Machine Learning Project 1

Name - Aniket Nagdeo

In [1]:
```
# Importing Packages
import numpy as np
import pandas as pd
import statistics
import matplotlib.pyplot as plt

import seaborn as sns
sns.set() # By default seaborn theme, scaling, and color palette
```

In [2]:
```
df=pd.read_csv("c:/Users/Ankit/Desktop/bank-marketing.csv")
df.head()
```

Out[2]:

	age	job	salary	marital	education	targeted	default	balance	housing	loan	contact	day	month	duration	campaign	pda
0	58	management	100000	married	tertiary	yes	no	2143	yes	no	unknown	5	may	261	1	
1	44	technician	60000	single	secondary	yes	no	29	yes	no	unknown	5	may	151	1	
2	33	entrepreneur	120000	married	secondary	yes	no	2	yes	yes	unknown	5	may	76	1	
3	47	blue-collar	20000	married	unknown	no	no	1506	yes	no	unknown	5	may	92	1	
4	33	unknown	0	single	unknown	no	no	1	no	no	unknown	5	may	198	1	

In [3]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 45211 entries, 0 to 45210
Data columns (total 19 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        45211 non-null  int64
 1   job        45211 non-null  object
 2   salary     45211 non-null  int64
 3   marital    45211 non-null  object
 4   education  45211 non-null  object
 5   targeted   45211 non-null  object
 6   default    45211 non-null  object
 7   balance    45211 non-null  int64
 8   housing    45211 non-null  object
 9   loan       45211 non-null  object
 10  contact    45211 non-null  object
 11  day        45211 non-null  int64
 12  month      45211 non-null  object
 13  duration   45211 non-null  int64
 14  campaign   45211 non-null  int64
 15  pdays      45211 non-null  int64
 16  previous   45211 non-null  int64
 17  poutcome   45211 non-null  object
 18  response   45211 non-null  object
dtypes: int64(8), object(11)
memory usage: 6.6+ MB
```

In [4]:
```
df.describe()
```

Out[4]:

	age	salary	balance	day	duration	campaign	pdays	previous
count	45211.000000	45211.000000	45211.000000	45211.000000	45211.000000	45211.000000	45211.000000	45211.000000
mean	40.936210	57006.171065	1362.272058	15.806419	258.163080	2.763841	40.197828	0.580323
std	10.618762	32085.718415	3044.765829	8.322476	257.527812	3.098021	100.128746	2.303441
min	18.000000	0.000000	-8019.000000	1.000000	0.000000	1.000000	-1.000000	0.000000
25%	33.000000	20000.000000	72.000000	8.000000	103.000000	1.000000	-1.000000	0.000000
50%	39.000000	60000.000000	448.000000	16.000000	180.000000	2.000000	-1.000000	0.000000
75%	48.000000	70000.000000	1428.000000	21.000000	319.000000	3.000000	-1.000000	0.000000
max	95.000000	120000.000000	102127.000000	31.000000	4918.000000	63.000000	871.000000	275.000000

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
age          0
job          0
salary       0
marital      0
education    0
targeted     0
default      0
balance      0
housing      0
loan         0
contact      0
day          0
month        0
duration     0
campaign     0
pdays        0
previous     0
poutcome     0
response     0
dtype: int64
```

In [6]:
```
df.shape
```

Out[6]: (45211, 19)

In [7]:
```
df.nunique()
```

Out[7]:
```
age            77
job            12
salary         11
marital         3
education       4
targeted        2
default         2
balance      7168
housing         2
loan            2
contact         3
day            31
month          12
duration     1573
campaign       48
pdays         559
previous       41
poutcome        4
response        2
dtype: int64
```

Describe the pdays column, make note of the mean, median and minimum values. Anything fishy in the values?

In [8]:
```
print('Mean is',df['pdays'].mean())
print('Median is',df['pdays'].median())
print('Mode is',df['pdays'].mode()[0])
```

```
Mean is 40.19782796222158
Median is -1.0
Mode is -1
```

Describe the pdays column again, this time limiting yourself to the relevant values of pdays. How different are the mean and the median values?

In [9]:
```
# Since for relevant pdays, need to drop -1
df1 = df[df['pdays'] != -1]
df1.info()
```

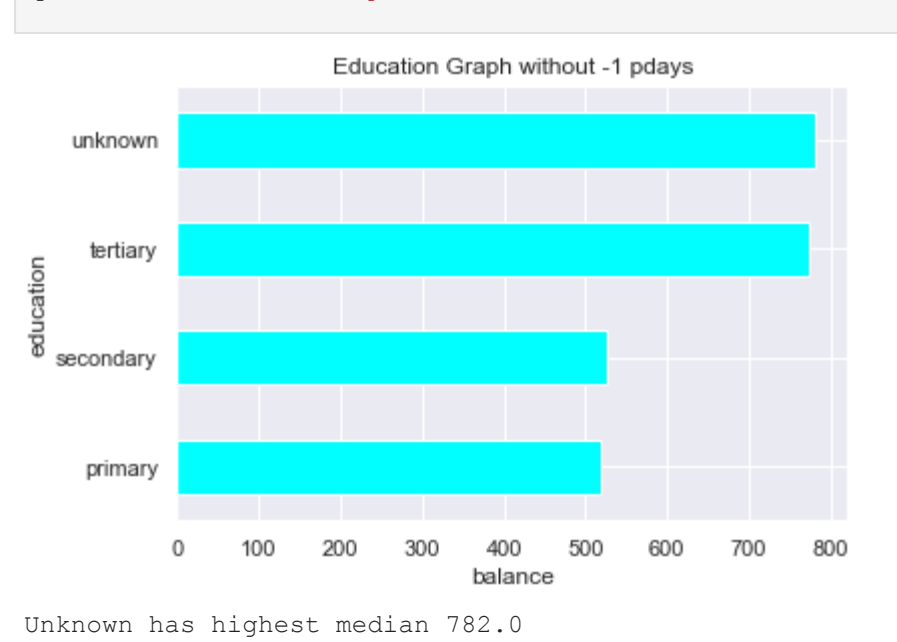
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 8257 entries, 24060 to 45210
Data columns (total 19 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        8257 non-null   int64
 1   job        8257 non-null   object
 2   salary     8257 non-null   int64
 3   marital    8257 non-null   object
 4   education  8257 non-null   object
 5   targeted   8257 non-null   object
 6   default    8257 non-null   object
 7   balance    8257 non-null   int64
 8   housing    8257 non-null   object
 9   loan       8257 non-null   object
 10  contact    8257 non-null   object
 11  day        8257 non-null   int64
 12  month      8257 non-null   object
 13  duration   8257 non-null   int64
 14  campaign   8257 non-null   int64
 15  pdays      8257 non-null   int64
 16  previous   8257 non-null   int64
 17  poutcome   8257 non-null   object
 18  response   8257 non-null   object
dtypes: int64(8), object(11)
memory usage: 1.3+ MB
```

In [10]:
```
print('Mean is',df1['pdays'].mean())
print('Median is',df1['pdays'].median())
print('Mode is',df1['pdays'].mode()[0])
```

```
Mean is 224.57769165556496
Median is 194.0
Mode is 182
```

Plot a horizontal bar graph with the median values of balance for each education level value. Which group has the highest median?

In [11]:
```
plt.title('Education Graph without -1 pdays')
plt.xlabel('balance')
df2 = df1.groupby(['education']).median()['balance']
df2.plot(kind='barh',color='cyan')
plt.show()

print('Unknown has highest median',df2.max())
```

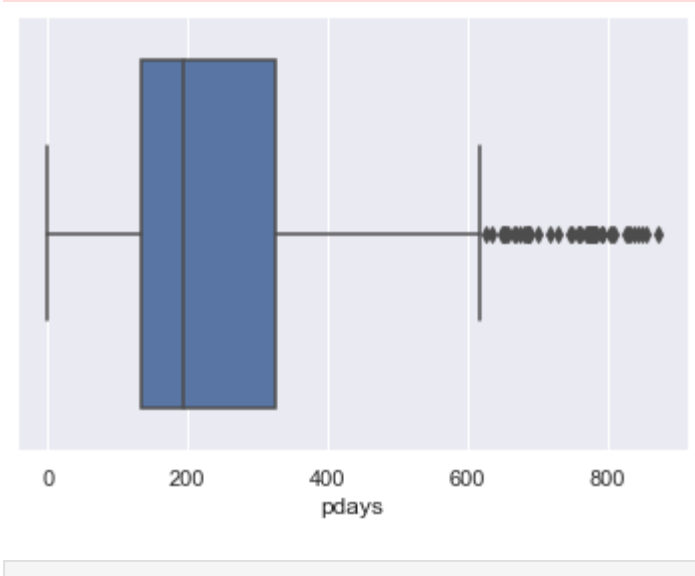



```
Unknown has highest median 782.0
```

Make a box plot for pdays. Do you see any outliers?

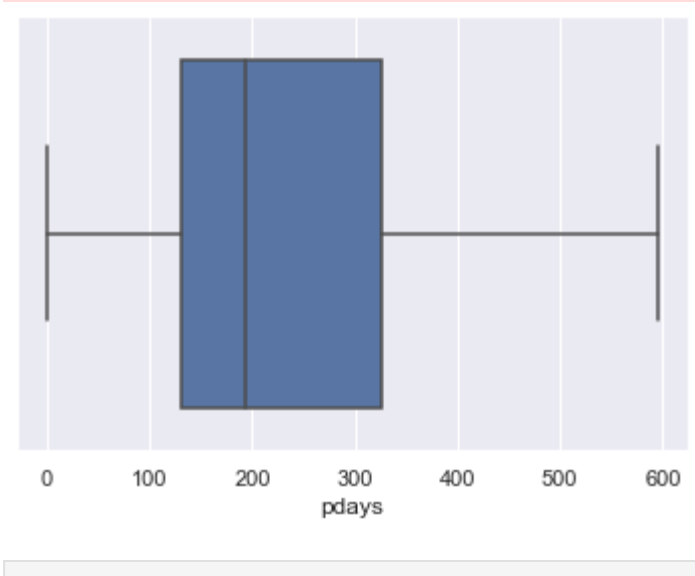
In [12]:
```
print('Boxplot without -1 pdays')
sns.boxplot(df1['pdays'])
plt.show()
```

```
Boxplot without -1 pdays
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
e as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other
arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```



In [13]:
```
# Handling the Outliers
df2 = df1[df1['pdays'] >= 600]
df1 = df1.drop(df2.index,axis=0)

print('Boxplot with no Outliers')
sns.boxplot(df1['pdays'])
plt.show()
```

```
Boxplot with no Outliers
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
e as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other
arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```



In [14]:
```
# Resultant New Data after filtering out ouliers & -1 pdays
df1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 8205 entries, 24060 to 45210
Data columns (total 19 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        8205 non-null   int64
 1   job        8205 non-null   object
 2   salary     8205 non-null   int64
 3   marital    8205 non-null   object
 4   education  8205 non-null   object
 5   targeted   8205 non-null   object
 6   default    8205 non-null   object
 7   balance    8205 non-null   int64
 8   housing    8205 non-null   object
 9   loan       8205 non-null   object
 10  contact    8205 non-null   object
 11  day        8205 non-null   int64
 12  month      8205 non-null   object
 13  duration   8205 non-null   int64
 14  campaign   8205 non-null   int64
 15  pdays      8205 non-null   int64
 16  previous   8205 non-null   int64
 17  poutcome   8205 non-null   object
 18  response   8205 non-null   object
dtypes: int64(8), object(11)
memory usage: 1.3+ MB
```

The final goal is to make a predictive model to predict if the customer will respond positively to the campaign or not. The target variable is "response". First, perform bi-variate analysis to identify the features that are directly associated with the target variable. You can refer to the notebook we used for the EDA discussion.

EDA

Convert the response variable to a convenient form

In [15]:
```
df1['response'] = np.where(df1['response']=='no',0,1)
```

In [16]:
```
df1.head()
```

Out[16]:

	age	job	salary	marital	education	targeted	default	balance	housing	loan	contact	day	month	duration	campaign
24060	33	admin.	50000	married	tertiary	yes	no	882	no	no	telephone	21	oct	39	1
24062	42	admin.	50000	single	secondary	yes	no	-247	yes	yes	telephone	21	oct	519	1
24064	33	services	70000	married	secondary	yes	no	3444	yes	no	telephone	21	oct	144	1
24072	36	management	100000	married	tertiary	yes	no	2415	yes	no	telephone	22	oct	73	1
24077	36	management	100000	married	tertiary	yes	no	0	yes	no	telephone	23	oct	140	1

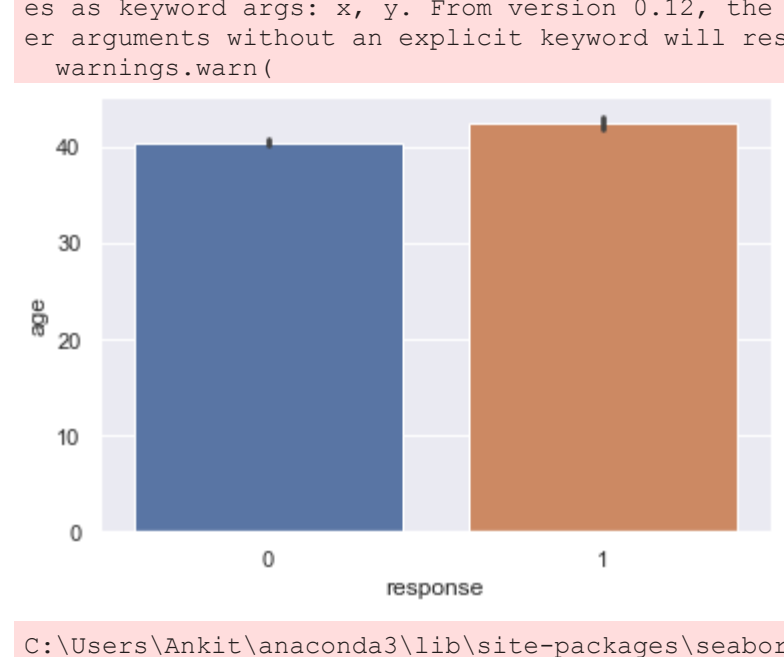
Make suitable plots for associations with numerical features and categorical features'

In [17]:
```
#Identifying Categorical and numerical columns
cols = df1.columns.to_list()
num_cols= df1._get_numeric_data().columns.to_list()
cat_cols = list(set(cols) - set(num_cols))

print('Numerical Columns')
print(num_cols)
print('\nCategorical Columns')
print(cat_cols)
```

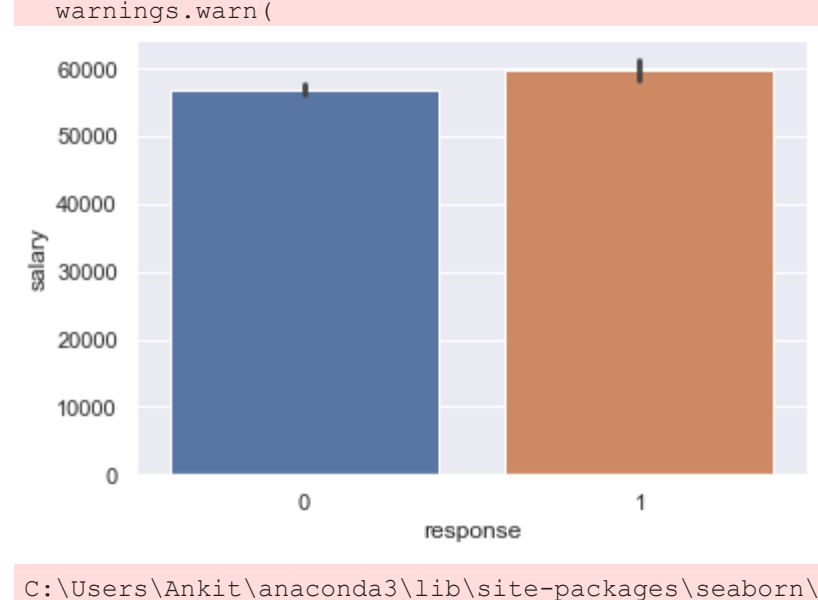
```
Numerical Columns
['age', 'salary', 'balance', 'day', 'duration', 'campaign', 'pdays', 'previous', 'response']

Categorical Columns
['default', 'job', 'marital', 'poutcome', 'month', 'targeted', 'loan', 'education', 'contact', 'housing']
```

In [18]:
```
#Visualizing Numerical Variables with response
for i in df1[num_cols]:
    sns.barplot(df1['response'],df1[i])
    plt.show()
```

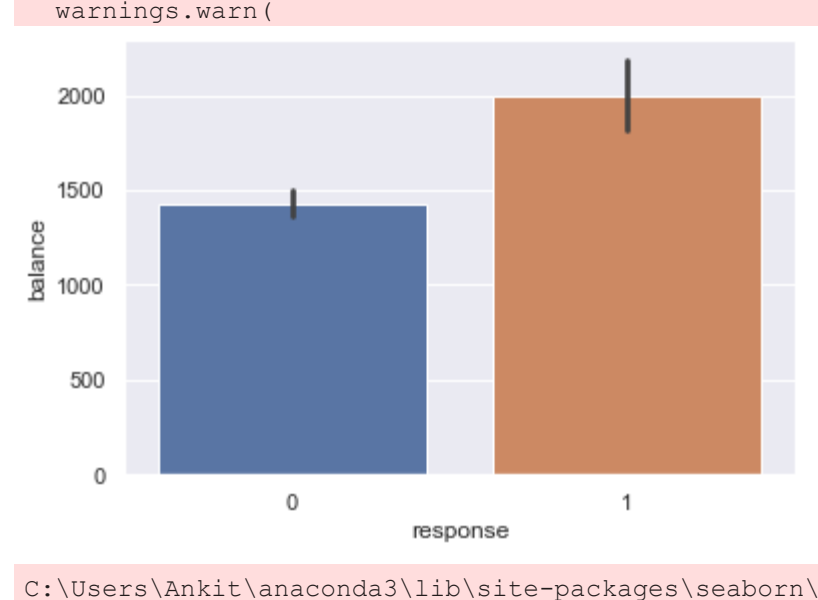
```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
es as keyword args: x, y. From version 0.12, the only valid positional argument will be `data`, and passing oth
er arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```




```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
es as keyword args: x, y. From version 0.12, the only valid positional argument will be `data`, and passing oth
er arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```




```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
es as keyword args: x, y. From version 0.12, the only valid positional argument will be `data`, and passing oth
er arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```




```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

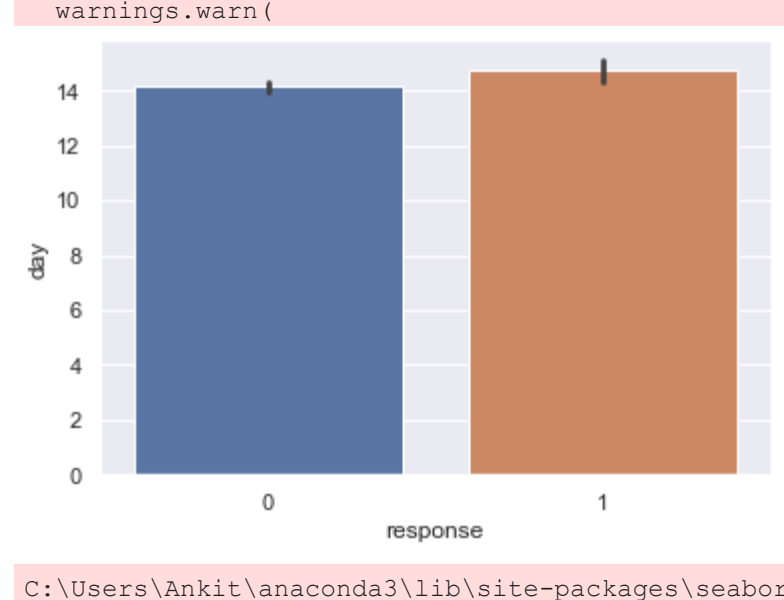


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

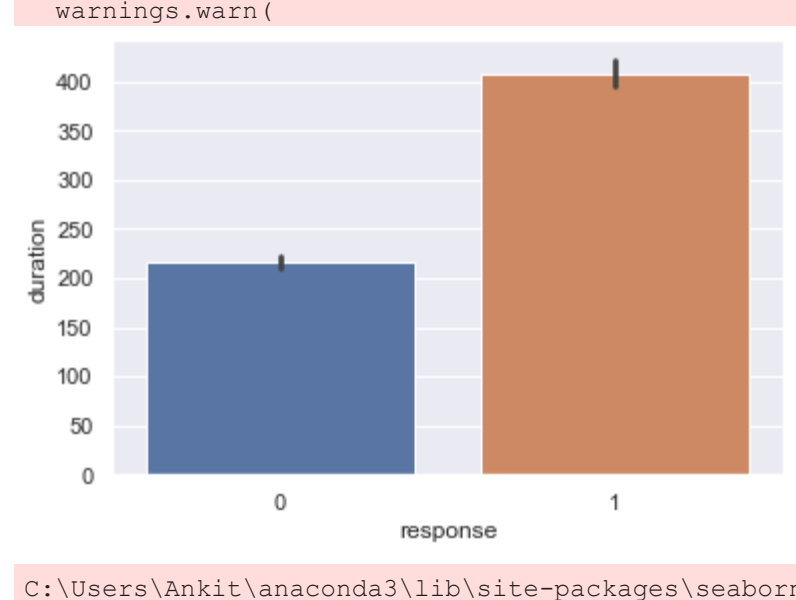


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

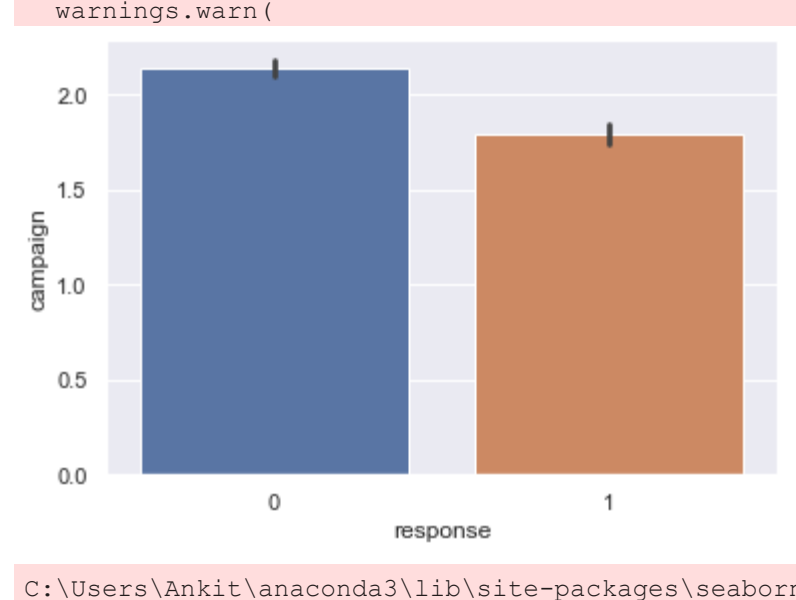


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

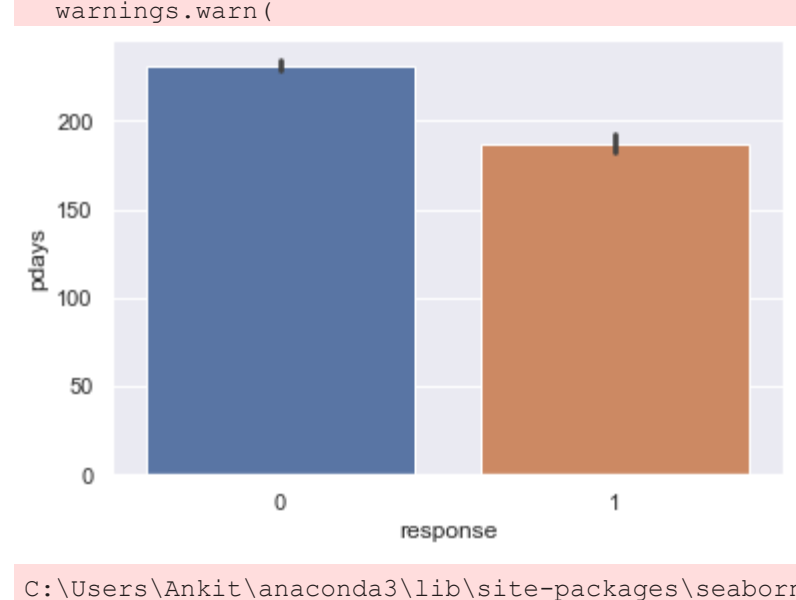


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

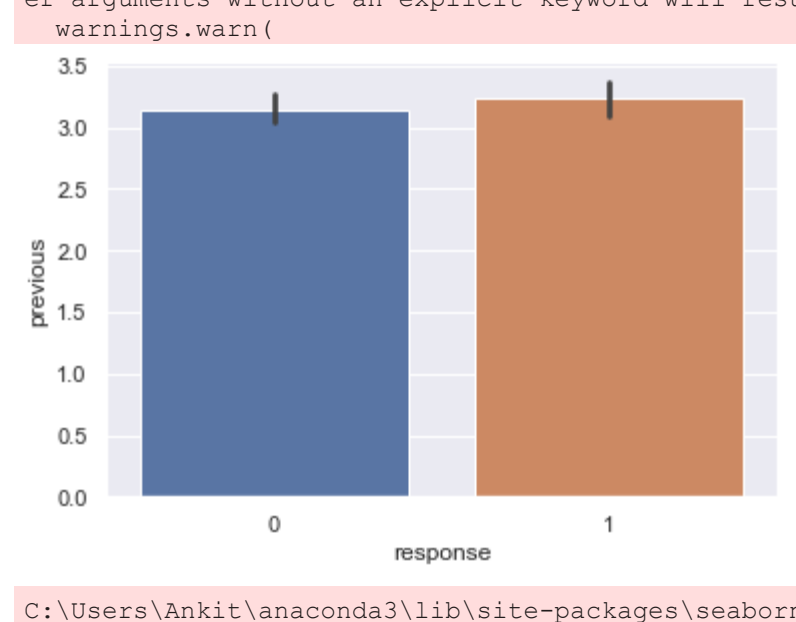


```
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  warnings.warn(
```
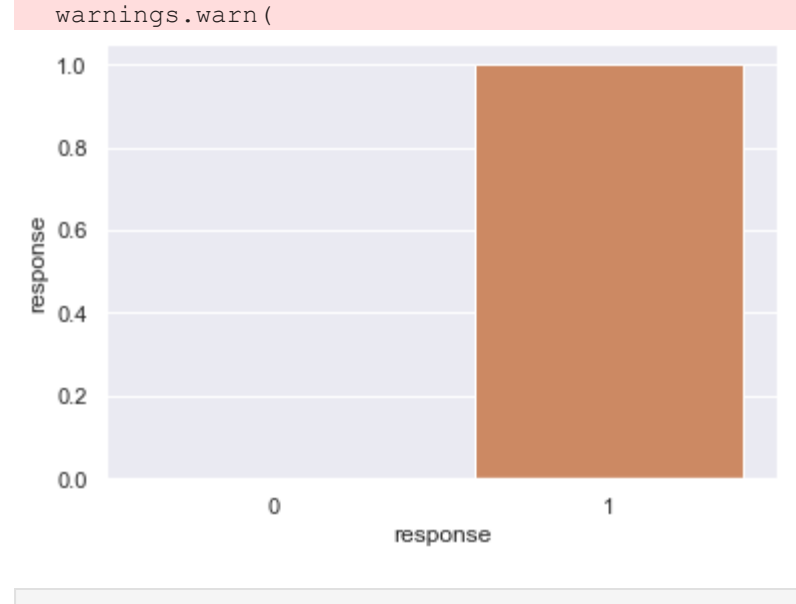
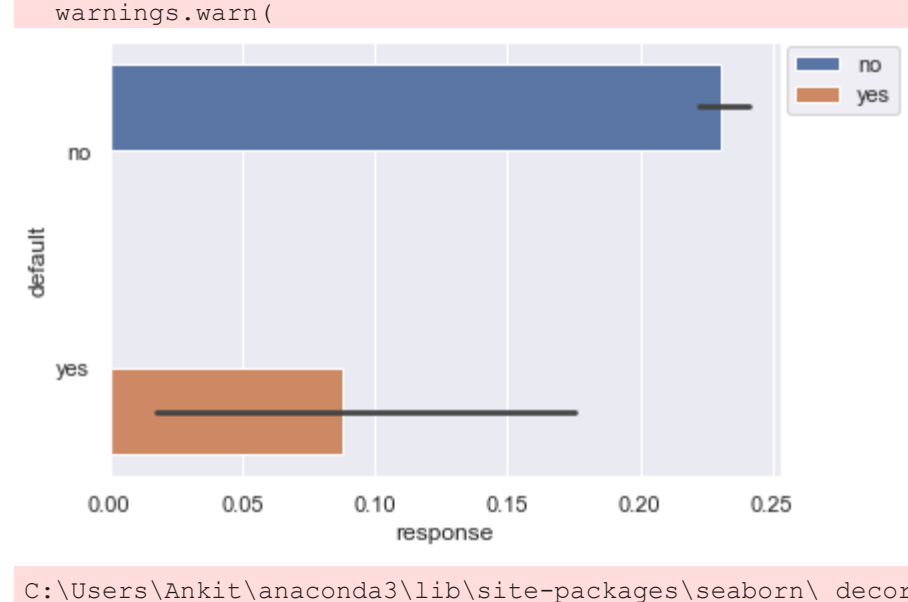



In [19]:
```
#Visualizing Categorical Variables with Response
for i in df1[cat_cols]:
    sns.barplot(df1['response'],df1[i],hue=df1[i])
    plt.legend(bbox_to_anchor=(1.01,.99),borderaxespad=0,loc=2)
    plt.show()
```

```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
es as keyword args: x, y. From version 0.12, the only valid positional argument will be `data`, and passing oth
er arguments without an explicit keyword will result in an error or misinterpretation.
  warnings.warn(
```




```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

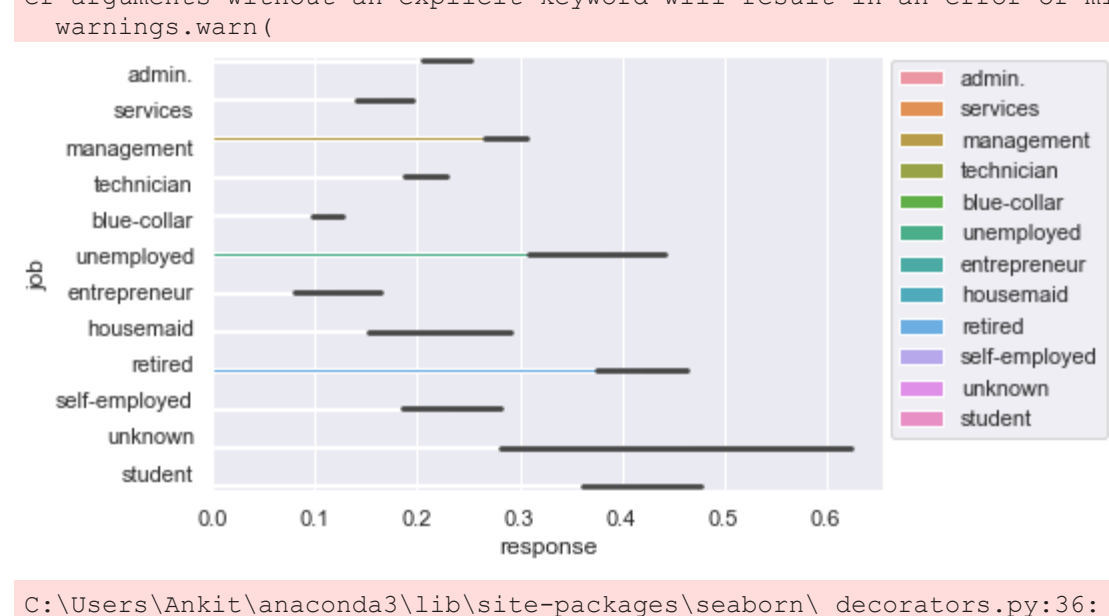


```
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  warnings.warn(
```

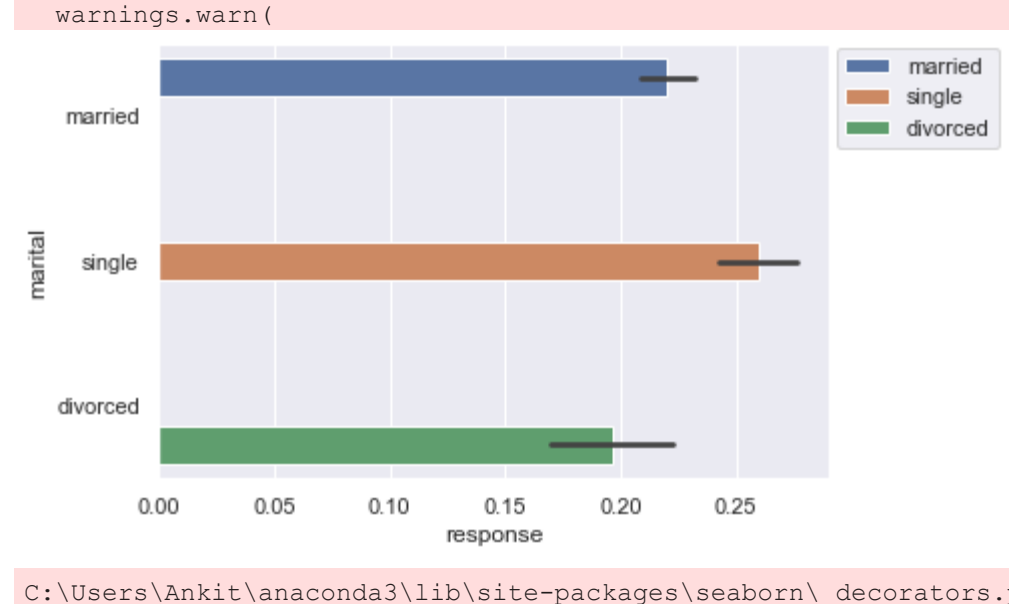


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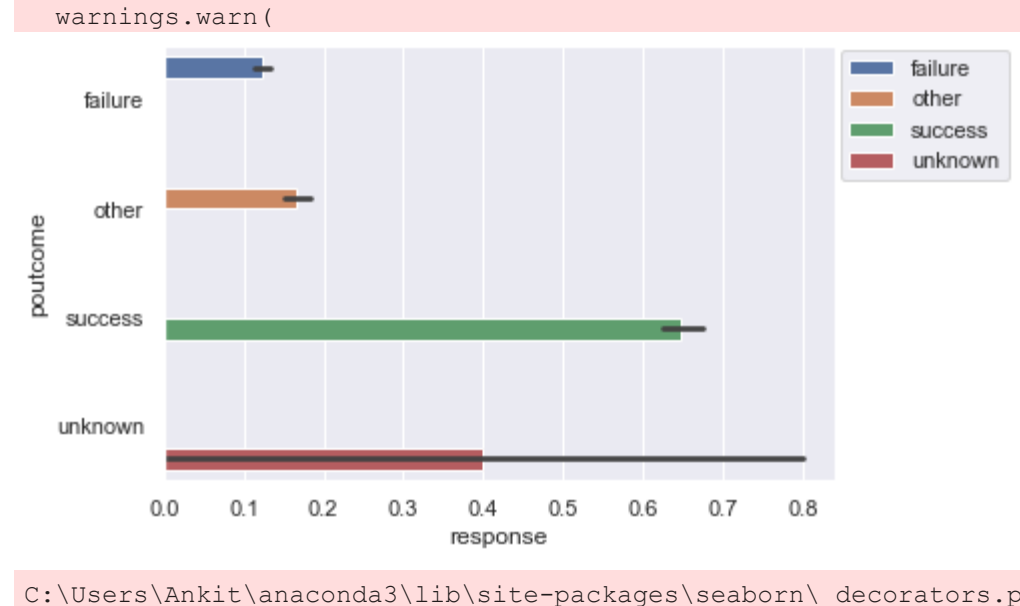


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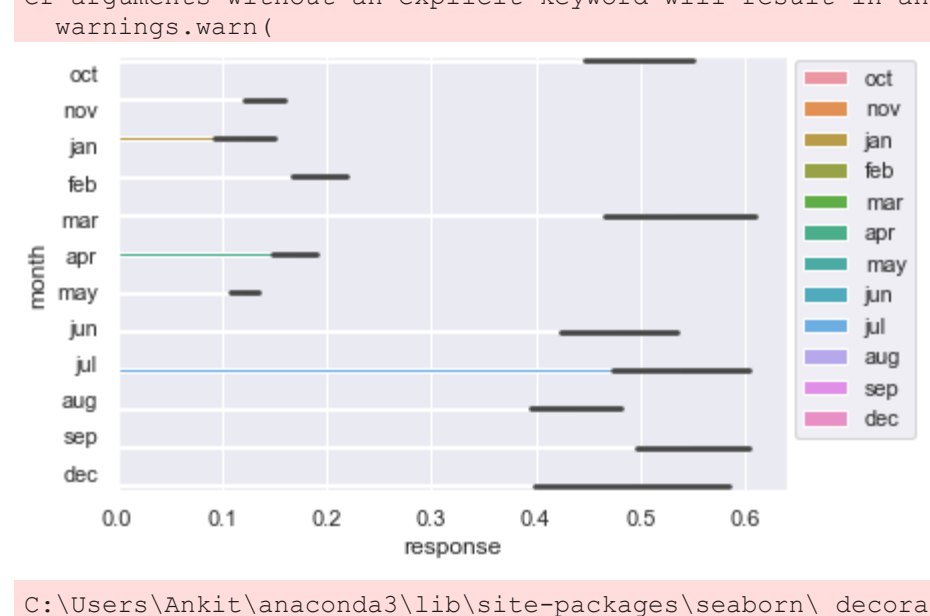
  warnings.warn(
```

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C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

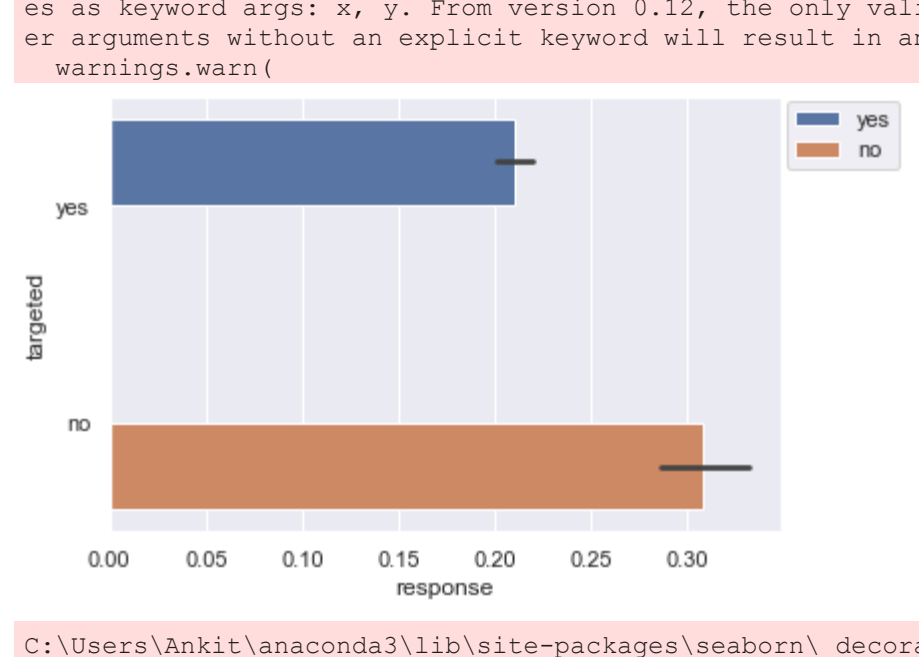


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

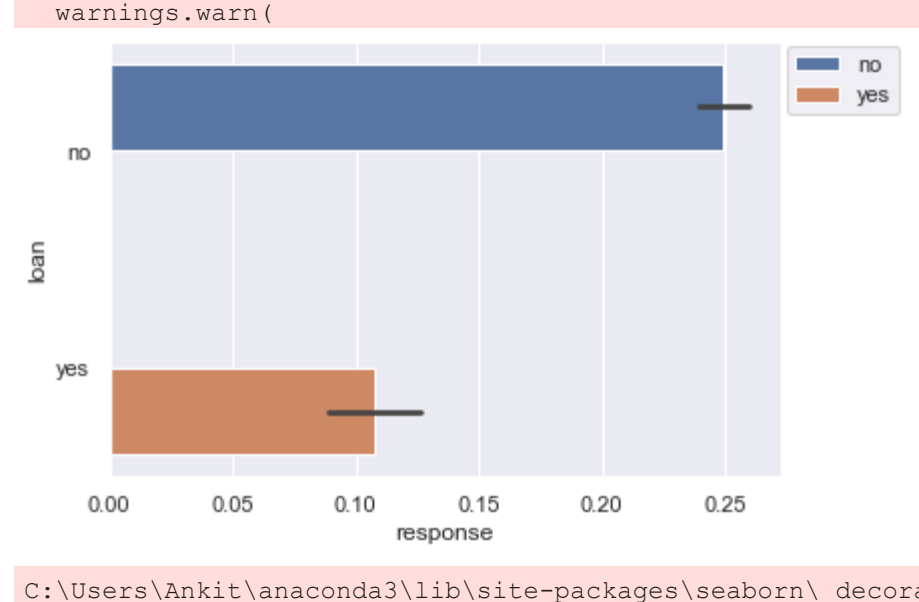


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
es as keyword args: x, y. From version 0.12, the only valid positional argument will be `data`, and passing oth
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  warnings.warn(
```

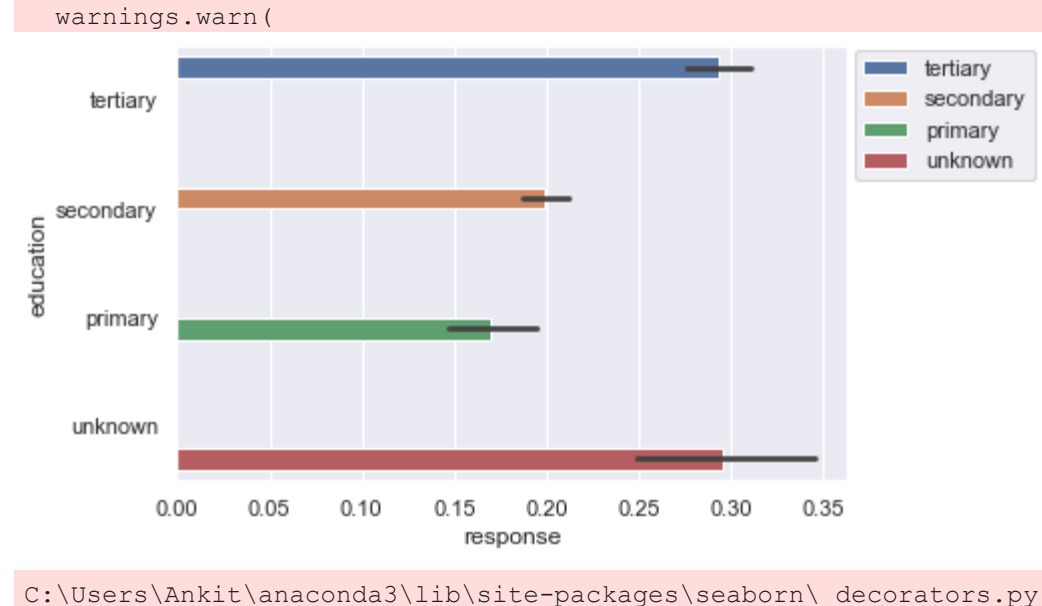


```
C:\Users\Ankit\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variabl
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  warnings.warn(
```

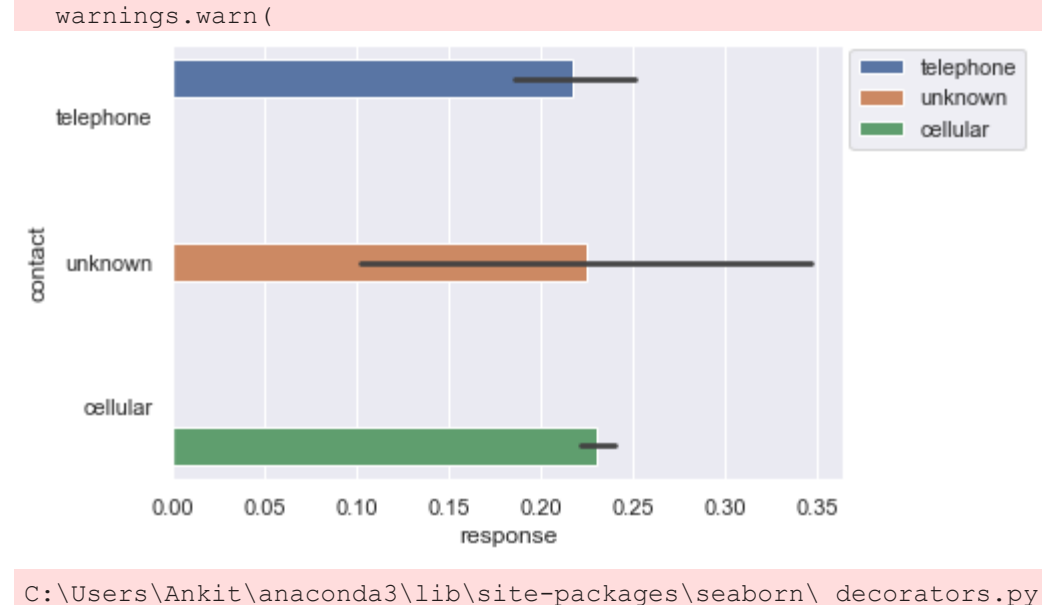


```
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  warnings.warn(
```
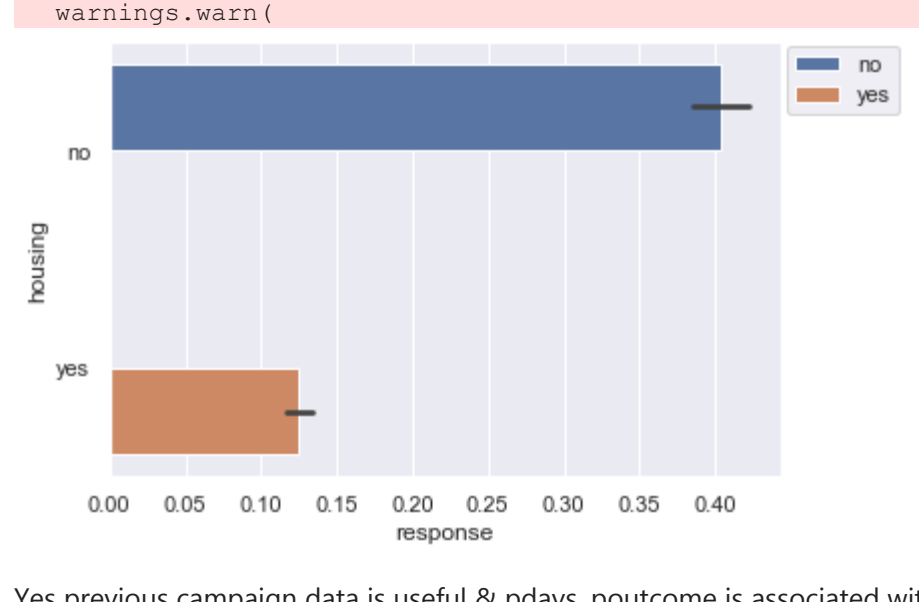
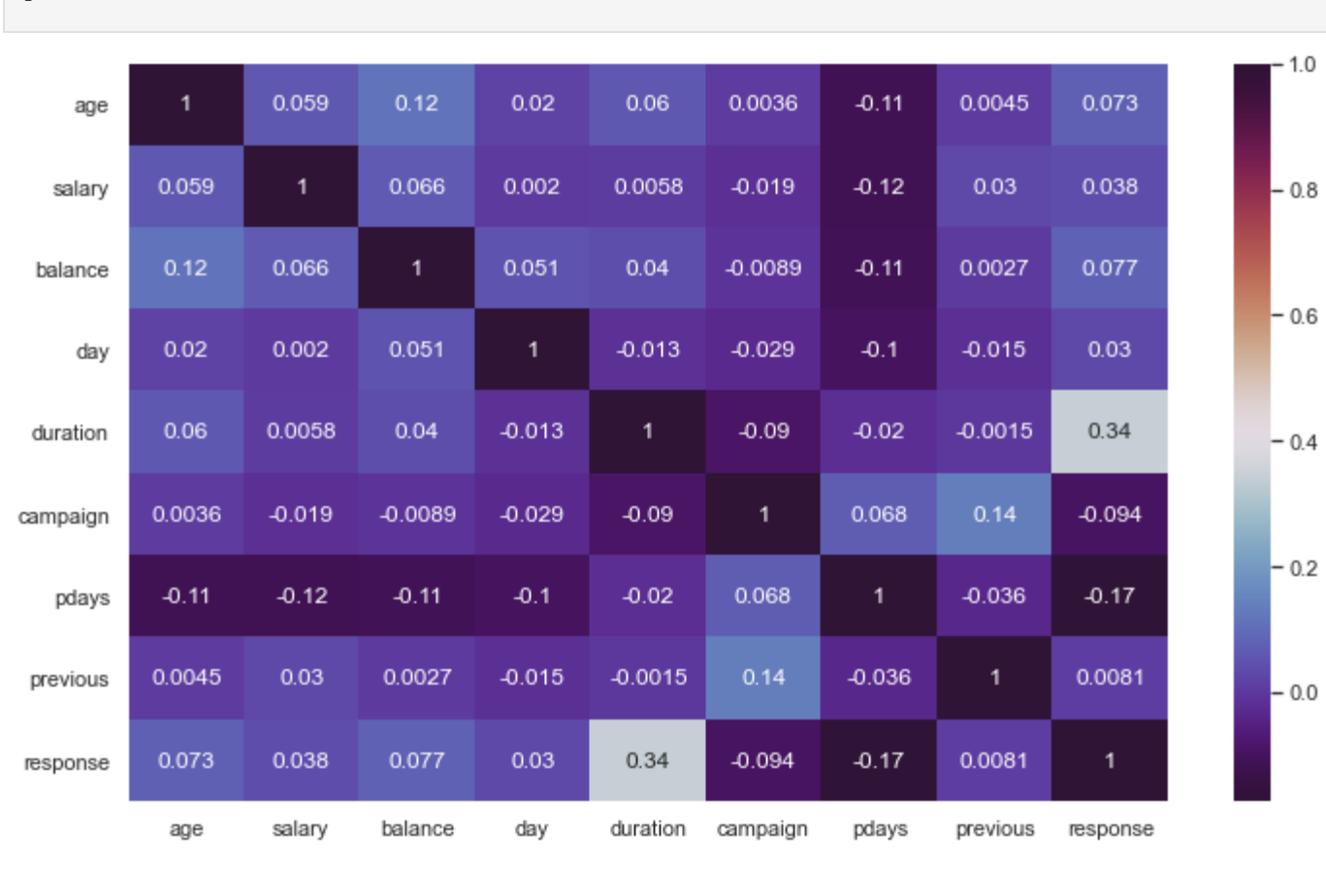



Yes previous campaign data is useful & pdays, poutcome is associated with the target variable 'response'

The -1 pdays or missing values or outliers are filtered out as we would not be using that in Modelling.

The necessary transformations for the categorical variables and the numeric variables

In [20]:
```
# Correlation Matrix on Resultant Data
plt.figure(figsize=(12,7))
corr = df1.corr()
sns.heatmap(corr,annot=True,cmap= 'twilight_shifted')
plt.show()
```



Logistic Regression

In [21]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import recall_score, precision_score, f1_score, confusion_matrix, accuracy_score
```

In [22]:
```
# Describing the resultant data
df1.reset_index(inplace = True)
df1.drop(['index'],axis=1,inplace=True)
df1.describe()
```

Out[22]:

	age	salary	balance	day	duration	campaign	pdays	previous	response
count	8205.000000	8205.000000	8205.000000	8205.000000	8205.000000	8205.000000	8205.000000	8205.000000	8205.000000
mean	40.955759	57552.833638	1560.162949	14.284217	260.359902	2.060695	221.312736	3.167093	0.229860
std	11.436643	31769.246532	3068.366410	7.918706	235.389504	1.564156	107.994505	4.515102	0.420768
min	18.000000	0.000000	-1884.000000	1.000000	1.000000	1.000000	1.000000	1.000000	0.000000
25%	33.000000	20000.000000	167.000000	7.000000	113.000000	1.000000	131.000000	1.000000	0.000000
50%	38.000000	60000.000000	602.000000	14.000000	193.000000	2.000000	193.000000	2.000000	0.000000
75%	48.000000	70000.000000	1752.000000	20.000000	324.000000	2.000000	326.000000	4.000000	0.000000
max	93.000000	120000.000000	81204.000000	31.000000	2219.000000	16.000000	595.000000	275.000000	1.000000

In [23]:
```
# Understanding the resultant data
df1.head()
```

Out[23]:

	age	job	salary	marital	education	targeted	default	balance	housing	loan	contact	day	month	duration	campaign	pd
0	33	admin.	50000	married	tertiary	yes	no	882	no	no	telephone	21	oct	39	1	
1	42	admin.	50000	single	secondary	yes	no	-247	yes	yes	telephone	21	oct	519	1	
2	33	services	70000	married	secondary	yes	no	3444	yes	no	telephone	21	oct	144	1	
3	36	management	100000	married	tertiary	yes	no	2415	yes	no	telephone	22	oct	73	1	
4	36	management	100000	married	tertiary	yes	no	0	yes	no	telephone	23	oct	140	1	

In [24]:
```
# Since contact,marital,education,month,poutcome,loan,job,default,housing,targeted column is categorical so fi
df1[['education', 'contact', 'default', 'loan', 'housing', 'targeted', 'month', 'poutcome', 'job', 'marital']].
```

Out[24]:
```
education     4
contact       3
default       2
loan          2
housing       2
targeted      2
month        12
poutcome      4
job          12
marital       3
dtype: int64
```

In [25]:
```
# One-Hot Encoding
E1 = pd.get_dummies(df1['education'],drop_first=True,prefix='education')
E2 = pd.get_dummies(df1['contact'],drop_first=True,prefix='contact')
E3 = pd.get_dummies(df1['default'],drop_first=True,prefix='default')
E4 = pd.get_dummies(df1['loan'],drop_first=True,prefix='loan')
E5 = pd.get_dummies(df1['housing'],drop_first=True,prefix='housing')
E6 = pd.get_dummies(df1['targeted'],drop_first=True,prefix='targeted')
E7 = pd.get_dummies(df1['month'],drop_first=True,prefix='month')
E8 = pd.get_dummies(df1['poutcome'],drop_first=True,prefix='poutcome')
E9 = pd.get_dummies(df1['job'],drop_first=True,prefix='job')
E10 = pd.get_dummies(df1['marital'],drop_first=True,prefix='marital')

dfd = pd.concat([E1,E2,E3,E4,E5,E6,E7,E8],axis=1)
dfd.head()
```

Out[25]:

	education_secondary	education_tertiary	education_unknown	contact_telephone	contact_unknown	default_yes	loan_yes	housing_yes	target
0	0	1	0	1	0	0	0	0	
1	1	0	0	1	0	0	1	1	
2	1	0	0	1	0	0	0	1	
3	0	1	0	1	0	0	0	1	
4	0	1	0	1	0	0	0	1	

5 rows × 23 columns

In [26]:

```
# Actual Dummies
df1.drop(['poutcome', 'targeted', 'month', 'loan', 'education', 'housing', 'contact', 'marital', 'job', 'defaul
df_dummy = pd.concat([df1,dfd],axis=1)
df_dummy.head()
```

Out[26]:

	age	salary	balance	day	duration	campaign	pdays	previous	response	education_secondary	...	month_jul	month_jun	month_mar
0	33	50000	882	21	39	1	151	3	0	0	...	0	0	0
1	42	50000	-247	21	519	1	166	1	1	1	...	0	0	0
2	33	70000	3444	21	144	1	91	4	1	1	...	0	0	0
3	36	100000	2415	22	73	1	86	4	0	0	...	0	0	0
4	36	100000	0	23	140	1	143	3	1	0	...	0	0	0

5 rows × 32 columns

In [27]:

```
## Generally X - Independent variable, y - Dependent variable

X = df_dummy.drop(['response'],axis=1)
y = df_dummy['response']

print(X.head())
print(y.head())
```

```
   age  salary  balance  day  duration  campaign  pdays  previous  \
0   33   50000      882   21        39         1    151         3
1   42   50000     -247   21       519         1    166         1
2   33   70000     3444   21       144         1     91         4
3   36  100000     2415   22        73         1     86         4
4   36  100000        0   23       140         1    143         3

   education_secondary  education_tertiary  ...  month_jul  month_jun  \
0                    0                   1  ...          0          0
1                    1                   0  ...          0          0
2                    1                   0  ...          0          0
3                    0                   1  ...          0          0
4                    0                   1  ...          0          0

   month_mar  month_may  month_nov  month_oct  month_sep  poutcome_other  \
0          0          0          0          1          0               0
1          0          0          0          1          0               1
2          0          0          0          1          0               0
3          0          0          0          1          0               1
4          0          0          0          1          0               0

   poutcome_success  poutcome_unknown
0                 0                 0
1                 0                 0
2                 0                 0
3                 0                 0
4                 0                 0

[5 rows x 31 columns]
0    0
1    1
2    1
3    0
4    1
Name: response, dtype: int32
```

In [28]:

```
# Train-Test split
X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=.3,random_state=11)
```

In [29]:

```
# Checking data split
print(X_train.shape)
print(y_train.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(5743, 31)
(5743,)
(2462, 31)
(2462,)
```

In [30]:

```
# Scaling

# Applying Standard Scaling to make both of them comparable
from sklearn.preprocessing import StandardScaler
mm = StandardScaler()

X_train = mm.fit_transform(X_train)
X_test = mm.fit_transform(X_test)
```

In [31]:

```
# Logistic Regression code
lg = LogisticRegression()
lg.fit(X_train,y_train)

y_train_pred = lg.predict(X_train)
y_test_pred = lg.predict(X_test)


print(y_train_pred)
print(y_test_pred)
```

```
[0 0 1 ... 1 0 0]
[0 0 0 ... 0 0 0]
```

In [32]:

```
# Validating on Training
print(recall_score(y_train,y_train_pred))
print(precision_score(y_train,y_train_pred))
print(f1_score(y_train,y_train_pred))
print(accuracy_score(y_train,y_train_pred))
print('\n')

# Validating on Testing
print(recall_score(y_test,y_test_pred))
print(precision_score(y_test,y_test_pred))
print(f1_score(y_test,y_test_pred))
print(accuracy_score(y_test,y_test_pred))
```

```
0.5460725075528701
0.6999031945788964
0.6134917267713194
0.8413721051715132


0.5284697508896797
0.6971830985915493
0.6012145748987854
0.8399675060926076
```

In [33]:

```
# Confusion Matrix
print('Confusion Matrix for training data is:')
print(confusion_matrix(y_train, y_train_pred))
print('\n')
print('Confusion Matrix for testing data is:')
print(confusion_matrix(y_test,y_test_pred))
```

```
Confusion Matrix for training data is:
[[4109  310]
 [ 601  723]]


Confusion Matrix for testing data is:
[[1771  129]
 [ 265  297]]
```

Random Forest

In [37]:

```
from sklearn.ensemble import RandomForestClassifier

rf_model = RandomForestClassifier(max_depth=14,min_samples_split=7)
rf_model.fit(X_train,y_train)

y_train_pred = rf_model.predict(X_train)
y_test_pred = rf_model.predict(X_test)

print(y_train_pred)
print(y_test_pred)
```

```
[0 0 1 ... 0 0 0]
[0 0 0 ... 0 0 0]
```

In [38]:

```
# Validating on Training
print(recall_score(y_train,y_train_pred))
print(precision_score(y_train,y_train_pred))
print(f1_score(y_train,y_train_pred))
print(accuracy_score(y_train,y_train_pred))
print('\n')

# Validating on Testing
print(recall_score(y_test,y_test_pred))
print(precision_score(y_test,y_test_pred))
print(f1_score(y_test,y_test_pred))
print(accuracy_score(y_test,y_test_pred))
```

```
0.8225075528700906
0.9510917030567686
0.882138517618469
0.9493296186662024


0.5302491103202847
0.7376237623762376
0.6169772256728778
0.8497156783103168
```

In [39]:

```
# Confusion Matrix
print('Confusion Matrix for training data is:')
print(confusion_matrix(y_train, y_train_pred))
print('\n')
print('Confusion Matrix for testing data is:')
print(confusion_matrix(y_test,y_test_pred))
```

```
Confusion Matrix for training data is:
[[4363   56]
 [ 235 1089]]


Confusion Matrix for testing data is:
[[1794  106]
 [ 264  298]]
```