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Empathy, but not mimicry restriction, influences the recognition of change in emotional facial expressions

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The current study addressed the hypothesis that empathy and the restriction of facial muscles of observers can influence recognition of emotional facial expressions. A sample of 74 participants recognized the subjective onset of emotional facial expressions (anger, disgust, fear, happiness, sadness, surprise, and neutral) in a series of morphed face photographs showing a gradual change (frame by frame) from one expression to another. The high-empathy (as measured by the Empathy Quotient) participants recognized emotional facial expressions at earlier photographs from the series than did low-empathy ones, but there was no difference in the exploration time. Restriction of facial muscles of observers (with plasters and a stick in mouth) did not influence the responses. We discuss these findings in the context of the embodied simulation theory and previous data on empathy.

Keywords: Emotion recognition; Empathy; Mimicry; Embodied simulation.

The discovery of the mirror neurons (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992), which activate both when an individual performs an action and when she perceives the same action performed by others, has caused an intense discussion between, let us call them, inferentialists (e.g., Kilner & Frith, 2008; Pascolo & Budai, 2013) and simulationists (e.g., Gallese, 2005). Inferentialists believe that observers understand or identify behaviour of others making inferences from past experience. They have perceived an action many times in different contexts, which is why they know its causes and consequences. Simulationists think that observers can understand an action not only by inferences, but also thanks to embodied simulation, which is when they perceive an action, the same regions (which contain the mirror neurons) in their brains activate as if they performed this action. Albeit there is a broad spectrum of evidence to support embodied simulation theory (see, for example, Gallese, 2005), there is no consensus on functions of embodied simulation, and particularly whether it supports understanding of others' actions (Hickok, 2013; Kosonogov, 2012). Simulationists suppose that the mirror neurons are a connecting link between cognition and action: When observers see an action they internally repeat (simulate) and sometimes externally repeat (mimic) it; that is why they understand this action. Following this suggestion, the simulationist point of view raises an interesting question to study: If people (and other animals) use

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representations of their own actions to process actions of others, do individuals, who can mimic others' actions, recognize others' actions better or faster than individuals, who cannot?

In this study we concentrate only on recognition of emotional facial expressions of others. Simulationists propose that at least four models of how simulation can subserve recognition of facial expressions (Goldman & Sripada, 2005). The first model, the generate-and-test model, (see, for example, Rajmohan & Mohandas, 2007) postulates that when observers see a face, they make inferences about its emotion, then unconsciously express the supposed emotion by micromovements, invisible to the naked eye, and compare their visual representation with the feedback from their own faces. The second model, the reverse simulation model, (Campbell, 1995; Goldman, 2006) assumes that when observers see a face, they mimic it, feel the same emotion, and thus understand this emotion. It was shown that when observers see an emotional face they involuntarily mimic it (Dimberg & Thunberg, 1998). This means that when observers see an emotional face and mimic it, they have the double input: the visual input from their eyes and the somatosensory and kinaesthetic input from their own faces. A question that inevitably comes to mind is whether this double input facilitates the recognition of other's emotions. Moreover, patients with insula damages could neither experience disgust, nor recognize it in others' faces (Adolphs, Tranel, & Damasio, 2003), which may entail the following assumption: Only when observers mimic and are able to feel an emotion can they recognize it. The third, simulation model of recognition of facial expressions, the reverse simulation with "as if" loop (Goldman, 2006), is similar to the second, but it assumes that after observers have seen a face and simulated it internally, the recognition can occur without mimicry within the somatosensory area. The fourth model, the unmediated resonance model, is based on the "shared manifold hypothesis" of Gallese (2001, 2003) and supposes only internal simulation in the mirror neurons (without mimicry) and the subsequent activation of "some cognitive center that 'recognizes' the experienced emotion" (Goldman & Sripada, 2005, p. 207).

A considerable amount of data on the role of mimicry in emotion recognition has been recently gathered by researchers. It has been shown that people who were asked to mimic some emotions did not recognize them better than controls did (Blairy, Herrera, & Hess, 1999). Interestingly, in spite of the absence of difference in recognition, participants who were not asked to mimic evaluated the subjective difficulty of the task higher than participants who were asked to mimic. Hence, although mimicry was not necessary in the recognition of emotional facial expressions, it made the performance of the task easier.

Another way to answer the question of whether mimicry influences emotion recognition is to find out whether the restriction of mimicry influences the quality of recognition of emotional facial expressions. For example, a study by Oberman, Winkielman, and Ramachandran (2007) demonstrated that participants with a pen in their teeth (that restricted some muscle movements) recognized happiness in static face pictures worse than controls did. No effect was observed for other emotions in pictures (sadness, disgust, and fear) and for other muscle conditions (holding a pen in lips, without touching it with teeth, and chewing gum). However, these data should be interpreted reservedly, because only 12 people participated in this study. In a study by Rives Bogart and Matsumoto (2010), controls did not show a better recognition of fear, sadness, happiness, contempt, surprise, anger, and disgust than patients with Moebius syndrome (who, because of congenital facial paralysis, cannot move their facial muscles).

However, though mimicry (or a restriction of it) does not influence the percentage of right answers in the recognition of emotional facial expressions, it may influence the speed of the recognition. For example, the data of Niedenthal, Brauer, Halberstadt, and Innes-Ker (2001) showed that while viewing freely a series of morphed face photographs depicting the gradual change (frame by frame) from happiness to sadness and vice versa, participants with restricted facial muscles (a pen in mouth) recognized the onset of happiness or sadness at later frames of the change than controls. The authors suggested that the feedback from facial muscles of an observer facilitates the processing of others' faces.

A study by Stel and van Knippenberg (2008) found that participants with restricted facial muscles were slower than controls on the task in which they were asked to identify static emotional facial expressions as positive or negative, but this effect was observed only in women. However, we are sceptical about the interpretation of this finding, because the mean values of reaction time were between 600 and 700 ms, and formerly it was shown that involuntary mimic micromovements of facial muscles begin 400–600 ms after the onset of a picture depicting an emotional face (Dimberg & Thunberg, 1998; Dimberg, Thunberg, & Grunedal, 2002), the median peak latency being 1000 ms (Oberman, Winkielman, & Ramachandran, 2009). We cannot be sure that the impulses from the muscles can go in such short time to the neural hubs where this feedback is processed, then to the neural hubs of decision making, and finally influence the reaction time.

Apart from mimicry there can be other factors that influence recognition of others' emotional facial expressions. For example, Cross, Cross, and Daly (1971) revealed effects of race, sex, and age of observers, and Niedenthal et al. (2001) found influence of mood. In our turn, we suggest that empathy, as one of the most important personality traits, which is necessary for efficient social communication and prediction of behaviour of others (Keysers, 2012), may influence recognition of emotional facial expressions as well. The concept of empathy has many meanings and may be defined, for example, as experiencing emotions that match another person's emotions (Levenson & Ruef, 1992) or knowing what the other person is thinking or feeling (Ickes, Stinson, Bissonnette, & Garcia, 1990). Hence, an empathic person is expected to be more sensitive and attentive to social stimuli or situations. Empathy is also linked to prosocial behaviour, because prosocial behaviour depends on understanding of others, emotion regulation, and social initiative (Miller, Eisenberg, Fabes, & Shell, 1996). In this line, Petrides and Furnham (2003) found that participants with low emotional intelligence (as measured by a self-report questionnaire), which is linked to empathy, recognized emotional facial expressions slower (i.e., they spent more time) and at later frames in a gradual change of morphed faces. There are also data showing that patients suffering from diseases associated with low empathy, such as autism (Hobson, Ouston, & Lee, 1988), Asperger's syndrome (Golan, Baron-Cohen, & Hill, 2006),[1] and schizophrenia (Kohler et al., 2003), can have problems with emotion recognition, though other studies have found diverging evidence (Kohler, Bilker, Hagendoorn, Gur, & Gur, 2000; Oberman et al., 2009).

We also supposed that there might be an interaction between muscle restriction and empathy. In a study by Stel, van Baaren, and Vonk (2008) participants who were asked to mimic the facial expressions of actors on a screen reported greater empathy with the actors than participants who were asked to avoid mimicking. However, in this study, empathy was considered a situational response provoked by deliberate mimicry, rather than a stable personal trait that could have been measured a priori. Moreover, the second group was explicitly asked not to mimic, but in our opinion, this would not have not influenced involuntary mimicking.

Thus, the aim of our study was to reveal possible effects of (a) restriction of facial muscles of observers and (b) empathy on the recognition of all basic emotional facial expressions in a series of morphed face photographs. We also tested whether there was an interaction between muscle restriction and empathy. We employed the same

[1] Golan, Baron-Cohen, and Hill (2006) referred to the diagnostic criteria for Asperger's syndrome from the *Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition* (*DSM–IV*). According to the *Diagnostic and Statistical Manual of Mental Disorders–Fifth Edition* (*DSM–V)*, Asperger's syndrome was replaced by autistic spectrum disorders and is no longer an official diagnosis.

paradigm as Niedenthal et al. (2001) did in their study—that is, we studied the subjective onset of an emotional facial expression in a series of pictures depicting a change (frame by frame) from one expression to the other. However, we saw a limitation in their work: They studied the possibility to recognize an emotional facial expression at earlier stages (frames), when it is less clear, but they did not record the speed of recognition. In our work we studied two variables: the frame at which an emotional facial expression subjectively changes and exploration time (i.e., the time spent on recognition) in each probe. In contrast to above-mentioned studies on healthy people, in which researchers restricted one or two regions of the face, we tried to prevent mimicry reactions of many muscles: muscles of mouth, forehead, and nose.

EXPERIMENTAL STUDY

Method

Participants

A sample of 74 volunteers (12 males, 62 females, mean age = 28.96 years, $SD = 8.68$) participated in the study. All of them were the students of Southern Federal University (Rostov-on-Don, Russia) and received course credit for their participation. All participants were blind to the aim of the study. All procedures were conducted in accordance with the Declaration of Helsinki.

First, they filled in the Russian version (Kosonogov, 2014) of the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004), and we split the sample into two groups (50% of participants with lower and 50% of participants with higher scores). Then we divided each of these groups in half, randomly assigning participants to a face muscle condition (free/restricted, see Procedure). Overall, 19 participants had low empathy (EQ = 36.63, $SD = 4.98$) and free facial muscles; 19 participants had high empathy (EQ = 50.58, $SD = 5.52$) and free facial muscles; 18 participants had low empathy (EQ = 36.00, $SD = 6.00$) and restricted facial muscles; and 18 participants had high empathy (EQ = 51.56, $SD = 4.34$) and restricted facial muscles. There was no difference in the EQ scores between participants with free and restricted facial muscles within subsamples with low and high empathy ($ps > .05$). This avoided a possible influence of one variable on the other in statistical analyses. Additionally, the subsamples were equilibrated according to the quantity of men and women—that is, there was the same number of men in each subsample.

Materials

As mentioned above, we applied the Empathy Quotient to measure empathy. We used only the overall score (based on 40 self-report questions) and decided not to analyse possible subscales of the EQ, because different factor studies do not agree about what questions each subscale should include. (e.g., Dimitrijević, Hanak, Vukosavljević-Gvozden, & Opačić, 2012; Kosonogov, 2014; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004). In our study, its internal consistency (each question was considered as an item) was .84.

A set of 14 coloured photographs of faces was selected from the Karolinska Directed Emotional Faces collection (KDEF; Lundqvist, Flykt, & Öhman, 1998)[2]. There were seven full-face photographs of a man and seven of a woman depicting emotional facial expressions: happiness, fear, surprise, anger, disgust, sadness, and neutral. To make sure that participants recognized the expressions in the photographs correctly (according to the KDEF), before the experiment we asked them to attribute a name from the list of seven basic expressions to each of 14 expressions. The faces displaying fear were recognized correctly by 57% of participants; the rest of the faces were named correctly by 86–99% of participants (the chance score was 14%).

With the help of the program Sqirlz Morph 2.1 (2009), we made 84 morph pairs of expressions

[2]Photographs from the KDEF used in the study are AF19AFS, AF19ANS, AF19DIS, AF19HAS, AF19NES, AF19SAS, AF19SUS, BM34AFS, BM34ANS, BM34DIS, BM34HAS, BM34NES, BM34SAS, BM34SUS.

(all possible 42 pairs of expressions, e.g., disgust–fear × 2 actors of different sex). In the photos we indicated key points of the face for the program to generate a gradual change of 100 frames from the first expression to the second one (e.g., from disgust to fear), The trials were quasirandomized so that an expression could never repeat, and an actor could not be presented more than twice in a row. All participants viewed the same sequence of 84 morph pairs.

Procedure

First, the participants filled in the EQ and attributed names to the facial expressions. Then the subsamples that were assigned to the condition "restricted facial muscles" underwent the following procedure: We placed wooden chopsticks (20 cm in length and 0.7 cm in thickness) in the mouth between incisors and cuspids and two sticking plasters (3 × 8 cm on the forehead and 2 × 10 cm on the nose from one cheek to another) to prevent facial muscle movements. Then the participants sat down in front of a computer monitor (with the diagonal of 44 cm) at the distance of 70 cm and performed the task with morphed face photographs. They were asked to push the arrow button "right" at their own pace changing frames with faces (from Frame 1 to Frame 100) and to stop when the face in the monitor clearly expressed the emotion indicated above the picture (Figure 1). Before the experimental part, the participants practised with four probes depicting other actors.

Data analysis

We registered the point of subjective change (the frame at which, as participants thought, a given expression appeared) and the exploration time in each probe (from the first switch to the next frame till the switch to the next probe). These two variables were studied by a mixed model analysis of variance where empathy (low/high) and muscle condition (free/restricted) were between-subject variables, and expression pair (42 pairs; sadness–anger/neutral–disgust/happiness–fear/etc.) was a within-subject variable. Additionally, we calculated the internal consistency of the task with morphed face photographs (84 probes were considered as items) to check whether all probes measure the same construct—that is, recognition of emotional facial expressions. The level of significance was .05 for all tests.

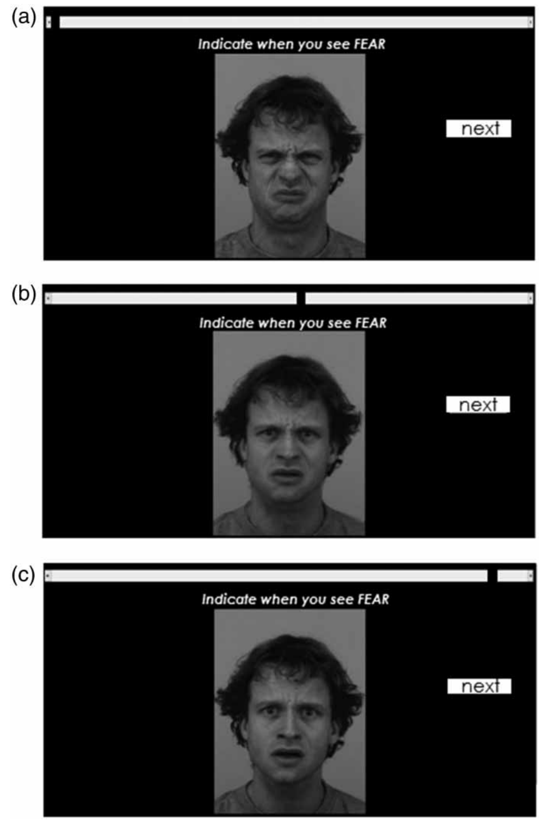

Figure 1. *An example of the participant screen showing the morph pair disgust–fear: (a) at Frame 1; (b) at Frame 52; (c) at Frame 93.*

Results

The internal consistency of the measure was excellent, $\alpha = .987$. We found a main effect of empathy on the point of subjective change, $F(1, 70) = 4.91$, $p = .030$, $\eta^2 = .07$. Paired Bonferroni comparisons showed that the low-empathy participants recognized the onset of emotional facial expressions at later frames than the high-empathy ones ($p = .029$, see Table 1). We did not reveal an effect of muscle condition on the point of subjective change ($p = .84$). We also found a main effect of expression pair on the point of subjective change,

Table 1. *The point of subjective change of emotional expressions and exploration time depending on empathy and muscle condition of participants*

	Empathy		*Muscle condition*	
Measure	*Low* M (SD)	*High* M (SD)	*Free* *M (SD)*	*Restricted* M (SD)
The point of subjective change, frame (1–100)	73.44[a] (12.06)	67.64[a] (9.94)	70.28 (11.54)	70.82 (11.32)
Exploration time, s	9.72 (2.78)	10.56 (3.24)	10.31 (2.82)	9.95 (3.26)

[a]The superscript means that there is a significant difference between the indicated values.

$F(41,\ 2870) = 80.58$, $p < .001$, $\eta^2 = .54$ (see Supplemental material for S-Table 1 with paired Bonferroni comparisons of all pairs of expressions). The interaction Empathy × Muscle Condition was not significant, $F < 1$.

Even though we did not find either a significant interaction Expression Pair × Empathy, or a significant interaction Expression Pair × Muscle Condition (*p*s > .050), we conducted *t*-tests for independent samples with Bonferroni correction, where each EXPRESSION pair was a dependent variable, and empathy or muscle condition were independent variables. Muscle condition did not influence the point of subjective change in any of 42 pairs of emotional facial expressions (*p*s > .05, see Supplemental material, S-Table 2 for means and *SD*s of the point of subjective change in all pairs). Empathy influenced significantly the point of subjective change in 16 pairs (disgust–anger, fear–disgust, neutral–disgust, neutral–fear, sadness–fear, anger–happiness, disgust–happiness, neutral–happiness, sadness–happiness, anger–neutral, sadness–neutral, anger–sadness, disgust–sadness, fear–sadness, neutral–sadness, anger–surprise): The low-empathy participants recognized the onset of expressions at later frames than the high-empathy ones in all cases (*p*s < .05). In the other 26 pairs the low-empathy participants also recognized the onset of expressions at later frames than the high-empathy ones, but differences were not significant (see Supplemental material, S-Table 3 for means and *SD*s of the point of subjective change in all pairs). Finally, we found a main effect of expression pair on the exploration time, $F(41,\ 2870) = 11.37$, $p = .001$, $\eta^2 = .14$ (see Supplemental material for S-Table 4 with paired Bonferroni comparisons of all pairs of expressions).

Discussion

We studied the recognition of the onset of emotional facial expressions (neutral, happiness, anger, disgust, sadness, fear, and surprise) depicted in a series of morphed face photographs depending on empathy and facial mimicry restriction. The internal consistency of the measure was excellent, which allows us to believe that all items measured the same construct. However, our results only partially agree with those of previous studies.

We did not reveal any influence of facial muscle condition on recognition of emotional facial expressions—that is, participants with restricted facial muscles and participants who could freely use their facial muscles recognized the change of expressions approximately at the same frame. There were no differences either in the average point of subjective change of all expressions or in the point of subjective change of all expressions in each pair of expressions in paired comparisons. These results do not agree with the data of Niedenthal et al. (2001) that demonstrated that participants who could freely use facial muscles recognized the expression change at earlier frames in a sadness–happiness morph range than participants who could not use facial muscles. However, in their work, only two pairs of emotional facial expressions were used, but each pair contained photos of 14 actors. In our study we used photos only of two actors for every pair, because we wanted to investigate all basic facial expressions. Perhaps these differences in experimental design led to greater validity of measurement of happiness–sadness and sadness–happiness change in the study of Niedenthal et al. and to greater validity of measurement of the onset of all basic emotional expressions in ours.

This divergence in results can also be explained by the fact that in the study of Niedenthal et al. (2001) there were only two expressions, the task was more routine, and in the course of it participants could learn to recognize expressions (or recover their ability), and, supposedly, in this case the usage of one's own facial muscles is a strategy that can improve recognition in the task with morphed face photographs. In turn, our task was more similar to everyday life in which we observe all the emotional facial expressions in a more or less random order, and participants were not supposed to show habituation or learning. Perhaps in such a task the usage of one's own facial muscles does not facilitate the performance of this task.

Therefore, we can conclude that our results do not support the idea that mimicry (i.e., the feedback from the observer's face) facilitates recognition of facial expressions. We also assume that recognition may occur before the feedback from the observer's face can reach neural hubs responsible for decision making. In a study of Malhi et al. (2007), the minimum average reaction time of recognizing emotional expression was 786 ms, while the minimum individual response time was 489 ms. This time is not enough to mimic and process the facial feedback. Although in our study we did not measure reaction time to each picture, we observed that participants in both muscle conditions recognized the emotion change at the same frame and spent equal time on every morph probe. We can conclude that mimicry restriction did not influence the temporal aspect of the recognition.

However, our data do not answer the question of what mechanism—simulation without mimicry or inference-making—provides recognition of facial expressions. Furthermore, we believe that these mechanisms are intertwined in normal subjects and can facilitate each other: When people perceive a face, they simulate and mimic it; this can facilitate inference making, which occurs simultaneously (Kilner, 2011).

On the other hand, empathy influenced the recognition of the onset of emotional facial expressions —that is, high-empathy participants recognized the onset of expressions at earlier frames than low-empathy ones. In other words, high-empathy participants recognized the onset of an expression when it was less clear. Curiously, empathy did not influence exploration time: High-empathy and low-empathy participants spent equal time on the task. This can be explained by the general predisposition of high-empathy people to pay more attention to others' faces (Penton-Voak, Allen, Morrison, Gralewski, & Campbell, 2007) and to understand behaviour of others better (Findlay, Girardi, & Coplan, 2006).

We are prone to believe that the link between empathy and recognition of emotional facial expressions is reciprocal—that is, one can reinforce the other and vice versa in the course of the development of personality. It is broadly accepted that empathy comprises of both cognitive (discrimination of others' states) and emotional (responsiveness) components (De Waal, 2008). Thus, the better we discriminate states in other people, the greater chance to respond to them we have, and, in its turn, the more responsive we are, the better we recognize others' states.

The interaction Empathy × Muscle Condition was not significant, which means that both high- and low-empathy participants showed similar recognition efficiency under different muscle conditions. In other words, a high-empathy person recognizes an expression better than a low-empathy person regardless of the muscle condition of their faces. We can suggest that, although in childhood mimicry is important in developing empathy, mimicry is not necessary to be empathic in adulthood. However, it is a question that should be considered in future studies.

As a by-product of our study, we also found many differences in the point of subjective change of basic expressions between different emotional pairs. However, we do not discuss them in detail, because our experiment aimed at a different goal.

We only can notice that disgust was recognized at earlier frames than other emotions, perhaps because it is the only emotion in our study in which nose movements are involved. Additionally, the onset of neutral expression was indicated at the latest frames, because neutral expression can be considered as a default state, in which all the muscles are relaxed, and other emotions fade gradually till the 100th frame.

Although pairwise comparisons are not recommended in a nonsignificant analysis of variance (ANOVA), they enabled us to notice that high-empathy participants were somewhat more efficient in recognizing happiness and sadness than other expressions. This may be explained by the frequency of these expressions in everyday life; however, we do not have any data for this assumption. On the other hand, other emotional expressions (fear, disgust, anger, and surprise) may be of great evolutionary importance and should be recognized quickly, because they could be signals of a sudden or considerable danger. For example, disgust is important for avoiding bad food, and all people, regardless of their empathy, recognize disgust easily in faces of other people who have just smelt such food. We suggest that this issue should be considered in future studies with a more appropriate experimental design.

We also noticed that in our work some participants said that they paid more attention to eyes or mouth, others studied only eyes, and others again worked intuitively. We believe that the strategies that participants use to facilitate recognition of emotional facial expressions would be an interesting question for future research.

Supplemental material

Supplemental content is available via the "Supplemental" tab on the article's online page (http://dx.doi.org/10.1080/13506285.2015.1009476).

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