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VISUAL PERCEPTION OF DYNAMICAL CHANGE IN EMOTIONAL FACES VS. OBJECTS

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ABSTRACT

The perception of dynamical changes in a visual scene is of paramount importance in the processing of environmental signals necessary for adaptation. These signals however rely on different kinds of causal interaction. While changes in inanimate objects require the intervention of an external cause, changes in faces relate to intentional properties. There could be thus specific patterns of brain processing for objects and for emotional faces, and these distinct patterns could lead to distinctive perceptual responses. To test this hypothesis we set up a morphing methodology allowing compare dynamic changes of emotion in faces with dynamic changes in natural and artificial objects. Seventy-two participants were presented videoclips of dynamical changes at various speeds to determine the optimal perception of the change of states with two orders of transformation (ABA, BAB). After each videoclip, the participants were asked to choose, among non-targets, the image that was B in ABA, or A in BAB. Behavioral data and Response Times were collected. Results show that participants were less successful in choosing the target emotion when confronted to fast transformations. The effect is reinforced when faces are presented in the BAB order. These data bring to light a significant effect of the speed of transformation, type of stimuli and order of transformation on the perception of facial and object transformations. They suggest that the complex cognitive processing of dynamic changes may differ according to the stimuli: face vs. object.

Keywords: *Visual perception, Dynamic process, Morphing, Emotional faces, Objects*

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1. INTRODUCTION

The perception of dynamical changes in a visual scene is of paramount importance in the processing of environmental signals necessary for adaptation [1]. However, it involves a fairly complex amount of computation over perceptual and representational aspects of changes. If the processes of object recognition, categorization and memorization have been intensively studied, there is still much to learn about dynamical changes. Only a few studies emphasize the importance of processing undergoing transformation in objects. Although emotional facial expressions have dynamic perceptive properties [9, 13], most of the experimental materials devoted to emotion recognition studies remain static [2, 3, 4, 5, 6, 7, 8]. Yet, the recognition of emotions through dynamical expressions [10], or inferences about intentions through perceived movements, have a crucial influence on physical and social interactions. The distinction between objects and faces point to a more general division between inanimate objects and agents. While changes in inanimate objects require the intervention of an external cause, changes in faces involve intentional properties. To what extent is it possible to compare the visual perception of the transformation of an inanimate object to the perception of a change in facial expression? The question remains open regarding the possible involvement of different cognitive processes for the two types of entities. Our hypothesis is that there could be specific patterns of transformation in objects and in emotional faces, that the brain could process separately these distinct patterns.

1.1. Dynamic changes of emotional face perception

The face is a special category of stimulus regarding the important volume of information it conveys [12]. In particular, faces allow the display of emotional expressions, which are mental states translated into muscular patterns having substantial quality: a dynamic aspect characteristic of a change of state [10]. Current cognitive neuroscience studies reveal specific effects of dynamic presentation of faces in their recognition [14, 15], as well as in the interpretation of emotions [16,17]. Neuroimaging studies confirm the positive role of movement in the recognition of emotional facial expression [18, 19, 20, 21, 22, 23]. According to these works, the dynamic presentation of emotional faces increases the activity of some specific parts of the brain, such as the amygdala, the superior temporal sulcus (STS), the MT+/V5 and the mirror system. It is likely that the implication of the amygdala, as well as the emotion resonance mechanisms via the activation of the mirror system, allows to identify quickly the intentional aspects of facial movements and to understand the type of emotions they convey.

1.2. Dynamic changes of objects perception

Contrary to human faces, physical objects can be handled (whether it is natural or a man-made artifact) and possess a set of properties that differ from those of faces. Cordier and Tijus [30] propose two general kinds of objects' properties: properties directly observable (visible properties) and properties attributed via knowledge or inference. Among the latter, functional properties describe aspects related to the way objects are handled. Man-made artifacts are a special kind of objects in that their structure is purpose-oriented, and that they can be used to perform actions on other objects with a particular usage in memory [32, 33, 34, 35, 36, 39]. Although natural objects (e.g. plants, minerals) can also have functional properties, the relationship between their physical appearance and these functional properties is less obvious [31], making the artifacts unique regarding the shape/function relationship [37]. In the domain of moving objects perception, most studies focus on spatial movement [24, 25, 26, 27, 40], translation or rotation [28, 29]. These spatial transformations don't imply directly a modification of the object' visible properties, making difficult a straightforward comparison with emotional faces' transformations. Although we don't have data about the perception of object transformation, mental rotation studies [28, 29, 43, 44, 45, 46] suggest that this kind of transformation could involve the simulation of manual movements (e.g. grasping). This motor simulation could be related to the activation of mirror neurons [41]. The mirror neurons are able to code the aim of an action and the temporal aspects of particular movements. The sole observation of an action makes possible, through the synchronization of internal motor representations of observed action, an immediate understanding and reproduction of this action. Thus, when someone sees his/her partner performing a movement, the brain is supposed to "simulate" internally the execution of this action. He is then ready to perform the same action if necessary [42]. According to some authors, this simulation mechanism could go along not only with the mental rotation process, but also, in a broader perspective, with perception of state transformation.

1.3. Emotional face and object perception

The present study aims at addressing the differentiated aspects of processing changes of emotional faces and objects. Our main goal is to compare - through the collection of behavioral data - the effects of varying speed of transformation as well as those of item properties on the capacity to process the dynamic of emotional faces and of objects. As far as we know, this comparative approach of dynamicity of facial stimuli and of objects has not been thoroughly studied. To remediate this, we have designed a material using morphing to produce the changes of state of emotional faces and of objects. This technique enables us to control the type of change and the transformation speed avoiding the stroboscopic effect (see Gepner's team technique [47]). We suppose that the change of state related to events for natural objects, actions for functional objects and emotions for faces, speed variation (slow or fast) and the order of the change of state (neutral to transformed vs. transformed to neutral), will allow us to evaluate the differential processing of the changes of emotional faces and of objects.

2. EXPERIMENT

2.1. Method

2.1.1. Participants

Thirty-nine male and thirty-three female participants took part in this experiment. Our sample comprised 27 children aged 7-9-year-old (mean 8,1 years, SD = 0,8), 27 children aged 10-12-year-old (mean 11,1 years, SD = 0,8) and 18 adults (mean 35 years, SD =15). All participants had normal vision and do not have any sight or attention problems and were volunteers recruited from visitors of the "Cité des Sciences et de l'Industrie".

2.1.2. Materials

Videos were videos of morphing transformation of natural objects, of man-made objects and of emotional faces. A video sequence is made of two changes of state from the morphing of 3 successive pictures. The first change of state is performed through the shift from the contextual picture (image 1) to the target picture (image 2) and the second through the shift from the target picture (image 2) to the contextual picture (image 1). From this transformation pattern (Image 1 to Image 2 to Image 1, we vary the item pictures in two different orders ("ABA" and "BAB"). For faces, the "A" state corresponds to the neutral expression and the "B" state to the primary emotional expressions. For objects, state "A" is the initial state and "B" the transformed/modified state. (See figure 1 and figure 2). 36 video sequences were used: 6 morphing videos of natural objects (banana, leaf, kiwi, chili, apple, tomato) implying the visible properties transformations (size, shape, color), 6 morphing videos of man-made objects with functional properties transformations (balloon, bottle, scissors, spoon, safety pin, pencil case) and 6 videos of primary emotional facial expressions (enjoyment, sadness, disgust, surprise, fear, anger, neutre) with emotional proporties transformations. The three types of transformations that all obey to the following principles: take account of the physical constraints defining the stimulus identity (degree of freedom for the faces, spatial development and gravity for objects), thus leading to an 'optimal state' of change. The amplitude of movement for each object and each emotional expression was controlled by the choice of optimal state for each item. Each category of stimuli was transformed in two orders (18 videos : transformation ABA and 18 videos : transformation BAB) giving 36 videos. All the videos were selected in our FOT-Database*.

Finaly, these 36 videos were declined in two speeds (36 fast sequences: 500ms and 36 slow sequences: 4000ms). To choose the transformations' speed we situated ourselves between two extremes provided by literature: the threshold of conscience in 30-33 ms [11] and the maximum value of transformation in 12000 ms [38]. In reference to these extremes, we chose two speeds among four (500 ms / 13 ips; 1000 ms / 25 ips; 2000 ms / 50 ips; 4000 ms / 101 ips), one that corresponds to a quasi complete success to our population of pre-test (91 %) and the other that is fair above the threshold of answer at random (63 %).

The movement type (elevation, depression and compression) as well as the amplitude of points' displacement are to be taken into account. But this parameter was not investigated as variable in this study, however the movements' amplitude for each object or emotional expressions was controlled by the choice of optimal state for each item.

* The Faces and Objects Transformation Database (FOT) was created by Bora Han, Charles Tijus ("Cognitions Humaine et Artificielle") and Jacqueline Nadel ("Centre Emotion") with the purpose of studying state transformations in a developmental psychopathology context of perception of emotions and intentions. This database contains 760 color morphing videos as well as 288 color pictures of objects and emotional faces. The object pictures database includes 54 functional objects and 112 natural objects. To create objects' transformation we have photographed various objects in different states. Each state for every item corresponds to a possible state and a change of state (i.e. as a tomato which deforms in time or as scissors which opens and closes as to cut a paper). For the faces database, 11 actors and non actors (7 men and 4 women) produced 7 typical emotional facial expressions (enjoyment, sadness, disgust, surprise, fear, anger and neutral). In order to achieve prototypical facial expressions [3], actors were asked to reproduce models extracted from http://artnatomia.net. All faces and most objects are presented in frontal view. The photography session was realized in the LUTIN lab under strictly controlled conditions. Image were processed wit Adobe Photoshop Element 4.0, and transformation process was realized with MorphAge 3.1.1. The morphing allows to produce changes of state of natural and of man-made objects, as well as of emotional patterns in faces. Each of the 760 videos can be displayed at each of 10 speeds of transformation (500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 5000, 6500 ms). FOT-DB is publicly available and can be obtained from http://www.lutin-userlab.fr/fot/

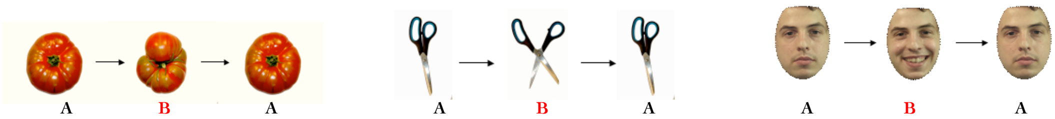

Figure 1: Change of state in order 'ABA' where target image is 'B' for each **category**

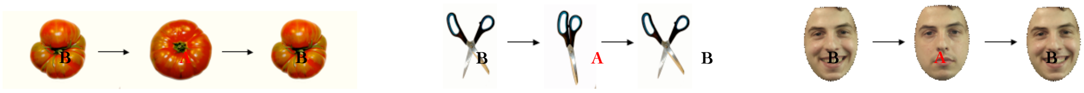

Figure 2: Change of state in order 'BAB' where target image is 'A' for each **category**

Each video sequence goes along with 3 Test images (context image and target image, from the video and an additional distractor image) that are displayed after the video, out of which the participant must choose the correct target picture once the sequence is over. At that time the three pictures are displayed side to side, the random order of display having been determined in advance. We have a total 72 test images in JPG format.

2.1.3. Procedure

A total of 41 video sequences were presented to the participants, 5 for the trial phase, and 36 for the test phase. Among the 36 test sequences, 18 were presented in v1 (500ms) and 18 in v2 (4000ms). These series of videos comprise respectively 6 sequences for each kind of items (Natural Object, Object with manual function and Emotional Face) with a counterbalanced transformation order (3 ABA and 3 BAB). In order to avoid displaying the same videos duplicated in two different speeds, we have parted the 72 sequences in two protocols (36 sequences in Protocol 1 and 36 in Protocol 2) and counterbalanced them according to the participants. The presentation of the experiment is prepared thanks to the programming software Psycope XB53. The order of presentation of series v1 (500ms) and v2 (4000ms) is defined randomly by the software.

The experiment took place in the "Laboratoie des Usages en Technologie de l'Information Numérique": the participant sits on a chair in front of a computer screen (13.3 inch and 1200 x 800 pixels) where the 36 video sequences and the 72 test images are presented. The computer is on a table, at 50 to 60 cm distance. The experimenter explains to the participant the change of state notion and the task with a demonstration with 5 videos. Participants have to watch the video and, then, to detect the target state among the 3 tests images. They have to press on the numeric keyboard: "1" if the target picture is on the left, "2" if the picture is in the centre of the screen, and "3" if it is on the right).

2.1.4. Experimental plan

Success rate and response time were collected from 72 participants divided in three age-based groups (a1: 27 children aged 7-9 year-old, a2: 27 children aged 10-12 years old, a3: 18 adults). Each participant was granted 3 trials for each of the 12 experimental conditions, whether the type of stimuli was objects with manual function (t1), natural objects (t2), or faces (t3), whether the type of transformation was fast (0.5 seconds; v1) or slow (4 seconds; v2) and whether the order of transformation was ABA (o1) or BAB (o2). The corresponding experimental plan is Pn <A3> T3 * V2 * O2 * E3, where Pn represents the number n of participants for A3 the 3 age categories (between). Each participant having to watch videos of T3 the 3 object types, at V2 two transformation speeds, being of O2 two orders of transformation and of E3 three trials (within). Having 3 trials per condition for each participant, we obtain with 72 participants a total of 216 observations per condition and of 2592 for the 12 conditions. Each observation includes Response (coded 1 for success and 0 for failure) and Response Time. Each observation includes the answer (coded 1 for success and 0 for failure) and the response time. According to the number of successful trials for each condition, a participant obtains a success score ranging from 0 to 3 and, for all the conditions, between 0 and 36.

2.1.5. Predictions

The dynamic display allows the participant to perceive a transformation. However, if the speed of display is too fast compared to processing capacities, the participant will not perceive the intermediate state of the transformation and cannot identify the target image. Thus we predict that a slow speed (4000 ms) will facilitate the detection of the target image compared to a fast speed (500 ms). Besides, the type of stimuli should have an effect on the rate of the target image detection. Emotional face transformation is related to an internal state and a usual phenomenon opposed to the man-made objects or natural objects transformations which have an external cause. In addition the natural objects transformations are not usual ones, contrarily to the man-made ones. Therefore, the changes of emotional state should be processed faster and better than the changes of state of objects because of the large practice we have of dynamical facial expressions. Man-made objects with manual function should be processed faster than the natural objects, because their perception suggests actions [39]. On the other hand, the pass rate should be much higher as the participant's age is higher. So, identifying the transformation states should be more difficult for young children in fast transformation and their performance should be much lower in the 'BAB' order than in the ' ABA ' order for unusual targetting and even more if the stimulus transformed is a natural object as opposed to a functional object, or even more an emotional face.

3. RESULTS

We first analyzed the pass rates (success rates), then the response times for each trial. We have parted the 72 sequences in two protocols. Each participant was randomly attributed one of the two protocols. There was no significant difference between the two protocols, either for the pass rate, or for the response time. Analysis concerns series of videos with 3 videos per condition and per participant, thus 2592 data couples (Response and Response Time).

3.1. Pass rate (success rate)

Regarding the principal pass factors, the results show a significant effect of speed, $F(2,69) = 9.3$, $p<.0003$, whatever the type of stimulus and the order of transformation, the slow speed has improved the response of all participants ($M = 14.5$ out of 18 trials, i.e. 80%) as opposed to fast speed ($M = 11$ out of 18 trials, i.e. 61%) The order of transformation, ABA has also favored the success of all participants (14.1 out of 18 trials, i.e. 78%) than the BAB order

(11.3 out of 18, i.e. 63%), and this effect is even stronger for children than for adults, $F(1, 69) = 39.2$, $p < .0001$. Besides, 7-9 year-olds were less pass score (1.8 out of 3 trials, SD = 1.09) than 10-12 year-olds (2.37 out of 3 trials, SD = 0.84) and than adults (2.21 out of 3 trials, SD = 0.99). This difference is significant; $F(2.69) = 9,304$, $p<.0003$. Yet 10-12 year-olds have a superior performance than adults, but this difference is not significant. However, when considering globally both speeds and transformation orders, the "type of stimuli" factor does not have a significant effect on participant's response score, $F(2.69) = 1.3$, $p< 0.27$; ns. When it comes to interaction effects, the results show that independently of the group age or object nature, the condition "4000-ABA" favors the highest pass score, whereas the "500-BAB" appears to be the most difficult one – See figure 3. Yet this joint effect of speed and transformation order is much more present among young children and tends to fade away with age. The transformation order effect, ABA vs. BAB, is also different according to the stimuli. The effect order is not significant for natural objects at slow speed ($p<.06$) and for objects with manual function at fast speed ($p<.06$). Only for faces presented at fast speed (500ms) is significant ($p<.002$). When comparing the means pass score between ABA and BAB, the three groups together, shows a .81 difference for objects with manual function, .4 for natural objects and 1.27 for emotional faces. The difference observed is much important for emotional facial than for both types of objects. Last, at a speed of 500ms, though there is no difference between the ABA and BAB orders for adults whatever the type of stimuli, the BAB order affects childrens' performances. This effect is more pronounced when emotional faces are concerned than functional objects.

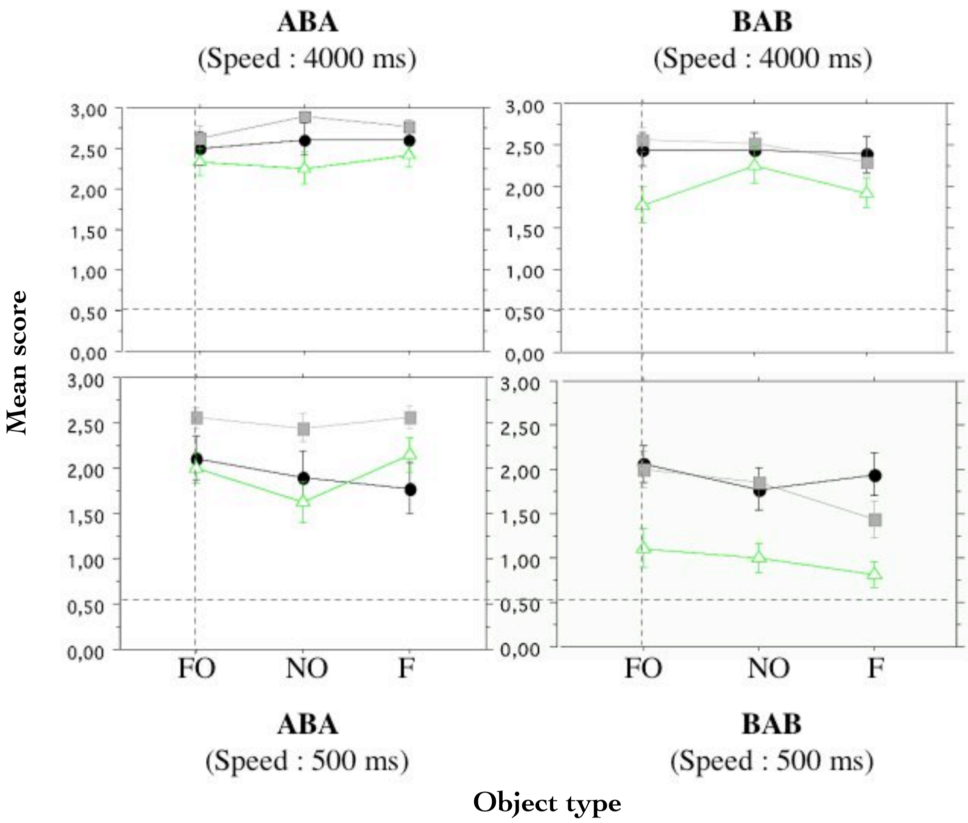

Figure 3: Effects of the type of stimuli (FO: functional object, NO: natural object, F: emotional face) on the number of successful trials according to the age of the participants in four conditions: 2

transformation orders (ABA, BAB) displayed in 2 speeds (500, 4000 ms), on 3 trials by condition; children (7-9); children (10-12); adults. This figure is displayed in an article in the *Enfance* review (in press).

Hence the difference observed in the average scores among the youngest children, in both 4000-ABA and 4000-BAB conditions is of .55 for faces, .48 for objects with manual function, whereas there is no difference for natural objects. To contrary, the difference observed in the average scores among the youngest children, in both 4000-ABA and 500-ABA, is of .33 for objects with manual function, .26 for emotional faces and .68 for natural objects. Hence the comparison of the average rates in both conditions "500-ABA" and "4000-ABA" show an effect of speed on natural objects, for 7-9 year-olds. Objects with manual function and emotional faces recognition are not made as easier by the slowing down of speed than for natural objects. But they principally benefit from the transformation order "ABA", whereas natural objects do not benefit at all of the latter, as the 4000-ABA / 4000-BAB difference is null.

3.2. Response time

In order to analyze response times, the values exceeding 3 Standard Deviation (SD) have been replaced by the average. This concerns 39 data items out of 2592, i.e. 1.5%. Furthermore, the data of three participants has been removed (108 data items) because their success rate is lower than 25%. The analysis therefore covers a total of 2484 data items.

Similarly to success rates, the 7-9 year-olds took more time to respond (3664ms, $SD = 2017$) than adults (2399ms, $SD = 1524$), themselves being slower to respond than the 10-12 year-olds (2307ms, $SD = 1384$). The RT difference between both groups is significant, $F(2.66) = 15.9$, $p<.0001$. Once again 10-12 year-olds perform better than adults, but this difference is not significant. The difference in response times obtained between both speeds is significant $F(2.66) = 13.1$, $p<.0006$. Both presentation orders and all three object types mixed, and with 3 trials per condition, i.e. over 18 trials, although the 4000ms speed leads to faster response times with a 2731 ms ($SD = 838$) average, the 500ms speed leads to longer response times with a 3081ms ($SD = 909$) average. This difference is observed in the three age groups. The order of transformation "ABA" or "BAB" does not have a big influence on response times. However, the 7-9 year-old groups take much more time to respond than older children and adults. This difference is significant: $F(2.66) = 15.8$, $p<.0001$. The difference in response times obtained in the three types of stimuli, both orders of transformation and both speeds together is very significant $F(2.64) = 13.1$, $p< .0001$. The youngest children take more time to answer when it comes to emotional face transformation than for natural objects, and even more than for man-made objects. This effect is all the more present when emotional faces are present in high speed.

4. DISCUSSION

Having designed a morphing set-up allowing the change of state of several categories of stimulus, we have compared the performances of three groups of subjects. The changes of state were presented with two different speeds and orders. This study is extensively exploratory because of the original usage of morphing on objects transformation and not only on faces as in previous studies [19, 20, 22, 23].

The results of this study show the main effects of factors (object type, speed, order and age) on the performances related to the visual perception of change of state. In particular, fast speed (500ms) affects children' perception for emotional transformations, increasingly when presented in BAB order. The analysis of the interactions between speed and order of transformation, allowed us to bring to light a difference in the processing of the natural objects and the stimulus involving perception and action couplings (natural object vs. objects with manual function and emotional faces) [39, 42]. Notably the response time was increased for functional objects and emotional faces foe children aged 7 to 9 years. A suggestion would be to explain the found increased response time in functional object transformation and faces, by the required activated motor mimicry during perception inhibiting response time. Also, the dominant effect of ABA over BAB could be explained by naturalness/ ecological validity of the transformation. We can thus suppose that the motor schemes facilitate the recognition of the changes of state, but in return, being more difficult to inhibit, the performances fall when the transformation correspond to the BAB order. This effect is more dominant for the children group, while this effect becomes blurred in the adult group. In the same way, the increasing response time for emotional faces and functional objects observed in the young children's groups suggest that the resonance mechanisms can slow down the speed of processing and inhibit response time. Besides, we notice that the processing of the natural objects' change of state is more sensitive to the variation of speed than to the morphing order. It would be possible that this speed sensibility is connected to the fact that the transformation does not match to the motor schemes, and that the absence of relation forms / function makes the perceptive processing less immediate [30]. Although the fall of performance of the functional objects and the emotional faces is present, they are not as strong as that of the natural objects. We also notice that our conditions do not allow the detection of an age effect for visual perception of natural objects change of state, because we observe almost equal scores for all participants for the natural objects as opposed to functional objects and emotional faces.

The results seem to confirm the hypothesis according to which the perceptive mechanisms involved in the perception of change of state differ according to the type of change of state (internal or external) belonging to the transformed entities. The differential matching to different representations levels (motor, emotional and cognitive) seems to have an impact on the type of processing triggered and therefore on the quality of identification of the change of state.

Application

Our results could help having a better knowledge of the perceptual-cognitive mechanisms involved in the perception of emotions versus object transformations. Notably developmental studies of autism can benefit from these exploratory results and the use of our set-up and our morphing database (FOT-DB). Within this perspective, we aimed at contributing to the development of new therapy or educational type of intervention techniques with autism diagnosed children.

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