot accommodates about 11 thousand square meters, 75 restaurants, 140 market points — quite a microdistrict. This place was opened in march and we can confidently say that it has gone viral with 15000 visitors per day.

6. Conclusion

This report sheds light on a problem of electric vehicle charging in Moscow. This niche is still very little developed. Consequently, there is almost no competition and a lot of potential for future growth and development. Despite the fact that the methods used in the work are rather primitive, I hope that this study will be interesting or even useful to the reader.