

# Emotional reactions to risk perception in the Herculaneum Archaeological Park

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**Abstract-** The evaluation of perceived risk by people is particularly valuable for safety and security management. Each person is based on the opinion of others to make a choice and the Internet embodies the place where these opinions are mainly researched, found, and reviewed. Social networks have a significant impact: 92% of consumers declare they trust more of social media reviews than in any other form of advertising. For this reason, Opinion Mining and Sentiment Analysis have found noteworthy uses in different context, among which the most advanced is surely represented by public safety and security. Security managers can use the perceptions communicated by people to find the unpredicted and possible faults of a monitored environment or anyway the risk and security perception of people that sometimes can be truly diverse from real level of risk and security of a given site. Since the perceptions are the effect of mostly unconscious elaborations, it is necessary to go deeper and to search for the emotions, triggered by the sensorial stimuli, that define them.

The purpose of this paper is to study the perception of risk within the Herculaneum Archaeological Park, providing emphasis to the emotional components, applying the semantic analysis of the textual contents present in Twitter.

**Keywords**—*Perceived risk assessment for security, Open-Source Intelligent Techniques for security, OSINT, opinion mining for security, sentiment analysis for security, cultural heritage security.*

## I. INTRODUCTION

Risk perception assessment is essential for security management. Each person depends on other people's opinion to do a choice and the Internet is where these opinions are mainly researched, found and reviewed. Opinion mining and sentiment analysis embody useful tools from this point of view. They were originally utilized as market research instruments to find out judgments about brands and products and they have now developed to become relevant in other sectors too such as safety and security.

Security managers can make use of the perceptions communicated by people to discover the unpredicted and possible weaknesses of a monitored environment or anyway the security perception of people that occasionally can be quite different from real level of security of a given site. This can embody a helpful tool to have continuously feedbacks about risk perception and when a suitable activity aimed at improving effective or perceived security is done, so that it is possible to know the effect on the perceived risk and security [1 - 11].

Collecting the opinions to be used for this purpose involves searching through various open sources (OSINT - Open Source INTelligence) and hence dealing with huge amount of data in digital form where information and knowledge are to be extracted from. In our case, Twitter has been utilized as source and a suitable analysis of keywords, included into various tweets, was performed. Keywords were carefully

chosen considering that the evaluation of the perceived risk is greatly related to psychological aspects, via emotional reactions arouse from a specific site.

The scope of this paper is to illustrate the methodology and show the results attained, considering, as case study, the Herculaneum Archaeological Park, Italy.

## II. HERCULANEUM ARCHAEOLOGICAL PARK

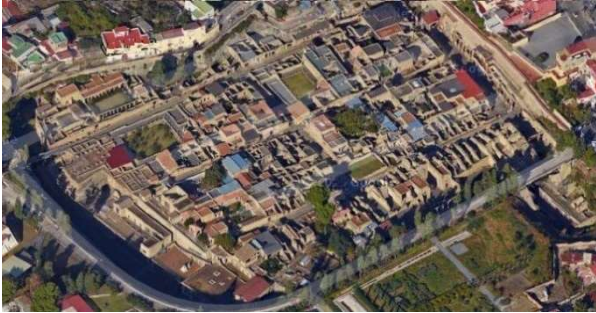


Fig. 1. Aerial view of Herculaneum Archaeological Park.



Fig. 2. View of a street of Herculaneum Archaeological Park.

Herculaneum (Figs 1-3) is famous for its terrible history, since in 79 A.D. a catastrophic eruption of Vesuvius volcano entirely buried the city with all its inhabitants, together with the close and wider Pompeii. It was only around 18<sup>th</sup> century that the investigations began with the consequent opening of the excavations. From that moment on, the fame Herculaneum, pushed even by the close Pompeii, spread all over the world thanks to its riches and, despite the centuries has been looted and stripped of numerous precious objects, it continues to surprise today. This is perhaps the reason why different hundreds of thousands of people visit this site each year. The great historical-artistic importance of this archaeological site is at the base of the uniqueness of Herculaneum confirmed by UNESCO in 1997 with the recognition of it as world heritage site, together with Pompeii and the surrounding archaeological areas. The marvel of Herculaneum with mosaics, painting, houses, and streets contrasts with the complexity of its management. In fact, most of the excavations are exposed to the natural environment and weather and this influences their conservation status. The material and structural deterioration, the erosion caused by rainwater or by the tourist impact are only some of the

most important reasons of weakening which can create significant damages, if they are not suitably contrasted.

Herculaneum archaeological park extends over an area of about 4 hectares, even if it is supposed that the ancient city extended over about 20 hectares, the most of which are still buried under the new town that was built later and that surround the archaeological park, which is located below its street level. The excavated area, of about 4 hectares, is divided into 12 zones named 'insulae' and includes even the ancient walls and the close villa of the papyri. In the site are visible numerous houses (named domus), paintings, mosaics etc. that cannot be illustrated here due to the limited space available.

This exceptional unique site unavoidably arouses emotions in visitors influencing their perception of the risk in the studied site.



Fig. 3. Reconstruction of ancient Herculaneum with Vesuvius volcano in the back.

Inimitable and composite cultural heritage sites, like the considered one, necessitate a noteworthy effort to guarantee security and safety, cultural heritage preservation and protection as well as accessibility for visitors, with particular reference to visitors with disabilities, and for personnel usually present for site management. These aims can be achieved using integrated systems [12, 13] and innovative technologies, such as Internet of Things (IoT) / Internet of Everything (IoE) which can connect people, things (mobile terminals, smart sensors, devices, actuators; wearable devices; etc.), data/information/knowledge and processes [14]. The IoT/IoE system must implement and support an integrated multidisciplinary model for security and safety management (IMMSSM) for this specific site [15]. For this reason, a proper project named Safety & Safety of Herculaneum Archaeological Park have been activated.

The scope of this paper is to study the perception of risk within the Herculaneum Archaeological Park, providing importance to the emotional components, applying the semantic analysis of the textual contents present in Twitter. It represents a useful tool since it allows to have constantly feedbacks about risk perception and when future activities aimed at increasing effective or perceived security is done, so that it is possible to know the effect on the perceived risk and security.

### III. DESCRIPTION OF THE USED METHOD

The semantic info included in the data can be obtained applying the Sentiment Analysis, also known as Opinion Mining. This assessment derives the subjective opinions of the users on an object of interest via the analysis of the polarity of the feeling (which can be positive, negative, or neutral) utilized to describe the experience with the latter. In general, the Sentiment Analysis is done according to the steps indicated in Fig.4.

Twitter has been selected as the supplier of data from which to get texts as it is one of the most used social networks in the world since it has one of the highest percentages of public profiles with respect to others (Facebook® profiles and comments are generally private). Furthermore, the text is the principal component (Instagram® contains mainly photos) whose brevity, 280 characters / tweet, lets assesses each tweet more simply and more efficiently.

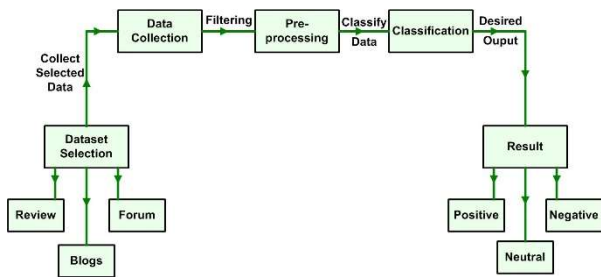


Fig. 4. General opinion mining steps.

There is many software available for network analysis, but NodeXL is usually the most common since it does not require the knowledge of any programming language. NodeXL is a free plug-in for Excel and the basic version, utilized for this work, permits to import data and process it by means of metrics. Due to the limitations of Twitter API, it is possible to extract up to 2000 tweets or at least tweets no older than 7-8 days. In the specific case, the metric ‘Words and word pairs’ has been utilized, which counts the words and the pairs of words that appeared in the tweets. Basically, this metric achieves the Sentiment Analysis just by scanning the text, recognizing the words that are present in the two ‘Lists of Sentiment Words’ with the related number of occurrences.

The study focused on the analysis of the tweets (both in Italian and English) of the Herculaneum Archaeological Park with the objective of obtaining the emotions and opinions of visitors to evaluate their perception of the risk of the considered site.

The keywords used as search term are listed in the Tab. I.

TABLE I. SUMMARY OF THE KEYWORDS USED AS SEARCH TERM.

Keywords	
Italian/English	English translation
Ercolano parco	Herculaneum park
Ercolano scavi	Herculaneum excavations

Herculaneum ruins	-
Herculaneum site	-

In addition to the list of positive and negative words, a third category named ‘Awareness words’ was implemented. It embodies a category fitting to highlight if and how the location is mentioned in the mass media. The words are therefore names of newspapers, TV channels, broadcasting companies and events (known above all to the Italian public) that took place in the Herculaneum Archaeological Park.

To ensure a meaningful result of the analysis, the word list, which groups the classification in one of the three categories, is created step by step, relying on the default English settings of the software. It is well known that vocabularies for the Italian language useful for this type of analysis are already available but, since some words are specific to the context, it was chosen to produce a new lexicon of sentiments.

Herculaneum is typified by the looming presence of Vesuvius volcano whose view instantly recalls the natural catastrophe that buried the city. For this reason, all the words related to the eruption (both in Italian and in English) were found and included in the negative list, since they are connected to the primary emotion of fear. At this point, to extract the emotional reactions of visitors, each word (positive or negative) was associated with the primary emotion evoked by it. To reach this goal, a proper questionnaire was created and filled by a randomly collected statistical reference sample consisting of 41 people, equally shared between male and female, aged between 17 and 70. Once the results of the questionnaires were collected and evaluated, it was possible to derive the dominant emotion related to each word.

### IV. RESULTS

The processing of the data thus carried out generated a vast amount of information, related to the considering collecting period. They summarized in Tab. II.

TABLE II. TOTAL NUMBER OF WORDS USED FOR THE ANALYSIS.

Word	Count
Words in Sentiment List#1: Positive	1817
Words in Sentiment List#2: Negative	220
Words in Sentiment List#3: Awareness	1259
Non-categorized Words	9759
Total Words	13055

It must be noted that the set of un-categorized words is widely populated and this due to the inclusion in this list of all the keywords and because in a usual conversation the words that express a clear polarity, whether positive or negative, represent a minority. Fig.5 shows the distribution of the number of tweets through the considered timeline.

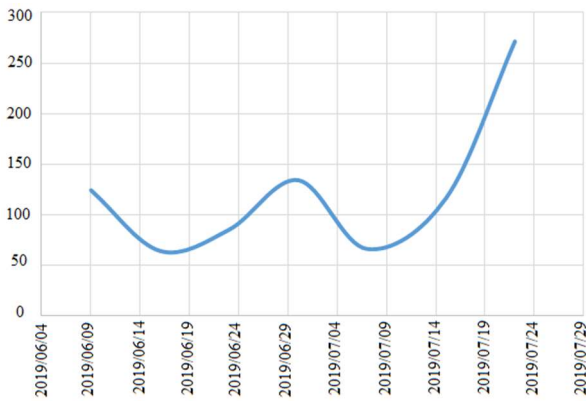


Fig. 5. Considered timeline of tweets.

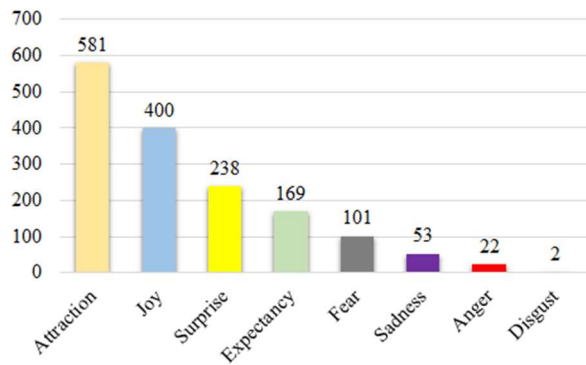


Fig. 6. Incidence of every primary emotion for English words.

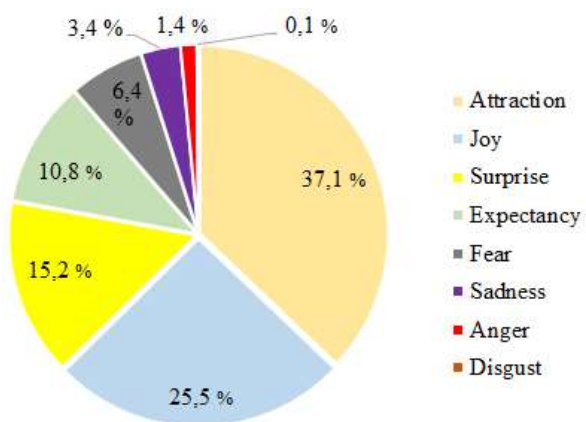


Fig. 7. Percentage distribution of each primary emotion for English words.

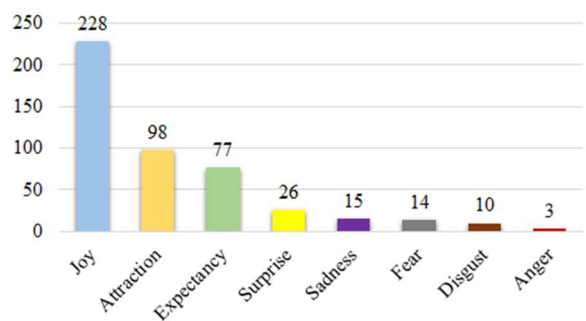


Fig. 8. Incidence of every primary emotion for Italian words.

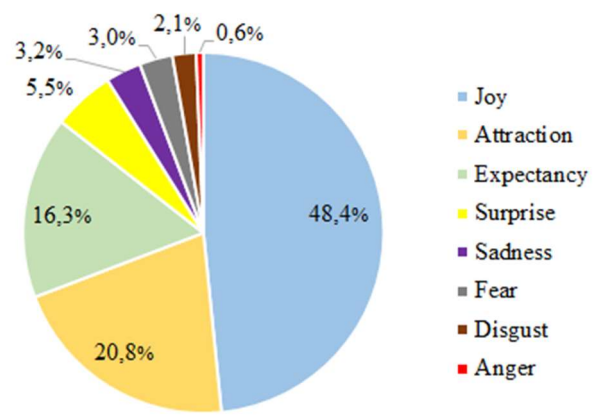


Fig. 9. Percentage distribution of each primary emotion for Italian words.

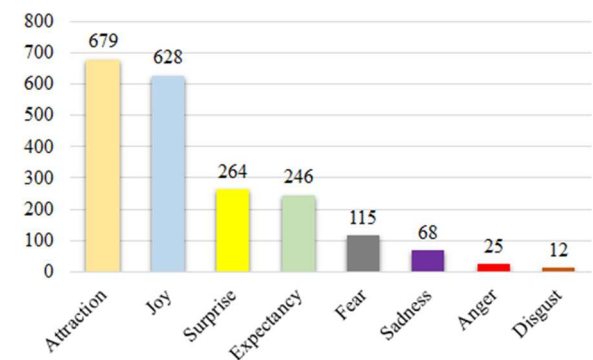


Fig. 10. Total incidence of every primary emotion for English plus Italian words.

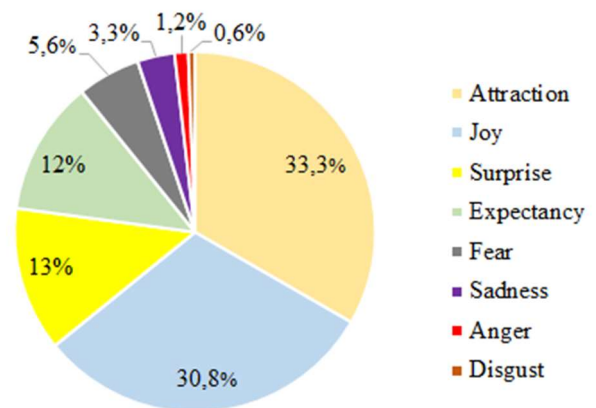


Fig. 11. Percentage distribution of each primary emotion for English plus Italian words.

It must be noted that the growth of the curve is due to the approaching summer season and the related holiday time, together with a series of cultural events, including musical events. These experiences have unquestionably turned the spotlight on the considered site and has triggered a lot of media excitement.

Regarding emotional reactions, however, it emerged that considering 1566 English words, between emotions with positive or negative valence, almost



37% express Attraction while almost 25% express Joy, as shown in Fig.6 and Fig.7.

Considering 471 Italian words related to emotional reactions, however, between emotions with positive or negative valence, it emerges that Joy is the dominant one, since it is about one half of the total, as shown in Fig.8 and Fig.9.

Considering all the English and Italian words, between emotions with positive or negative valence, it emerges that the most dominant positive emotions are represented by Attraction and Joy, as shown in Fig.10 and Fig.11.

It is therefore possible to state that the overwhelming emotion aroused by the experience of visiting the Herculaneum Archaeological Park is Attraction (33,3%) and Joy (30,8%). Negative emotions are represented in low percentages except for Fear (5,6%), which is the more frequent negative sentiment, followed by Sadness (3,3%), Anger (1,2%) and Disgust (0,6%), as shown in Fig.11.

Analysing suitably the opinions on the experience of the visit to the Herculaneum archaeological park, it is found that the more frequently used words most in the English language are represented by ‘explore’, followed by ‘amazing’ and ‘extraordinary’ which refer to feelings aroused by the attractiveness and the positive nature of the visit, as shown in Fig.12.

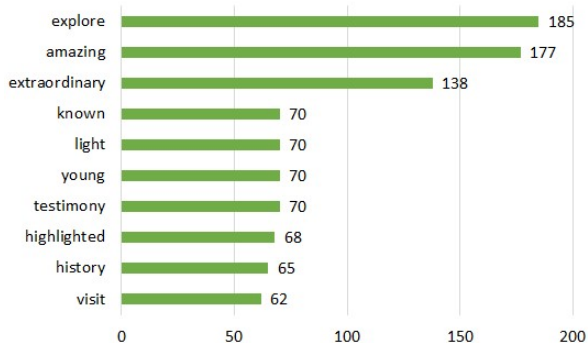


Fig. 12. Ranking of the most mentioned positive words in English.

In the Italian language instead, words like ‘music’, ‘feast’, ‘integrated’ and ‘muse’ prevail, and they are related to the different events that took place during the period of data collection, defining even in this case the feeling of full delight, as shown in Fig. 13.

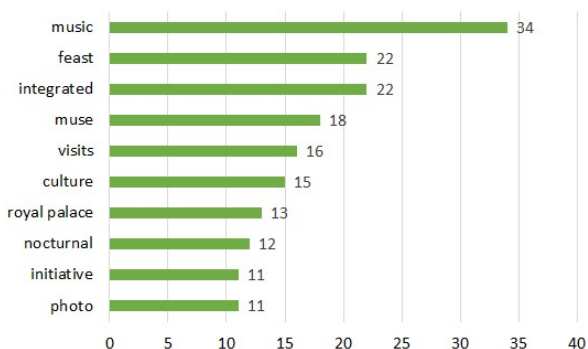


Fig. 13. Ranking of the most mentioned positive words in Italian.

The negative words most widely used by English-language visitors is represented by ‘skeleton’ followed by ‘eruption’ which, in this case, are attributable to the history of Herculaneum where are still present the skeletons of people who died due to the volcano eruption more than to the place itself, as shown in fig.14.

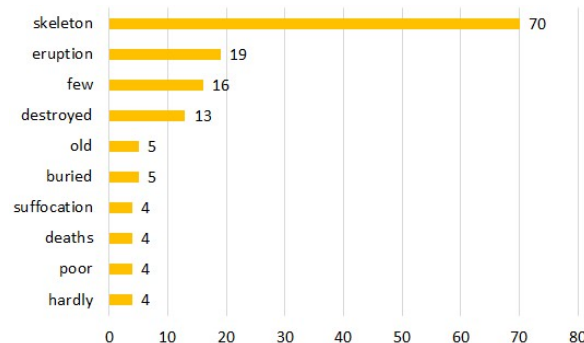


Fig. 14. Ranking of the most negative words in English.

Negative words in Italian language, as shown in Fig.15, are focused on the eruption. In fact, the first term is ‘mouse’ that is a word used in a typical Italian slang sentence to describe a terrible way to die. The second is ‘cremate’ and it evidently relates to the way the people die because of the volcano eruption.

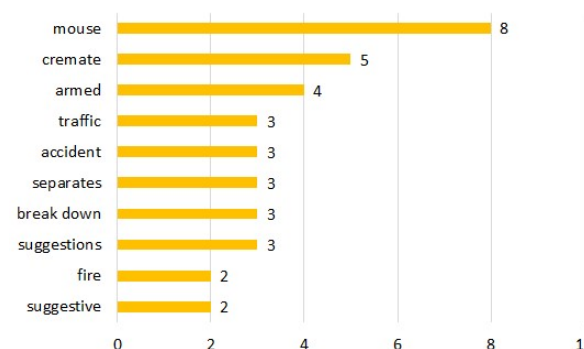


Fig. 15. Ranking of the most negative words in Italian.

Therefore, the term that is most often used in English language about Herculaneum archaeological park is ‘explore’. This underscores the pleasure and the interest with the amazement that visitors feel when they go to discover an ancient city that has been buried for centuries.

The term that is most often used in Italian language is ‘music’ and it is related to the events that took place during the period of data collecting, underscoring, even in this case, a positive feeling of visitors.

It is evident, from the obtained results, that the Archaeological Park of Herculaneum, according to visitor experience, promoted a very gratifying experience. Emotional experiences of a predominantly negative nature, on the other hand, are extremely limited: considering 2037 words, only 220 over 2037 words are characterized by this connotation and they are often referred to terrible event of volcano eruption that buried the ancient city of Herculaneum.

It pursues that the perception of risk is minimal, as all the emotions judged widely positive can confirm the absence of perceived risk, while the negative ones can be considered as a demonstration of the fear of some adverse events. In fact, it is well known that the intensity and the value of the perceived risk are deeply connected to the affective aspects. Beginning from sensory stimuli, via emotions, one is led to the perception of security as feeling-need. It is conceivable to achieve the complete lack of risk perception when the meaning of the lived experience is in total harmony with the existential expectation of the person. For this reason, if a person who visits a place can ascertain the presence of satisfactory security measures, he feels a state of absolute risk-freeness.

Furthermore, the assessment of the achieved results lets state that there is a broad sharing of positive emotions, that is not an ordinary result, and to state the existence of two general average emotions, represented by Joy and Attraction, confirming Herculaneum archaeological park to be a strong catalysing environment.

#### V. COMPARISON WITH RESULTS OBTAINED FOR POMPEII ARCHAEOLOGICAL PARK

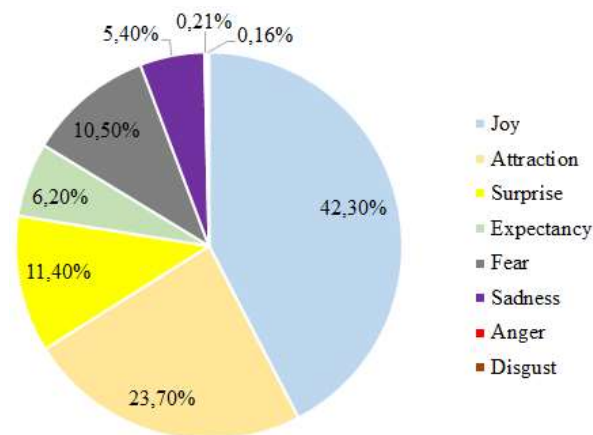


Fig. 16. Percentage distribution of each primary emotion for English plus Italian words in Pompeii Archaeological Park.

It is interesting to compare the attained results with the results deriving from a similar study done in Pompeii Archaeological Park [7], that are shown in Fig.16. As is it possible to see from Fig.16, comparing it with previous figures related to the results obtained in the present work, in Pompeii Archaeological Park (PAP) the dominant emotion is represented by Joy (42,30%) while in Herculaneum Archeological Park (HAP) Joy and Attraction are comparable and equal to about 30% each. Further, Fear in PAP is the dominant negative emotion as in HAP and Anger and Disgust are neglectable in both.

#### VI. CONCLUSIONS

In the present work, a methodology for the evaluation of risk perception within the Herculaneum Archaeological Park has been presented, providing importance to the emotional components, by means of the semantic analysis of the textual contents present in Twitter.

It represents a valuable means since it permits to have continually feedbacks about risk perception and when future actions aimed at improving effective or perceived security is done, so that it is possible to know the impact on the perceived risk and security.

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