Final Assignment

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Reviewing PNAS article titled

'Facial color is an efficient mechanism to visually transmit emotion'

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1 Motivation

For my final assignment, I've decided to analyze and comment about a recently published paper from the Spring of 2018, in the PNAS journal called 'Facial color is an efficient mechanism to visually transmit emotion'. My motivation behind choosing this paper is that it approaches a fairly easy to understand topic, which it will help me maintain my audience attention throughout my presentation, but I believe that it touches a pretty intriguing topic. Even though I might mistakenly generalize, I tend to consider that people tend to judge others' emotions solely on their spontaneous face mimic without taking into account extra inputs when releasing an opinion.

2 Context

Until now, both philosophers and scientists were considering that people can transmit emotions to one another by a certain combination of action units (an action unit is either a contraction of a relaxation of a certain facial muscle which has an observable result).

Anyway, what this paper brings into the picture is the large network of blood vessels that could be found behind each one's skin layer. This network looks like an unexplored resource of transmitting and receiving emotions to one another. Researchers' main hypothesis

was that there is a certain pattern of color for each category of emotions (or at least for positive vs. negative valence emotions) that is brought forward with the help of blood flow variations. Secondly, if there are such patterns, they would be curious to find out if the human eye could perceive them and interpret them accordingly.

2.1 Results

Throughout this article they've managed to provide proof in order to support both of their hypotheses, which are that emotions from the same category are expressed in the same manner on one's face and that people are able to identify emotions by only judging color pattern on someone's face, without taking into account action units. Therefore, they've also proven that action units and color patterns are at least partially independent.

2.2 Article's structure

This research paper discusses their work by presenting two experiments on how emotions could be separated into clusters, therefore, proving the first hypothesis, while the next two experiments are meant to support the fact that people are able to recognize emotions even without an adjutant mimic and that the addition of action units do not influence one's perception of color patterns.

3 Experiments

For the first experiment, there is used an already verified database which gathers faces with 18 different emotion types from all kinds of genres and ethnicities. It is known that emotions are shown in the same action units combination for all genres and ethnicities, so all humans have the same mimic when revealing happiness for example. Anyway, what we don't know is if all people have the same facial color patterns when expressing different emotions. Having that database, each person's face represented a contour or a convex surface which had inside multiple points each one corresponding to a facial component such as mouth, eyes or eyebrows. Having this structure, there was made a Delaunay triangulation so that each

section is associated with a portion from the blood vessels network. With the help of these regions, there could be computed the $\hat{x}_{ij}$ feature vectors. Its value has the significance that the i-th image has in that amount the j-th emotion.

The Machine Learning technique used is a linear discriminant analysis where they've separated the main dataset into training and testing subsets. They've also used the 10-fold cross-validation method in order to avoid overfitting, meaning that at the beginning we would consider that our database is composed of 10 disjoint subsets of equal sizes and for each round one of these subsets will be used for testing while the other nine will be used for training.

This first experiment was made in two manners, bearing in mind the fact that results do not depend on ethnicity. For the first one, we had 18 categories of emotions such as angry, disgusted, fearful, sad, surprised and so on therefore a random choice would have a 5.5% success rate, while their model achieved a 50.15% accuracy score. The second manner in which this experiment was ran was by differentiating only two main categories of emotions: positive and negative. For this one, the chance was one in two to successfully identify an emotion (50% success rate), but their model managed to classify with an accuracy of 92.93%.

The second experiment comes as an addition to the first one in order to identify the most distinguished emotions, therefore it runs a one-versus-all method. By stating 'the most distinguished emotions' they were actually looking for color patterns for each particular emotion since the first experiment already proven that a limited number of emotions can be grouped into distinct clusters. For the second experiment, they've trained 18 separate machine learning models, each one of them having two possible classes: the target one (which was one of the 18 emotions at a time) and all the other 17 categories together forming the non-target class. Each one of these models also used the k-fold cross-validation method in order to avoid overfitting. At the end of those experiments, the lowest accuracy obtained was for the fearfully disgusted emotion which was around 65% accuracy, and the highest accuracy was around 90% when training for the happy emotion category against all others. In the end, when illustrating the importance of each facial area with two different color channels (the

first one was blue and yellow, while the second one was green and red) it was even more obvious how each emotion has its own color pattern on the facial surface. Even though some categories, such as happiness, had almost mirrored patterns for the two color channels, when combined they would increase the overall accuracy.
This experiment was then repeated for obtaining a similar pattern but this time not for facial color, but for muscle activation. When results were put next to each other, they supported the initial proposal which stated that mimic and facial coloration is at least partially independent for transmitting an emotion. Also during this experiment, there were annotated by expert coders spontaneous facial expressions of 27 subjects. These expressions were categorized into 5 classes: neutral, happy, sad, surprised and angrily surprised by making those 27 subjects to watch a certain video which was meant to trigger those feelings. For this dataset with the previously trained classifier, it was obtained a 95.53% accuracy (in comparison to 20% random picking chance).

The third experiment from this research paper had the purpose to serve as a supporting proof for the second hypothesis which stated that people may be able to recognize an emotion on one's face only by its color pattern. Since the initial dataset had not only the 18 reactions but also a neutral face for each individual, on each of these neutral faces were layered up different color patterns but only for 6 of the 18 emotions (happy, sad, disgusted, angry, happily disgusted and fearfully disgusted). This third experiment contains two smaller ones: the first sub-experiment gives each person one pair of images colored blank faces (without eyes, mouth or any other feature), while the second sub-experiment challenges the player even more by making him choose a blank face as in the previous case but between six options. The process for the 2-choice experiment consisted of 6 blocks, each one of them having 20 trials in total. Let us say that we are at the j-th block and it is known what category of emotion we are looking for. For this current block, each person has 20 trials during which the following process is repeated: for 500ms they see a so-called mask (a completely black screen), for the next 500ms there is the fixation phase where there's a cross right in the center of the black screen and afterward the two faces appear. For fifty percent of those

trials, the image from the targeted class is found on the left side and the paired image is randomly chosen from the other 5 possible emotion categories. On the other hand, for the 6 choice experiment, the two initial phases from each trial no longer exist and each subject has to choose from all of the 6 categories the one which seems the most appropriate for the given color pattern.

For both of these sub-experiments, each player had to press one key for each response. Also, the results showed that for the 2 choice version the accuracy was over 80% which is a lot better than the random alternative which had 50% success rate and for the 6 choice version the experiment gathered an approximately 33% accuracy. One notable finding is that the lowest accuracy for the 6 choices experiment percentage was found for the happily disgusted category which was frequently mistaken for happy. Furthermore, when addressing the question of positive versus negative valence for several colored face images the accuracy was more than 75% (if we would consider positive emotions happy and happily disgusted and negative all the other ones).

For the fourth and last experiment, the researches wanted to focus on how color patterns are at least partially independent from the action units patterns for each emotion. Therefore they've created two additional datasets for later use on testing their hypothesis. The first dataset consisted of adding on each expression for all of the 184 individuals the corresponding color pattern, while the second dataset was made by adding color patterns from non-target classes to each initial dataset image. After forming these two new datasets, the researchers used one of the methods used for their third experiment. They've given each participant the 2 choice experiment following exactly the same pattern with the 6 blocks, each one with 60 trials this time where they would firstly watch a black screen for 500ms, followed by the one with a cross in the center for 500 more ms and in the end they would have to choose by pressing a key which of the faces (this time with action units activated, checks, mouth and all the features in place) better fitted the emotion targeted by the current block. This experiment's results were also better than randomly picking an answer. Moreover, when repeating the same experiment on positive versus negative valence the accuracy score was

approximately 85%. As a conclusion, with this final experiment it was proven how color patterns can still be perceived even when there were added activated action units.

4 Future development

Since the beginning of times it was believed that only facial muscle contribute to transmitting emotions to another being, but this paper had the major contribution of bringing forward a secondary mechanism of expressing emotions. This mechanism comes as an addition to the already recognized way with no wish of replacing it.

4.1 Other results in favor

From Biology one may know that our eyes have several stimuli interpreters inside the retina which are activated by motion or, in our case, by colors. Therefor, even in our own eyes, there are two distinct networks that take care of these two independent processes, motion and colors.

Another helping argument for the newly discovered mechanism of transmitting emotions comes from the facts that us humans are the only specie that has no facial hair, thus being able to take advantage of how our blood flow through different portions of our face. Also, it is believed that this mechanism was one of our features developed through evolutionary forces.

4.2 Questions raised

With this newly gathered information, the first question that comes in everyone's mind is if there are other color patterns not yet associated with an emotion. Also, if there are other frequently encountered patterns, what emotions do they express? Are there multi-valued valences for emotions or are we still limited two positive and negative valences? These questions could be answered by pursuing research into the field of brain perception analysis and how are pathways from brain to blood flow intensity created.

Another field that may be drastically influenced by this article is related to Computer Vision

in general. All the current models should be updated to take into account not only activation units, but also color patterns and these changes should impact branches such as human-robot interaction.

Furthermore, Psychopathology always encoutered the issue of misclassifying emotions, but they've never taken into consideration color patterns until now.

4.3 Influence in Arts

Humans practicing arts in general were stating how color solely can influence emotions. One of the most eloquent example is Mark Rothko, a painter whose works of art consisted only of blurred block of colored rectangles in different positions and shapes. Thus, this paper comes to aid in better understanding both his and other artists' works in general.

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