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Cognitive dissonance and social influence effects on preference judgments: An eye tracking based system for their automatic assessment ☆

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ABSTRACT

Researchers have investigated the social influence on the human decision making process. Social pressure and individual cognitive dynamics are complex variables in decision making that can give very useful insight in predicting human behavior. This is also useful in exploiting important factors that can be embedded in ICTs in order to equip them with human cognitive-inspired features. By tracking eye movements and measuring reaction times, we investigated the decision making process made when asked to rate two photos against each other. We manipulate the social information available to participants: no information (blind), information about responses of other participants (others), and information about responses of the community of friends of the participants. In particular the investigation of the social pressure effects (e.g., In–Out group bias and cognitive dissonance effects) on the human decision making represents an inspiring perspective of research for several domains. In this paper we demonstrate how this approach allows us to investigate both, the decision making process at individual level, and the role played by the social dimension. The possibility to create a formal model of these processes can give very useful clues and inputs to the ICT domain. On one hand, the computational modeling approach could allow us to predict the behavior of human people in order to optimize the interaction between users and ICTs. On the other hand, this new understanding can allow computer scientist equip technological systems with some interesting features that characterized the human cognitive system towards the Self-Awareness in autonomic centric systems.

1. Introduction

From the classical Sherif (1936) and Asch (1956) experiments on conformity, social influences on human decisions have been described by a broad literature (Cialdini and Trost, 1998). Empirical evidences support human conformity to group pressure, (i.e., people tend to do what others are doing). A variety of factors related to the pressure of others influence decisions: unanimous opinions, task difficulty or task importance (to name a few). These enhance the conformity effect whereas private responses (compared to public, face-to-face) are associated to less social influence (Cialdini and Trost, 1998). Moreover, the In group and the Out group dynamics are very relevant factors affecting social in conformity (Cialdini and Trost, 1998). People are more prone to be influenced in their decision by a group that an individual who belongs to group (the In group) compared to a group of people that an individual neither belongs nor he or she identifies with. In this manuscript, we investigate social influences in esthetic judgment manipulating the In group/Out group dynamics. Social pressure has been investigated in a variety of perceptual tasks (such as determining which line is longer) but few researches have been conducted on esthetic judgments. With expression esthetic judgments we intend a task requiring a subjective opinion about which object or element a person prefers on personal basis. Such a task is less affected to the conformity phenomenon compared to more physical and objective judgments (Cialdini and Trost, 1998). We employ this esthetic judgment task along with other factors that alter the social pressure effect. Measuring reaction times and ocular movements can help to investigate different processes behind a decision (Bednarik and Tukiainen, 2006; Hayes et al., 2011). In order to investigate how opinions are influenced by peers and community structure, we have developed a web application

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called PhotoRating. The PhotoRating application shows a series of photos by pairs and let the participants select their preferred one by sliding a cursor toward the chosen photo. Positioning the cursor at the extreme left means a strong reference for the left photo and vice versa. The average rating score from previous participants (or from friends of the current judge) was shown to the participants. Reaction times and ocular movements are recorded. Through this application it is possible to investigate both the influence of others choices on individual judgment and the cognitive processes that lead to that decision. We present an experiment about esthetic judgment employing this application. The main idea behind this experiment is to investigate through reaction times and ocular movements how social influence (i.e., In-group Out-group effect) conditions the esthetic decision. Moreover, this task can also give insight about what is going on in the individual cognitive system. In particular, we can suppose that an individual participant can experience a cognitive dissonance effect (Festinger, 1985). With this expression we are referring to a feeling of discomfort that rises in a person when he or she simultaneously holds two conflicting cognitions (Cooper, 2007). Regarding the PhotoRating task we suppose that when a participant has to make a decision (i.e., to decide what image he prefers), he is exposed to the social influence in different ways. Such an exposure can be represented as a factor affecting the cognitive process of the task, altering or even disruptively changing the process itself. The In–Out group bias effect and the cognitive dissonance represent fundamental factors that can help us to investigate not only social decision processes but also the individual organization of the human cognitive system. Understanding how these two levels (the individual and the social aspects) work (though the measure of reaction times and ocular movements) in a decision task can give new insights. The possibility to create a formal model of these processes can give very useful clues to ICTs (Cook and DasSmart, 2005). On one hand, the computational modeling approach could allow us to predict the behavior of human people in order to optimize the interaction between users and ICTs. On the other hand, these new insights can allow computer scientist in equipping technological systems with some interesting features that characterize the human cognitive system.

2. Experiment

We employ the PhotoRating task in order to investigate different cognitive processes behind an esthetic judgment influenced by different levels of conformity. The experiment provided three setups: blind, others and friend. In the Blind condition, no administered ratings were informed to the participant, i.e., the average rating score was not shown on the screen. Others condition showed the average position of the cursor of previous participants. Finally, the Friend condition provided individual friends rating. From the conformity effect perspective, we can expect that in the Friend condition participant will be influenced from the rating of their friends. Since in the others condition an individual observes the average rating of previous participants (unknown people), we can expect a lower influence of the conformity effect. The blind condition should represent a baseline in which the choice between the two photos is not influenced by social information. However, the PhotoRating task is characterized by some factors that weaken the conformity effect. So it could be that average rating of previous participants and rating of friends do not influence the decision of the observer. We think that although there are no differences in participants response, our methodology can shed light about how people evaluate social information.

2.1. Procedure

Eighty students of the University of Cambridge were recruited and have participated in the research. All were instructed at the beginning of the experiment in the same way about the usage of the devices (i.e., the laptop used to acquire the data, and the eye tracking system), and the dynamics of the experiment. The experiment consists of a set of 40 pairs of photos which are displayed one pair at a time. The participant is asked to indicate which of the two photos in each pair they prefer using a bar. Clicking far to the right on the bar indicates they greatly prefer the right hand picture, and slightly to the right indicates they slightly prefer the right picture. The position clicked on the bar is then transformed into an integer value ranging between 0 and 100, with 0 corresponding to greatly preferring the left hand picture and 100 corresponding to greatly preferring the right hand picture. Once the participant has rated all 40 pairs, the pairs are displayed in a different order, but now the average of all participants is calculated for each pair and displayed. The average that is calculated is derived from an average of all 3 phases of the experiment for all participants, i.e., so the average is actually changing in every experiment, nevertheless we got into account just the shift produced by the information delivered to the participants, instead of the absolute value of the rating. Noteworthy, the first participant was administered with a random generated information about the others ratings. Note this is not the average of just one of the phases, but an average of all the ratings made on this pair of photos. The participant is asked to rate all of the 40 pairs again with this extra information available. Finally, the 40 pairs are displayed again, but now the average of all 3 phases for the people in the participant's friend group is displayed. Again this average is calculated by taking all of the ratings made in each phase, but only for the people in the participants friends group.

The eye tracking data was been collected using a Tobii X20 Eye Tracker, with preliminary data analysis under- taken in Tobii Studio and further analysis performed in MATLAB (Bednarik and Tukiainen, 2006; Hayes et al., 2011). The eye tracker was placed so that the distance between the participant's eyes and the eye tracker was about 70 cm, and the maximum vertical angle that the screen made from the participants view was less than 35°. The eye tracker can only detect fixations made by the eye, and not the peripheral vision. To determine the point when a photo rating was made, the clicking made by the participant was tracked. A box was defined around the input bar that they used, and when they clicked inside of it this counted as moving on to the next photo, ending the current rating interval and beginning a new one. By defining time intervals like this, the eye tracking data can be split down so that there was eye tracking data for each pair of photos rated. For each interval there were two main paths of analysis that could be followed, one that focuses on the spatial distribution of the eye gaze and one that looks at the temporal information. The spatial information describes the amount of time that the participant looks at specific parts of the experiment, while the temporal information shows the flow from one point of interest to the next (Fig. 1).

2.2. Data analysis

In order to investigate the experimental hypotheses delineated in the introduction, the experimental log files have been exploited extracting (or mining) and defining 7 observables as order parameters (i.e., dependent variables). From the log file produced by the eye-tracking system (Fig. 2) we extracted 4 dimensions describing the gaze's dynamics characterizing the subjects' inspection of the picture during the rating. Such variables are the

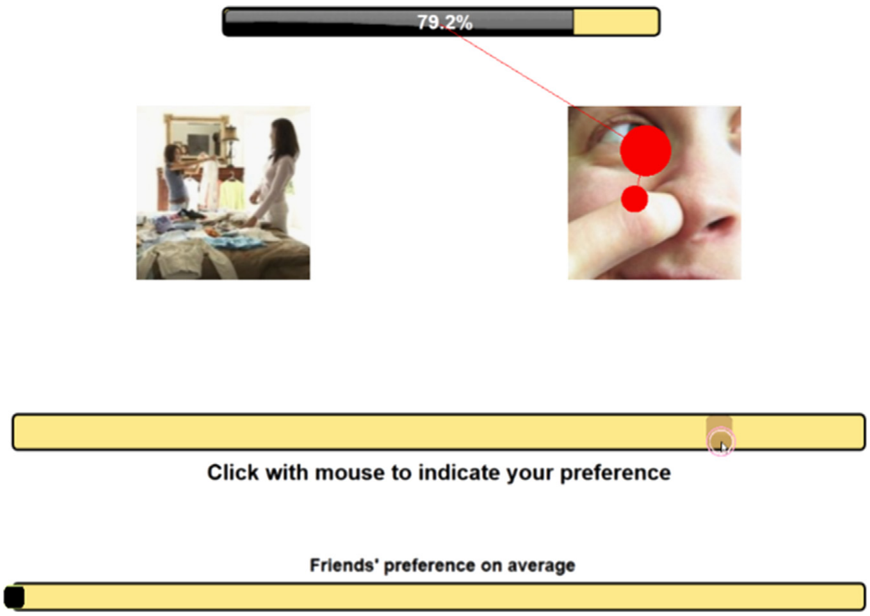

Fig. 1. Experimental task. Participants were shown two pictures and asked to indicate their preference on the bar. Other participants rate is also shown.

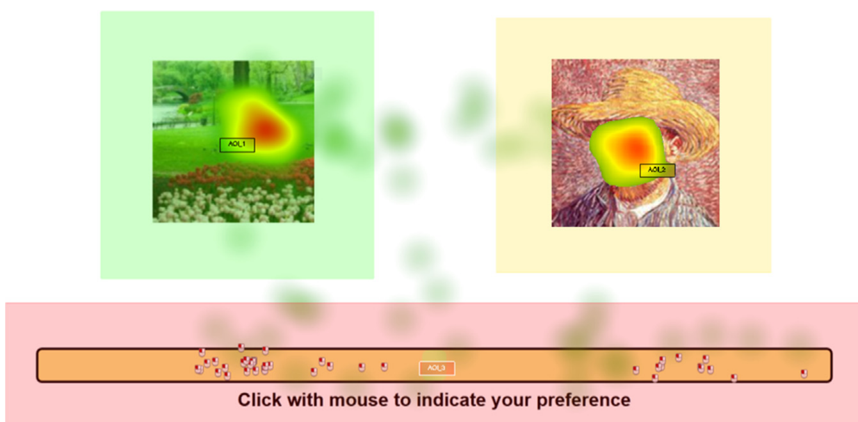

Fig. 2. Tobii X20 Eye Tracking analysis example. We can see the spatial distribution of the eye gaze over the two pictures (color red means that more looks in that particular point and various looks at the rating bar). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

number of looks that a subject i gives to an image j, (L_j^i); the time spent inspecting the image j, (T_j^i); and the number of looks given to the preferred image k (L_k^i, i.e., the image that will be selected by the subject at the end of the choice), and the time spent on the preferred image (T_K^i). The last 3 order parameters have been defined starting from the subjects' ratings (R_j^I), which have been used to compute the average rating score ($\overline{R}_j$). Finally comparing R_j^i and $\overline{R}_j$ we defined the Conformism of the answer by the following equation:

$$\delta R_j^i = \begin{cases} 1 & \textit{if both } R_j^i \, \& \, \overline{R}_j \textit{ are } < \textit{or} > 50 \\ 0 & \textit{Otherwise} \end{cases} \quad (1)$$

The only control parameters considered in this paper (i.e., independent variable) were represented by the experimental condition (i.e., blind, others and friends) within the subjects who were asked to perform their ratings. Such empirical dimensions have been preprocessed assessing the consistency of the statistical properties required to run the inferential analysis (i.e., distributions' skewness and kurtosis, homogeneity of the examined variances, and balancing or bootstrapping of the groups size). Finally the order parameters were analyzed using the analysis of variance method (i.e., ANOVA) in order to reveal statistically significant differences between and among the experimental conditions. The challenge was to investigate the theoretical effects predicted in the introduction (i.e., the In–Out group bias and the cognitive dissonance) within the experimental data.

3. Results

The analysis' outputs of the experimental data can be organized in two different sections, concerning the eye tracking dynamics of the choice (A), and the differences related to the experimental condition regarding those features concerning the cognitive processing affected by the In–Out group effects on the decision making processing, and the effects of the cognitive dissonance on the Conformism tendency (B).

3.1. Eye tracking indicators of liking

The inspection of Fig. 3 reveals how the dynamics of the visual exploration of the two images, reported on the x-axis as Left and Right pictures, substantially flip depending on the winning (i.e., the preferred) image. The effect is statistically significant, as reported in Table 1, indicating even a greater magnitude of the

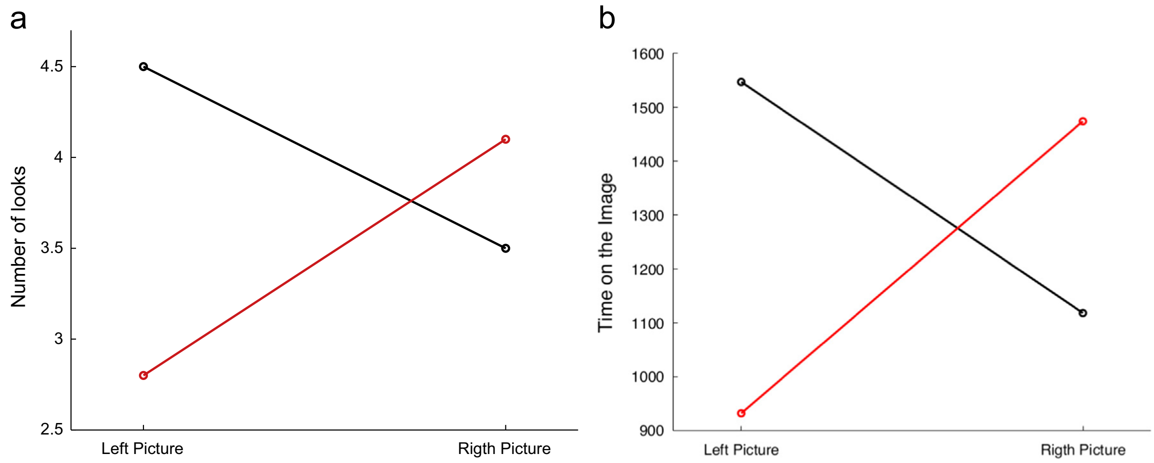

Fig. 3. Relation between what participants observe and their choice. (a) Number of looks at the left picture (black line) or right picture (red line) when they choose left or right picture (on the *x*-axis). (b) How much time is spent on the left picture (black line) or right picture (red line) when they choose left or right picture (on the *x*-axis). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1
Analysis of variance between preferred and unpreferred pictures.

Preference	Number of looks		F	Looks duration (s)		F
	Left P	Right P		Left P	Right P	
Left Picture	4.5	3.5	49.5*	1547	1118	87.5*
Right Picture	2.8	4.1	101.6*	932	1474	141.9*

* $p < 0.01$.

effect when the preferred picture is the right one ($F=101.6$) with respect to the left one ($F=49.5$). The same trend can be revealed with concern to the inspection time of the two pictures ($F=87.5$ versus $F=141.9$) and it is probably due to the occidental reading style (i.e., from the left to the right), even because the oriental subjects were a little percentage of the total. The analysis indicates that the picture which is selected as the preferred one, at the end of the rating, is always observed more times and longer than the others (Table 1).

3.2. *Same choices but different cognitive processing: the conformism case*

In order to determine the effect of the experimental condition, namely the In–Out group bias effect predicted by the psychological theories, we first have compared the probability to get a conformist or an anti-conformist choice along the different conditions. The results show that no statistically significant effects are revealed with concern to the qualitative decision (Fig. 4), as well as assuming the rating as a continuous variable by using the parametric approaches.

Despite that the final decision always appears as unaffected by the experimental condition, the same does not happen for the others observables, suggesting how different cognitive processes could characterize the different experimental phases and the dynamics of the different choices. In particular, Fig. 5 shows the statistically significant differences emerging, whenever the dynamics of the visual scanning of the preferred images along the different experimental conditions is taken into account. The Friends condition is always characterized by the smallest value (i.e. with respect to the number of looks and the time spent on the preferred image). This effect suggests that the In-group bias would help/make the decision process faster. On the other hand, the others phase ranks always between the Friends and the blind phases. The only difference between the Friends and the others

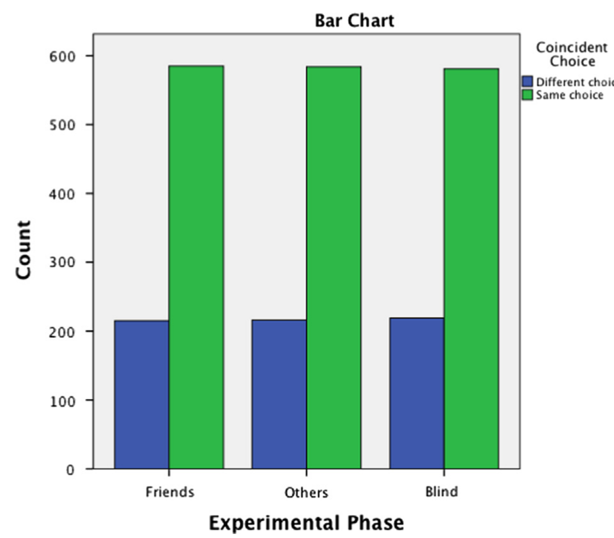

Fig. 4. Number of anti-conformist (blue bar) and conformist choices (green bar) in the three experimental phases (friends, others, and blind). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

conditions is with regards to the time spent on the preferred image, while no statistically significant differences emerge with respect to the number of looks given to the images. The blind condition appears as the more time expensive, as well as the condition in which apparently the subjects pay significantly more attention to get a decision (Table 2).

Table 2 summarizes the magnitude and the statistical significance of the model generated by the ANOVA approach to the data. The significance of the general model indicates that the subjects probably adopt different approaches to the decision making process they are facing along the three different conditions, either for the inspection duration ($F=122$, 70, $p < 0.01$), or for the number of the inspection looks ($F=83$, 66, $p < 0.01$). The Scheffe analysis has been adopted to evaluate the principal effects between the single experimental conditions, both in terms of significance and magnitude of the effect.

A most complete scenario emerges if we combine the dynamics of the choice (i.e., the eye tracking variables) with the Conformism of the given rating/choice. In more detail we have considered only the variables regarding the inspection of the preferred image (i.e., the image selected as the preferred one at the end of the rating) as

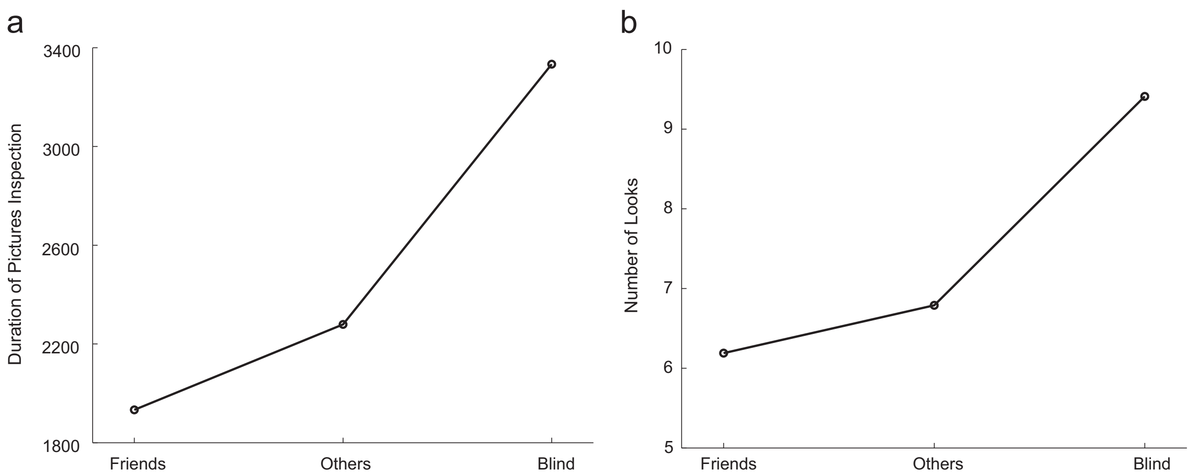

Fig. 5. Relation between experimental phases and temporal/spatial characteristics of the decision process. (a) Experimental phases (friends, others and blind) on the *x*-axis and the duration of pictures inspection on the *y*-axis. (b) Experimental phases on the *x*-axis and the number of looks on the *y*-axis.

Table 2
Analysis of variance between the experimental conditions with respect to the duration of the average picture observation.

ANOVA: General model			
Variable	Sum of squares		*F*
	Between groups	Within groups	
Inspection duration	4.26×10^9	3.47×10^7	122.70*
Inspection looks	2336.6	27.9	83.66*
ANOVA: Principal effect (duration)			
Comparison		Difference (ms)	Scheffe
Friends vs blind		−1400	$p<0.01$
Friends vs others		−3466	$p<0.01$
Blind vs others		1054	$p<0.01$
ANOVA: Principal effect (looks)			
Comparison		Difference	Scheffe
Friends vs blind		−3.2	$p<0.01$
Friends vs others		−0.6	ns
Blind vs others		2.6	$p<0.01$

* $p<0.01$.

dependent variables, introducing as factor under scrutiny the Conformism of the answer. As a consequence we obtained two new experimental conditions, the former, labeled as Anti-conformism, is represented by the cases in which the subject selected the images which were opposite to the average choice, and the latter, labeled as Conformism, when the subject selected the same image. In order to compare the two conditions, we extracted two subsamples from the original dataset by a bootstrap method, in order to obtain two groups of the same size for the ANOVA analysis. In Fig. 6 the functions representing the three experimental conditions, for the number of looks, as well as for the time spent on the preferred image are reported with different colors. The functions appear as linearly separable, and this feature makes more robust than the previous result about the In–Out group bias. Within the Friends condition, the time spent on the preferred image, as well as the number of looks given to it, is always smaller than the others, even splitting the cases analyzed in the previous paragraph in two subgroups. Moreover, for the others two conditions the structure of the statistical relationship also reproduces the general analysis presented in Table 2.

Nevertheless, Fig. 6 shows another interesting feature regarding the angle defined by the functions, namely the difference between the Conformist and the Anticonformist cases. As we know such a difference can be connected to the cognitive dissonance following the Festinger legacy (Festinger, 1981). In other

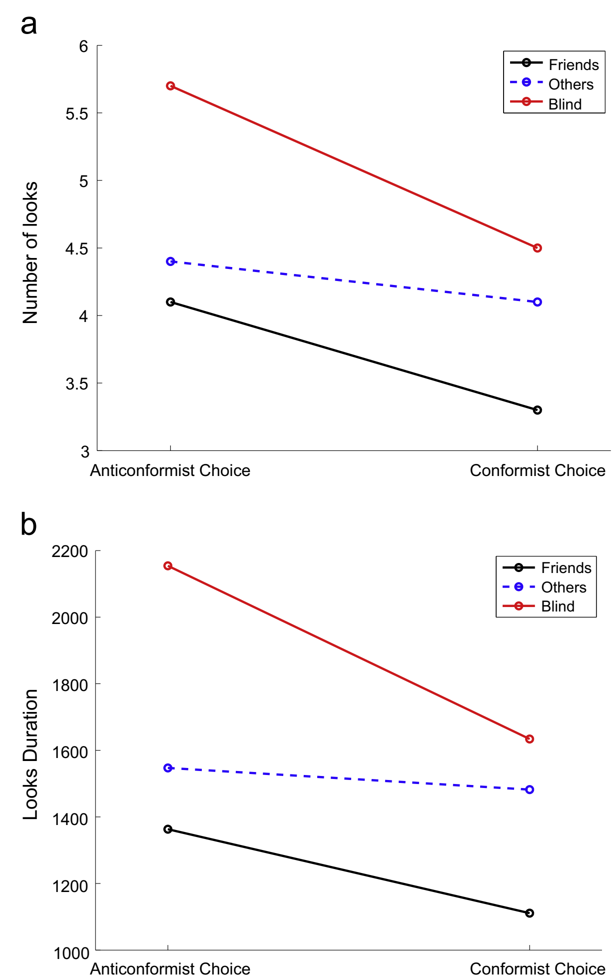

Fig. 6. Relationship between choice and temporal/spatial characteristics of the decision process in the three experimental phase (black line for friends, blue line for Others and red line for blind phase). (a) Kind of choice (anti-conformist and conformist) on the *x*-axis and the number of looks on the *y*-axis. (b) Kind of choice (anti-conformist and conformist) on the *x*-axis and the duration of looks on the *y*-axis. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

words, while the differences among the three functions put in evidence the In–Out group bias, the angle characterizing the single function reveals the magnitude of the average cognitive

Table 3
Analysis of variance within the experimental conditions with respect to the dynamics of decision making for the preferred picture.

ANOVA: Number of looks to the preferred picture			
Exp. condition	Sum of squares		F
	Between groups	Within groups	
Others	8.1	9.2	0.87
Friends	65.1	9.3	7.01*
Blind	142.76	11.7	12.22*
ANOVA: Time spent observing the preferred picture			
Others	4.24×10^6	1.22×10^7	0.35
Friends	6.17×10^7	1.02×10^7	6.06*
Blind	2.82×10^8	1.65×10^7	17.08*

* $p<0.01$.

dissonance associated to the choice (i.e., conformist or anti-conformist). It is obvious how the blind function appears as characterized by the greater difference between the two conditions, while the Friends condition shows a lighter difference, and the others condition seems to report a null magnitude of the effect (Table 3).

The ANOVA conducted on the data actually supports the esthetic evidences in Fig. 6, and in particular confirms the blind condition as the phase in which the magnitude of the effect is significantly greater both, for the number of looks ($F=12.22$), and for the time spent on the preferred image ($F==17.08$). The Friend condition puts in evidence a significant but moderate effect again for both the variables ($F==7.01$, and $F==6.06$). Surprisingly the other s condition does not show any statistically significant effect on the decision conformism 3.2.

4. Discussion and conclusion

The target of this paper was to investigate the human decision making process under the social influences in esthetic judgment, manipulating the Ingroup/Outgroup dynamics. More in particular we were moved by the motivation to investigate whether it would be possible to reveal the effects of the In–Out group bias and of the cognitive dissonance, on the cognitive processing adopted by the subjects, just using an eye-tracker and a simple computer based task. The preliminary analysis has taken into account the forecasting capacity of the eye-tracking system with concern to the final rating of picture 3. About 3 s appear to be the time required to understand whether a subject likes an image when it is compared with another. Such an effect is clearly revealable on the time spent on the preferred image, as well as on the number of looks given to such an image. Despite no effects were detected on the final decision due to the experimental condition (i.e., on the picture choice as well as on the rating's magnitude) (Fig. 4), through the measurement of the reaction times and the ocular movements, we have revealed the existence of different processes behind the decisions got by the subjects. In particular we revealed the In–Out group effect, as well as a possible feature revealing the cognitive dissonance effect experienced by the participants. The social influence of the group seems to be detectable at least on two different dimensions partially uncorrelated by the time/effort required to get a decision (i.e., the time/looks spent analyzing the preferred image), and the tendency to the Conformism (i.e., the difference between the time/looks spent on the preferred image depending on its popularity). The In–Out group effect appears to make the decision making process faster, probably furnishing more information to the cognitive system. Nevertheless such an information appears not to influence the quality of the final decision (i.e., the chosen image, or the magnitude of the rating), but it appears to alter the amount of attention paid to the images. The effect is stronger for the Friends condition, even if the others appears as not so different with respect to the time spent to get the decision, and not statistically different with concern to the number of looks. Given that the average scores administered in the different phases were not the same, the previous evidence suggests that the role of this effect is more likely automatic (i.e., embedded on the first stages of the cognitive elaboration) than deliberative (i.e., cognitive heuristics based), actually such effect can be connected to the cognitive dissonance theory. With regard to the PhotoRating task, we can suppose that when a participant is going to select an image which he knows is not the Popular one, he would experience a cognitive dissonance as large as the distance between his judgment and the average opinion. Interestingly such an effect is revealed mainly for the blind phase, suggesting how the In group bias, and so as the Out group bias, appear to play a protective role within the experiment we conducted. In particular the Out group bias seems to protect effectively the subjects from the cognitive dissonance elicited by an anti-conformist decision. The model resulting from the analysis can be summarized and effectively represented by a schematic representation as in Fig. 7. The picture shows how a function describing the features of the decision making processing that were taken into account could shed light on the existence and the magnitude of the effects considered in this paper. In particular the angular coefficient of function a (Fig. 7) seems to be related specifically to the cognitive dissonance effect, showing an apparent positive correlation between the degree of the dissonance and the degree of the angle. On the other hand the same function seems to capture even the In–Out group bias magnitude, which can be assumed as affecting the vertical displacement of function b (Fig. 7). It is obvious that the two effects cannot be considered ever as independent. Nevertheless their interaction is revealed as more complex than a simple linear relation (i.e., probably characterized by a non-linear interdependency). An interesting feature of our model is its rather simple and ecological (i.e., ergonomically) nature, as well as its temporal effectiveness (i.e. few seconds). In particular it is apparent to be able to estimate (in real time) how much a subject is exposed or under the social pressure, within a certain condition. The model delineated by the results of the present work can drive the analysis of the subjects' decision dynamics at the technological

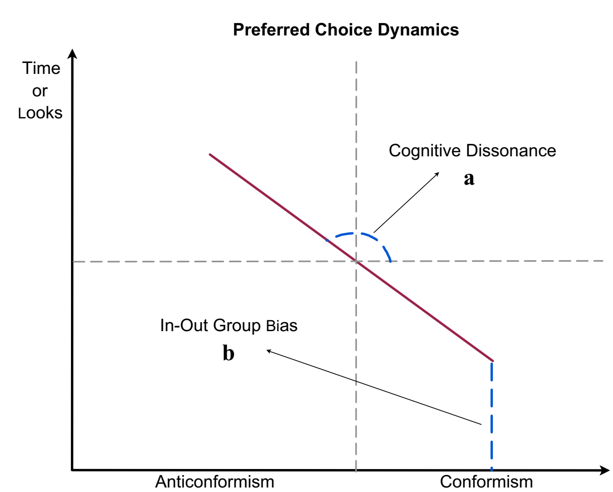

Fig. 7. Dynamics of the preferred choice. It is possible to represent the cognitive dissonance (a) and the In–Out group bias (b) observing the relation between the kind of choice (anti conformist or conformist) and the time spent on the stimulus by the number of looks.

and ICT levels (Cook and DasSmart, 2005), as well as to be used to equip the technological entities with such a cognitive inspired mechanism of social problem solving. Such a direction could be promising regarding the achievement of the self-awareness equipping the technological devices and services, but the researches on that direction have revealed even different and unexpected possible applications. Among these, the most appealing one is related to the development of ICT Decision Making Platforms, as environments, where it is possible to effectively and ecologically control the social pressure effects, in order to make faster, easier and effective decision process (and hopefully the decision itself). In sum, since the ICT world has become more and more social, when we need to make a decision using these technologies it is fundamental to take into account social pressure phenomena such as In–Out group bias and cognitive dissonance. This paper has provided new insight in how these social pressure variables influence the decision making process in a simple esthetic task. In particular, we have developed a model about how the In–Out group bias and cognitive dissonance interact. This model can help automatic system to predict human behavior when it is influenced by social pressure in order to facilitate the human–computer interaction. Moreover, this model can be easily implemented in order to provide technologies with cognitive human inspired capacities so as to make them smarter. Another interesting feature of our work is the PhotoRating application. We have shown that through the measure of reaction times and ocular movements it is possible to have clearer information about the actual process behind a decision. Through this application it is possible to investigate both the influence of others' choices on individual judgment, and the cognitive processes that lead to that decision. In particular these measures can be very useful in the study of recommender systems in order to analyze the influence of social information on the selection and purchase of items.

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