Applying Visual Analysis Methods for Mapping Emotions Felt along Daily Trips

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Abstract. Visual analytics are tools and methods allowing the visual analysis of large sets of movement data. We here use these methods to analyze intra-urban daily trips of individuals as well as the emotion felt by the individuals along their trip. The interdisciplinary research project ECDESUP (Evaluation, Choice and Decision in the use of Urban and Peri-Urban Spaces, www.**ecdesup**.org/*)* allowed us to obtain the data via a survey done in the town of Besançon (Eastern France). The first objective was to determine if some places in the city gather a specific type of emotions (either positive or negative) with respect to the day of the week and/or the time of the day. The second objective was to explain the differences observed: are they explained by the origin or destination place, the goal of the trip, or either the time at which the trip occurred. First results obtained show spatial differentiations in the location of the emotions felt. They also suggest that neither the goal of the trip nor the time of the day can univocally explain those spatial differentiations.

Keywords: Visual Analytics, Daily trips, Emotion Maps

1. Background

The method proposed here combines the visual exploration of the information (Fekete et al. 2008) and the graphic information processing (Bertin 1977). It consists in creating an upper level of information to allowing the extraction and analysis of the relevant information and finally increasing knowledge about the concerned phenomena. Since the publication of the book of Jacques Bertin (1977), access to data and information processing are much easier. However, the basic principles and the stages of the visual processing remain of current event: defining a problematic, arranging the data, choosing the way of processing,

simplifying data (reducing but not destructing), and then communicate the results.

Nowadays, new technologies create a large amount of collected data. Recent progress in positioning and tracking technologies provides us large sets of information about mobile objects. Obviously, graphics processing has also evolved; the adapted and accepted term is now *visual analytics*. Keim et al. (2008) define visual analytics as a combination of *automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex data sets*.
Since the mid 2000's, visual analytics are used to understand specific large data sets, in particular movement data (GeoPKKD 2005, Andrienko et al. 2007, 2010, Schreck et al. 2009, Ho 2009). These researches enriched the visual analysis methods by adding the principle of aggregation (Bertin 1977). Three types of aggregation exist: spatial aggregation (**S**), temporal aggregation (**T**), and attributive aggregation (**A**) (Fredrikson et al. 1999). The choice of the most appropriate aggregation type depends on the question asked (Andrienko et al. 2010).

In the case of the ECDESUP's survey data, movement data related to individual daily trips are associated to the emotion felt during the journey. The question we try to answer is: is there a specific spatial pattern (S) of the distribution of emotions (A) along daily trips (T)?

2. Context and Available Information

2.1. Context and acquisition

During the year 2010, 250 persons have been surveyed in the framework of the ECDESUP project. All of them had their residence inside the administrative group of municipalities around Besançon called *Grand Besançon* (*Figure 1*).

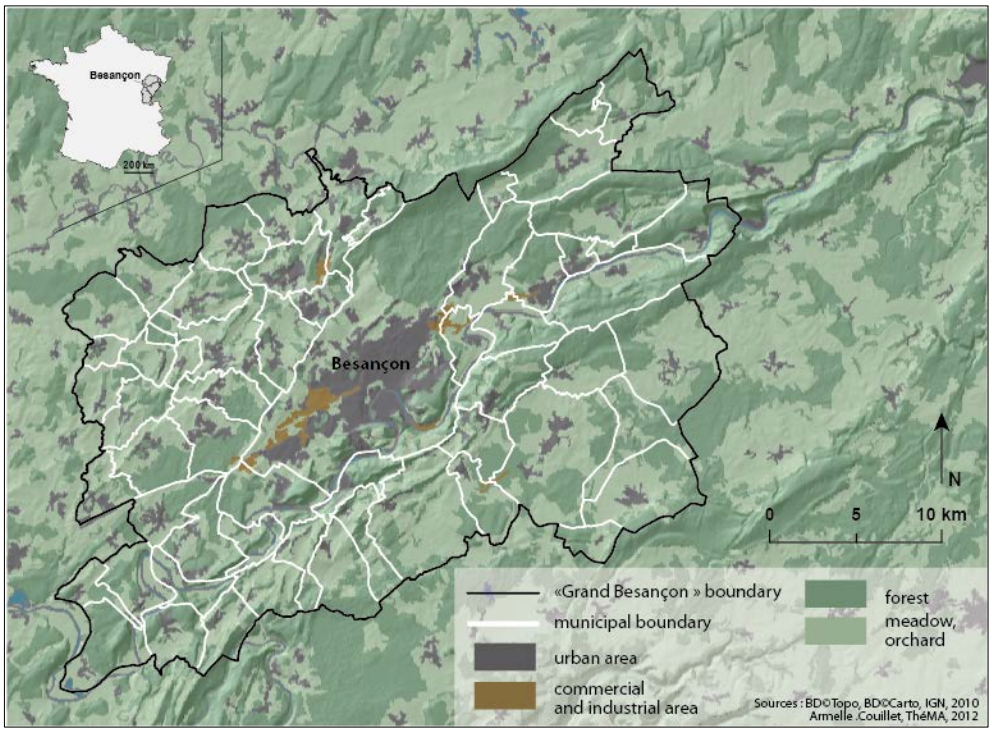

Figure 1. The *Grand Besançon* - 180 00 inhabitants among which 117 000 inhabitants are living in the municipality of Besançon.

Each individual who had agreed to participate in the survey had to report information about all of his/her trips during 7 days in a notebook; information concerned the place where the movement took place, the moment when it occurred and its duration, the purpose of the movement and the transportation mode.

Every destination must be located with more or less precision according to the choice of the persons: at least the code of the destination zone, and additionally either the precise address with the street number, or name of the street.

The hour of departure from the origin place and the hour of arrival in the destination place are informed with minute precision.

For describing the trip purpose, 42 motives were suggested grouped into eight types: family activities, shopping, social visits, medicals, administrative procedure, work, return to residence, and finally others.

Each person had also to associate a feeling to each journey. To help to choose the right feeling, a document with suggestions was included in the notebook survey (*Figure 2*). Individuals could choose another term if none of the proposed one was satisfying.

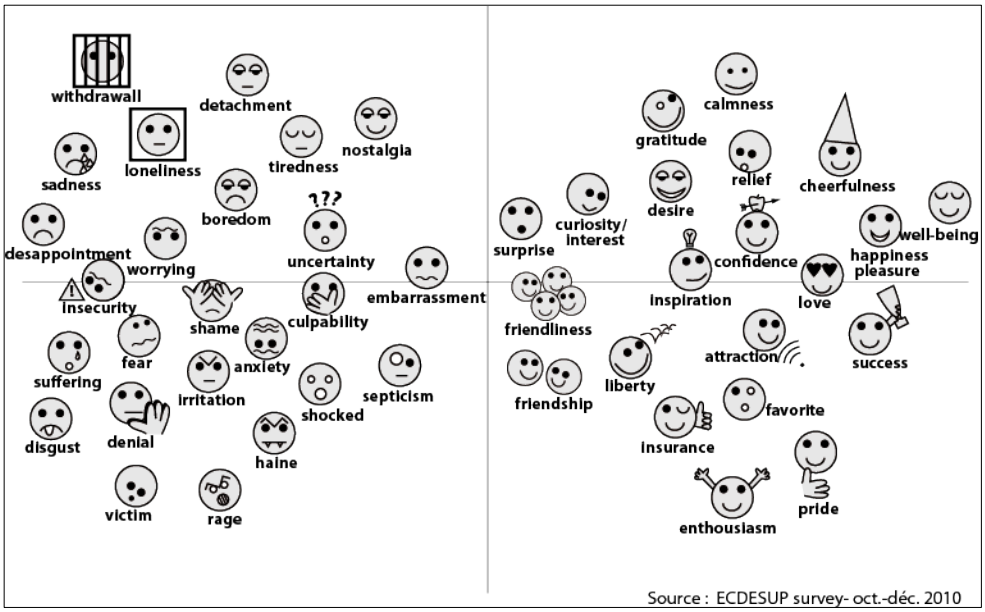

Figure 2. Emotions: in the left emotions rather negative, in the right, emotions rather positive.

2.2. Structuring Information

When inquiries were ended, information collected has been entered into a series of tables (*.xls* files): one file for one person, one sheet corresponding to one day, one raw to one movement.

Once the survey data were stored, their quality has been carefully verified. Indeed, strong thematic inconsistencies resulted of the coding process. As an example, returns to residence after midnight were often registered with the date of the day before (the date of the beginning of the evening). Many other incoherencies have been detected and it takes a quite long time to correct them. The verification and correction of the survey data is currently not finished. Hence the application presented in this paper concerns only 80 survey respondents, for which information has been checked. Results obtained are thus purely exploratory.

A unique identifier has been created for each movement: it consists of the individual identifier, *plus* the number of the day in the week, *plus* a number that represents the rank of each movement of a day. This single ID allowed

us to classify movements of each surveyed individual in a chronological order.

Finally, all registered movements of all individuals have been gathered into a single file with no risk of confusion because of the existence of this single ID.

2.3. Geolocation

Each housing as well as each destination place have been geocoded using *batchgeocodeur* (http://www.batchgeocodeur.mapjmz.com). The recovered geographic coordinates have been used to create shape files. This procedure is the first step to move further on spatial visual analysis.

Once geographic coordinates were affected to all destination places, which are at the same time origin places, destination points have been linked one to each other according to a chronological order. Links were represented as a line between each point. For every survey respondent, a line connected the frequented place x_1 of the day d_1 to the place x_2 of the day d_1 ... Finally, the place x_{n-1} of the day d_7 was connected to the last place x_n of d_7.

The line shape files were created using the *hawthtolls* extension in ArcGis (http://www.spatialecology.com/htools/tooldesc.php). Lines represent crow flies distances because we have not any information about the real path between two places used by each individual. Working on crow flies distances is appropriate because our aim is to detect feeling concentrations at a global scale. If our aim had been to highlight the location of congestion places, it would have been necessary to work with real path distances.

Finally, at the end of the geolocation stage, we obtained a map representing all the trips realised during a week by the 80 survey respondents (*Figure 3*).

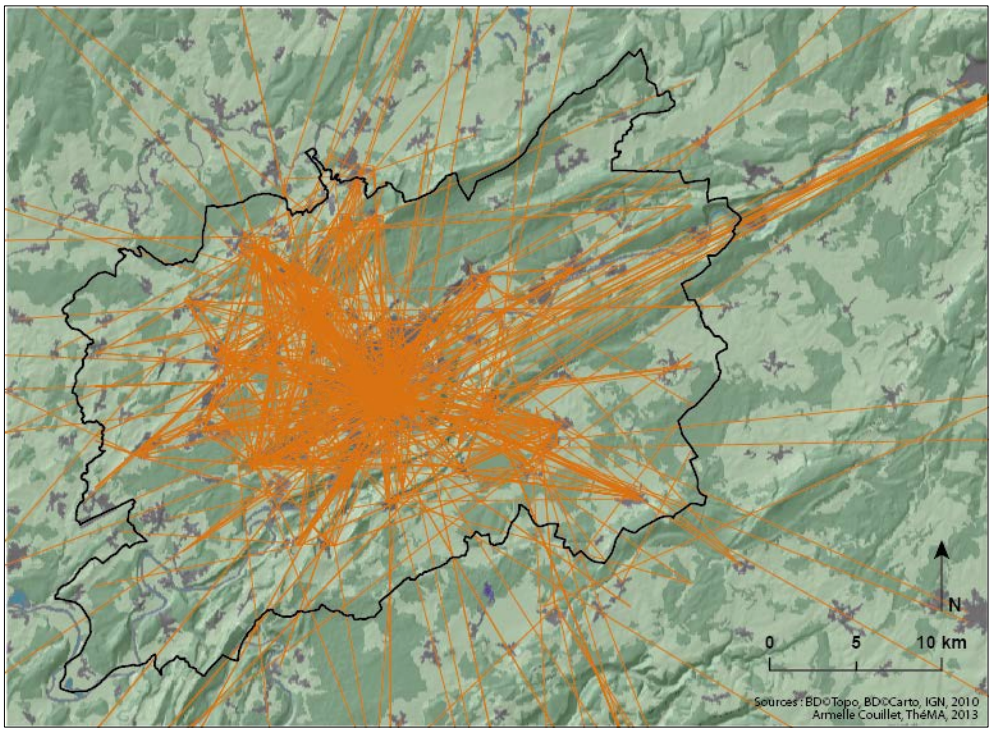

Figure 3. Mapping all the trips: information level 0.

3. Aggregation and Maps

3.1. Method

On the one hand, learning from the experience and the aggregation method developed by Andrienko et al. (2008), and on the other hand according to the method used bay Orhan (1998), we have superimposed a regular and hexagonal grid[1] on the map of all the trips (*Figure 4)*. Each grid cell has a width of 1500 m; each cell constitutes the basic structure for aggregating information.

[1] We preferred a hexagonal grid to a square one in prevision of future spatial arithmetic: a hexagonal grid allows us to achieve less calculation errors.

Each trip line representing a movement was cut according to the limits of the cells, so we obtained sections of trips. Each line section has the same characteristics as the initial trip line. On the basis of this information, it was possible to perform computations as well as spatial aggregation (**S**), temporal aggregation (**T**) or attributive aggregation (**A**), on line sections contained in each cells.

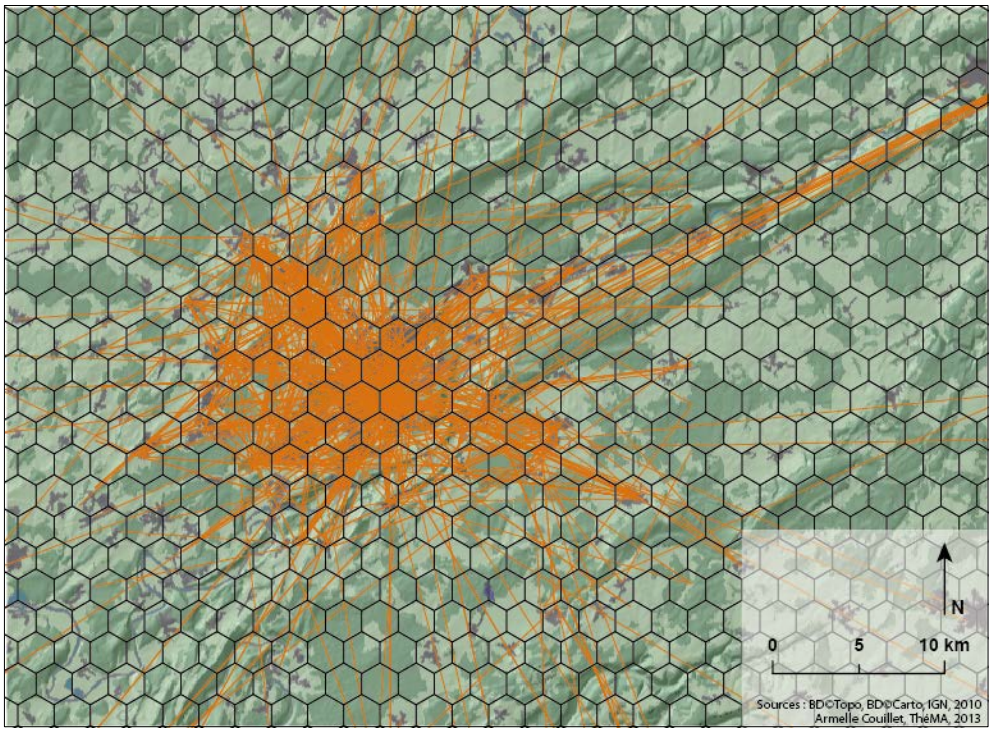

Figure 4. A hexagonal grid superimposed on the map representing the trips; lines are cut according to the limits of the cells.

3.2. Emotion maps

Using combinations of the aggregation method described above, two emotions maps have been designed (**SxA**)[2]. One concerns emotions that are rather positive (*Figure 5*); the other one concerns emotions being rather negative (*Figure 6*).

[2] Saturdays and Sundays are not taken into account because of their specificity.

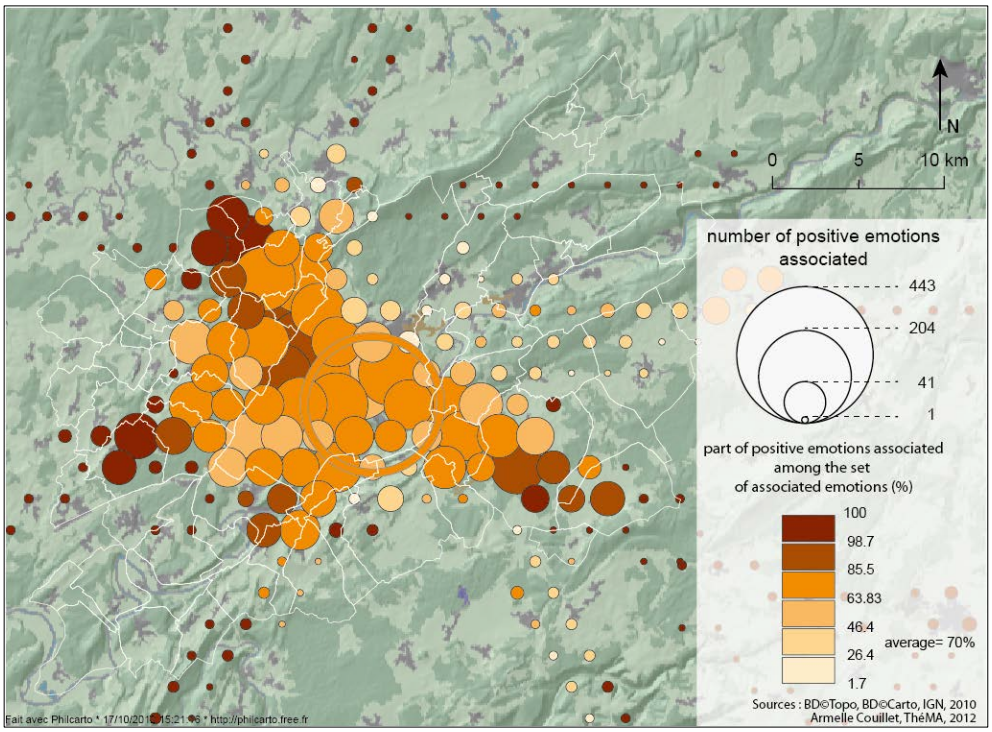

Figure 5. Location of the positive emotions associated to movements during a week.

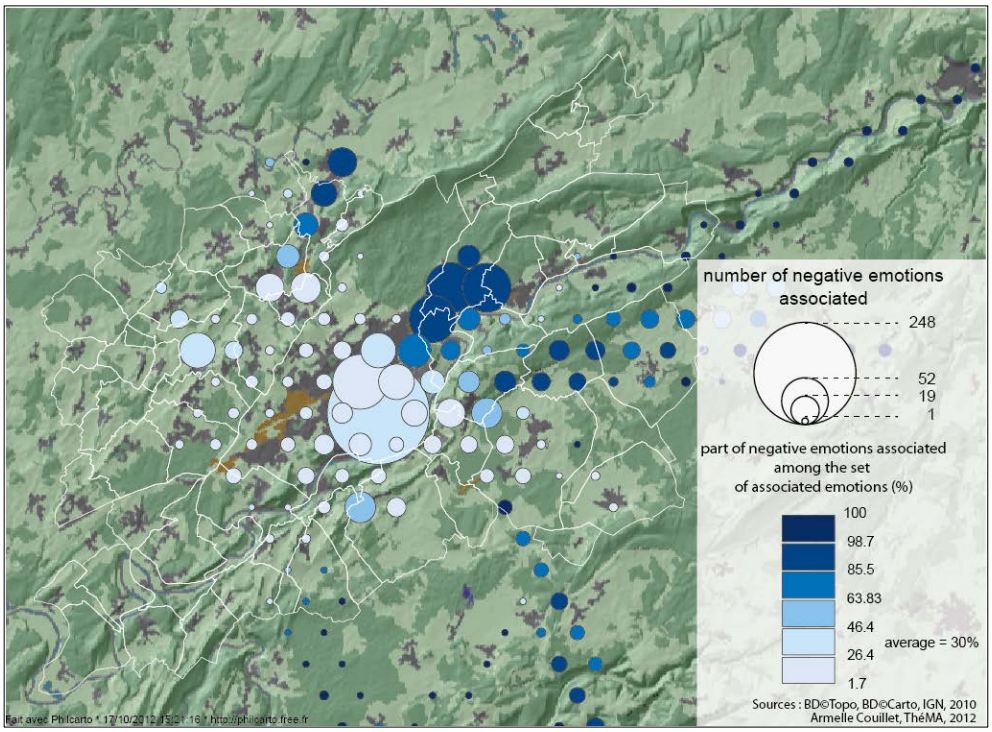

Figure 6. Location of the negative emotions associated to movements during a week.

The comparison of the two maps shows, first, that the number of positive emotions is higher than the negative one.

Moreover, the spatial distribution of the positive *versus* negative emotions is clearly different: places located to the left of a NW/SE oriented line are more affected by positive emotions than places located to the right. On the opposite, higher rates of negative emotions are concentrated on the right of the line. We can also notice that high rates (positive or negative) are essentially located on the outskirts of the studied area whereas Besançon inner city is characterized by emotions rates close to the average. Finally, we observe that the more the places are located far from the inner city, the more the feeling rates are high.

The spatial structure of the emotions associated to individual trips exhibits both a West/East dichotomy and a core-periphery organisation.

For visualizing a daily spatio-temporal distribution of the emotions associated to the movements, we used another combination allowed by the aggregation method: in each grid cell, line sections were aggregated according to their characteristics (positive or negative emotions), and the moment of the day (**SxTxA**) (*Figure 7*).

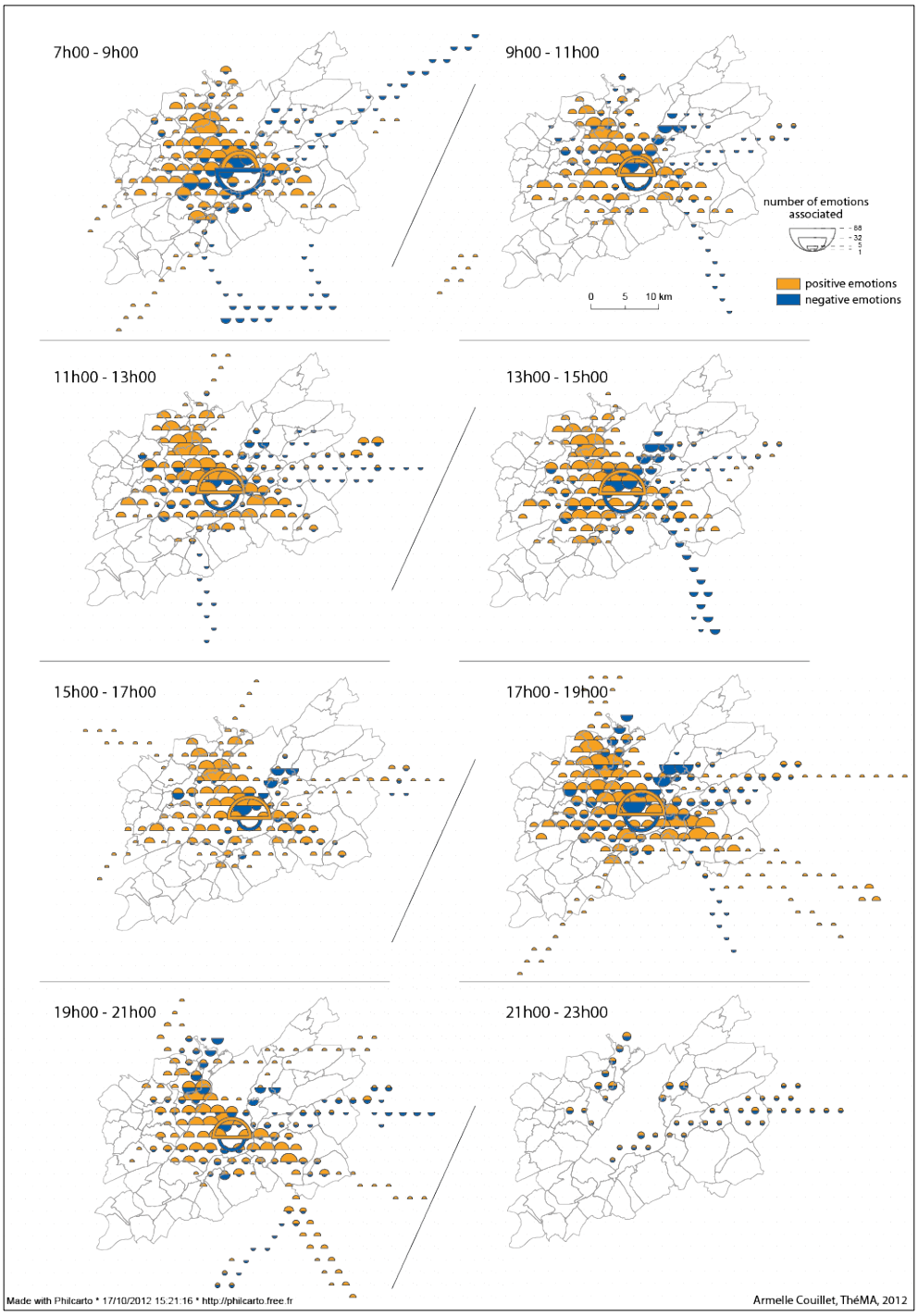

Figure 7. Daily spatio-temporal representations of the emotions associated to trips (time interval: 2 hours).

Here we considered that a two hours time interval allows us to highlight the main events that occur daily: the departure from house in the morning, the lunch break, and the return to house at the end of the day (*Figure 8)*. Later on, it would be interesting to define which time interval would be best appropriate (Antoni et al. 2012).

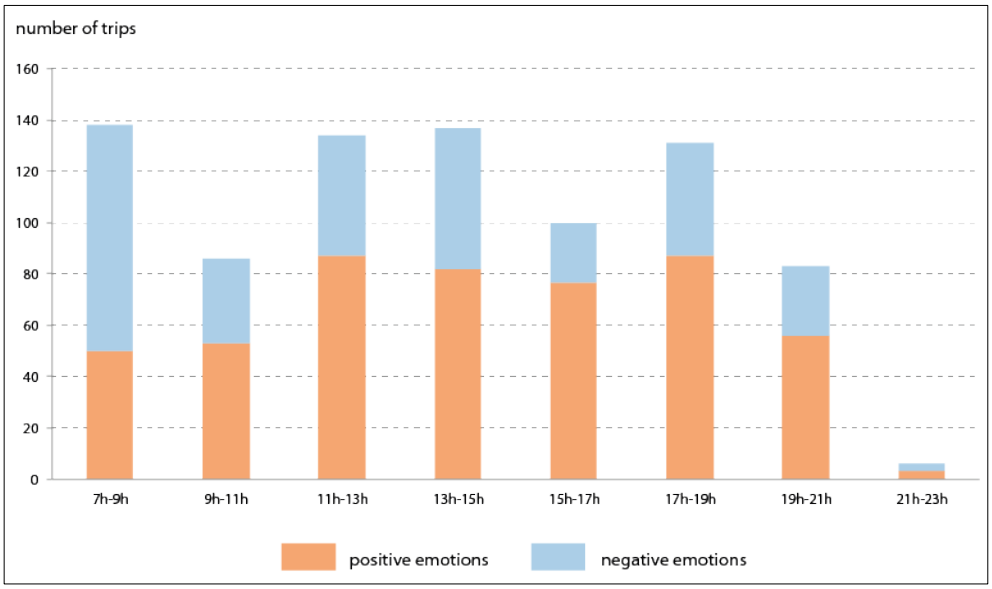

Figure 8. Daily temporal distribution of the trips.

Figures 7 and 8 also show that most of positive emotions are associated to trips from 9h the morning to the end of the day; however, this is not the case in the time interval 7h-9h. This phenomenon is clearly visible in the inner city centre of Besançon (the high number of trips that take place in the city centre between 7h and 9h probably influences the global repartition between positive and negative emotions in *Figure 8*).

The spatio-temporal distribution of emotions shows that the positives emotions have a similar organisation as observed on *Figure 5*: they are mainly located on the West of the NW/SE oriented line. Concerning the negative emotions, it is difficult to identify a specific and permanent distribution during the day although negative emotions are often located in the East. The spatial distribution of negative emotions varies between each time interval.

4. Hypotheses and Discussions

This first exploration of the survey data using visual analysis showed facts we did not suppose before: most trips are associated to positive emotions; the spatial distribution of emotions along the trips is different according to positive or negative emotions; positive emotions prevail in the West of the study area and negative emotions prevail in the East; this spatial structure appears fairly stable during the day except the city centre where most of negative emotions occur at the beginning of the day only.

4.1. A Majority of Positive Emotions

Emotions associated to daily trips are positive in most cases (60%). At this stage of the research, it is difficult to find any explanation. Nonetheless, learning from the *cognitive dissonance theory*[3] (Festinger 1957), we may assume that people cannot depreciate the place where they are living. In other words, it is difficult, for anybody, to express negative emotions about places frequented by obligation.

Next months, the cognitive scientists of the research group ECDESUP will try to verify this hypothesis.

4.2. West/East, Positive/Negative

The West/East differentiation highlighted in *Figure 5* and *Figure 6* looks like the spatial dynamics that occurs in the *Grand Besançon* in terms of demographic change and economic development. While West is growing, East is declining or, at least stagnating. Actually planners have designed the future tramway line (that will be operational at the end of 2014) in order to revitalize the East of the city.

Thus, we suggest that the area where people have their residence place may affect the way they associate an emotion to a trip. People who are living in the western area tend to associate more positive emotions than people living in the eastern area).

The analysis of the emotions associated with the place of residence allows distinguishing three types of residence areas; the western one (29 persons), the eastern one (27 persons) and the city centre (24 persons).

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[3] Festinger's cognitive dissonance theory suggests that we have an inner drive to hold all our attitudes and beliefs in harmony and avoid disharmony (or dissonance).

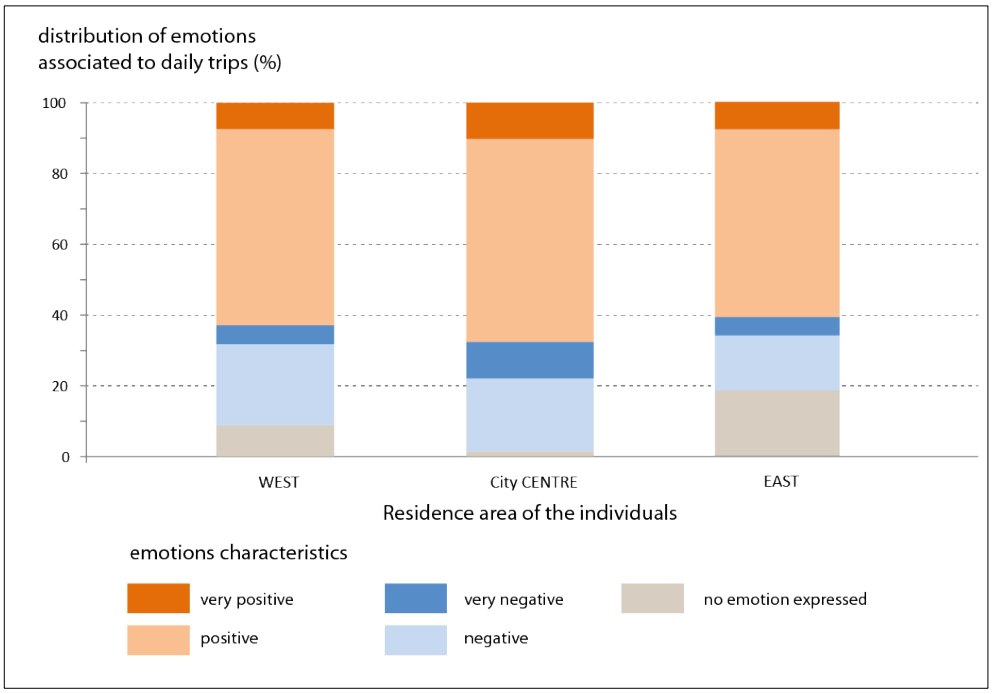

Figure 9. Emotions associated to daily trips according to the area of residence.

The distribution of emotions associated to each area of residence (*Figure 9*) shows that in any area the proportion of positive or negative emotions is not a factor that distinguishes them, whereas the existence or not of trips without associated emotions differentiates them: the city centre (1%), the West (9%) and the East (almost 18%).

One explanation could be that people who are living in the East wish not to express themselves about their emotions. Here again, it will be interesting to examine the high proportion of non-expressed emotions with the perspective of the cognitive dissonance theory.

4.3. High proportion of negative emotions in the city centre in the morning

As Besançon is the administrative capital of the region, employment in the city centre is mostly concentrated in service units such as administration departments, academic services, health services... In the morning, many employees move toward the city centre to reach their job place. We can imagine that the purpose of their trip (here going to work) partly explains the high proportion of negative emotions from 7h to 9h a. m. recorded in the city centre.

To confirm this assumption, we analysed the trips in the city centre focusing on their purpose (*Figure 10* an *Figure 11*). We designed two charts, one about the distribution of the negative emotions associated to trips that occur in the city centre all day long; the second one is the same for positive emotions.

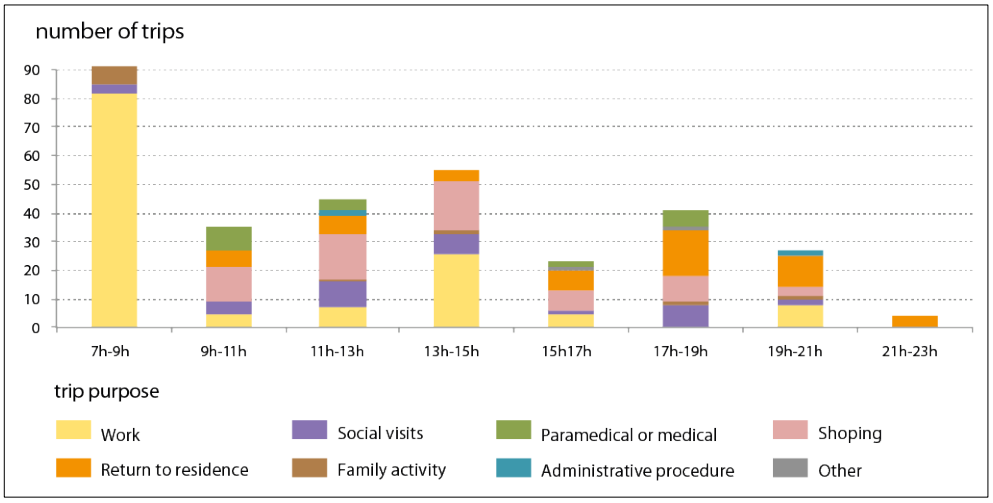

Figure 10. Trip purposes associated to negative emotions in the city centre.

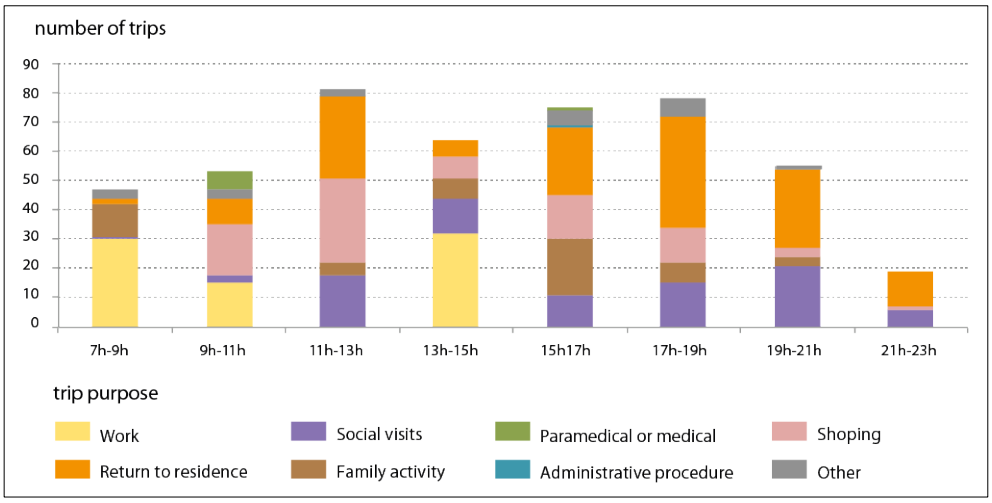

Figure 11. Trip purposes associated to positive emotions in the city centre.

These graphs allow us to verify that most of trips in the city centre are associated to rather positive emotions. They also demonstrate that the trip purpose (work) may explain the existence of a high proportion of negative emotions in the interval 7h-9h. This is one possible explanation, but

probably not the only one; for instance, the traffic in the morning may also have a role.

5. Conclusion and Perspectives

A visual analytics approach allowed us to highlight variations on spatial or temporal distributions of emotions associated to daily trips.

Regarding to the visual analytics loop from Wijk (2005) (*Figure 12*), research presented in this paper situates in the stage of exploration and analysis. Other processing methods like statistics or spatial analysis will further be useful to better understand the spatial and spatio-temporal distributions we observed above.

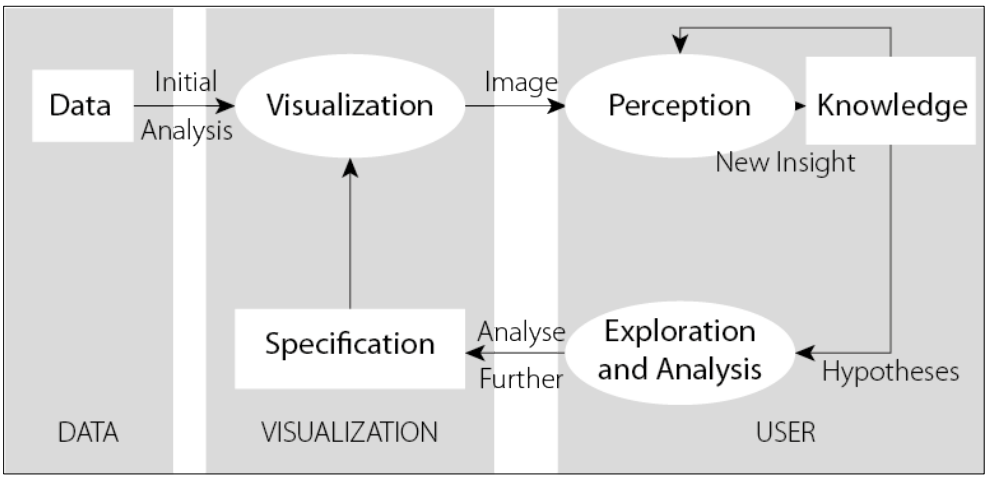

Figure 12. The sense-making loop for Visual Analytics based on the simple model of visualization (Van Wijk 2005).

Furthermore, because of the thematic, i.e. daily mobility and emotions, only an association with geographers and cognitive scientists could provide answers and explanations to the spatial structure observed on both side of the NW/SE line defined above.

To go further in the analysis of information contained in survey notebooks, we would like to distinguish emotions according to the frequency places are visited. We also would like to take into account the length of the trips and their duration, and also the transportation mode as well. We believe that these factors influence the way people associate an emotion to their trip. In order to have chances to obtain some results, we first have to locate the trips on the road and railway networks. Then we hope that we also could

study relations between the emotions associated to trips and the landscape where they take place.

Acknowledgements

This work is funded by the ANR (French national research council) (ECDESUP project) and the European Regional Development Fund (ODIT project).

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