Running head: SOCIAL MEMORY FOR GAZE DIRECTION

Social updating: The role of gaze direction in updating and memorizing emotional faces

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Abstract

The aim of the study was to investigate how gaze direction of same identity faces impacts on memorizing and updating processes. Faces are multidimensional stimuli, crucial for interpersonal relations. All their features must be bound and combined together to form a coherent social percept; in particular, the combinations between gaze direction and facial expression convey very relevant information concerning behavioral and social appraisal. In two experiments we manipulated the face's social and adaptive meaning by means of different association between gaze direction and facial expression: strong observer self-meaningful associations (e.g., joy-direct gaze) were compared to weak ones (e.g., joy-averted gaze). Shorter latencies were needed to update strongly associated combinations than weak ones (Exp. 1). More interestingly, the updating of strongly associated combinations was faster than simply memorizing them (Exp. 2). The findings are discussed with reference to updating and memorizing processes in social cognition.

Keywords: social appraisal; gaze direction; facial expression; memory processes.

Human faces are significant stimuli for interpersonal communication and social interaction because through faces people express not only their emotional states but also their behavioral intentions. Face appearance matters because some facial aspects or dimensions, in particular gaze direction and emotional expression, are so useful in guiding adaptive behaviour that they elicit a fast and implicit evaluation of a person (see Todorov, Said, Engell & Oosterhof, 2008 for a review). Faces are special and complex stimuli and all the features and configural properties of a person's face must be bound and combined together to form a coherent social percept. Indeed, from facial appearance people derive trait judgments which reflect evaluation of a person (i.e., appraisal; see e.g., Todorov et al., 2008). In particular, a combination of gaze direction and facial expression conveys the most relevant information concerning motivational behavior; therefore they are key elements for evaluation of a person. Wide evidence has demonstrated that these two facial dimensions interact in signaling basic behavioral tendencies such as approach or avoidance.

An ecological approach to social perception states that people's faces provide adaptive information about the social interactions they offer (Zebrowitz, 2006). In other words, face perception reveals social interaction opportunities (i.e., behavioural information) and is thereby closely linked to action. This means, for example, that an angry face encourages defensive behaviours and even more so when associated with direct gaze. Approach-oriented facial expressions such as anger or joy are enhanced when associated with direct gaze. Similarly avoidance-oriented facial expressions such as fear or sadness benefit when associated with averted gaze, this is because their combination facilitates behavioral tendency evaluation (Adams & Kleck, 2003; 2005; N'Diyae, Sander & Vuilleumier, 2009). According to appraisal theories of emotion, in fact, the combinations of gaze direction and facial expression indicate to the perceiver the self-relevance of the seen face: they convey information about behavioral motivation (e.g., approach or avoidance) and intentions towards her/him (Mumenthlaler & Sander, 2012; N'Diyae et al., 2009).

Face and person evaluation, first impressions from faces, along with how faces are memorized are key topics in social cognition (see Adolphs, 1999; Meyer et al., 2012; Spreng, 2013) since we respond to people on the basis of their facial appearance and our past experience with them. Pioneering work on the role of memory in social cognition, and specifically of person memory, can be found, for example, in Hastie et al. (1980) and in Srull and Wyer (1989). The authors found evidence of the importance of face memory on social behavior (e.g., judgment and social perception). Recently, the focus has moved to more specific aspects of memory, particularly to the role of working memory (WM) in social cognition, that is the capacity to maintain and manipulate information about people's beliefs, traits, and mental states, referred to as social working memory (see Meyer et al., 2012). Within this framework, memory is seen as a key cognitive process of the brain whose function is not simply to recall the past but also to form and update a representation of our social world which allows us to navigate in it (Spreng, 2013). To successfully do so, we need to maintain, retrieve, manipulate and update information about other people. In other words, to be engaged in a social interaction people need to keep track of different social information, such as for example first impressions and relationships among people. In addition, the people we interact with are not always consistent and social interaction requires continuous, flexible updating of our initial impression in the light of new information.

More importantly for the scope of the present study, social WM requires the processing and maintenance of a combination of several face dimensions such as emotional expressions, gaze direction, and identity, which are crucial to evaluate behavioural intention. However, to date very little research has been done on the social function of WM and in particular on memory updating. In fact, traditional WM research has focused on basic stimuli, but has neglected to incorporate social information that is necessary in the representation of our social environment.

Updating is a crucial function for WM as it consists of selecting and maintaining available relevant information, and removing it from a memory set when no longer relevant (e.g., Morris & Jones, 1990; Palladino, Cornoldi, De Beni & Pazzaglia, 2001). Indeed, updating represents a specific memory function; it is different from simply memorizing information, since when we memorize some stimuli we try to maintain all of them in memory; on the contrary, when updating memory, we do not have to maintain all stimuli but to just select some of them (those that are goal-relevant) and to remove the others. As such, updating should be especially important when dealing with any dynamic source of information. Research has traditionally investigated verbal messages or spatial sequences of different positions (see for example Palladino et al., 2001), but usually not human faces. However, this function should be especially important with faces, since to form person impressions people have to rapidly select relevant information from a face, to maintain it and if necessary, to update the initial appraisal of the observed person.

Faces are dynamic stimuli and request the joint processing of their invariant features for identity recognition, as well as the processing of their changeable features, such as gaze direction or facial expression (Haxby, Hoffman & Gobbini, 2000). Several studies have investigated the impact of one dimension, i.e., gaze direction or facial expression, on some aspect of human memory. For example, Mason, Hood and Macrae (2004) found that recognition memory for faces that participants saw in a learning phase with a direct gaze was better than memory for faces shown with averted gaze. Similarly, Vuilleumier and colleagues (2005), and Weisbuch, Lamer, and Ford (2013) reported higher memory accuracy for faces displaying direct gaze rather than averted gaze. Shimamura, Ross and Bennett (2006) showed an advantage for happy face memorization even when faces were inverted. Other studies investigated the combined effects of gaze direction and facial expression on memory. For example, Nakashima, Langton and Yoshikawa (2012) found that recognition memory for faces with angry expressions displaying averted gaze was poorer compared to that for faces with angry expressions displaying direct gaze. On the contrary, recognition memory for happy faces was unaffected by gaze direction. Similarly, D'Argembeau, Van der Linden, Comblain and Etienne (2003) observed that happy faces displaying direct gaze were remembered better than faces with angry expressions.

Altogether, these studies speak in favor of the importance of the combinatorial nature of social perception. Binding is a term mainly used in cognitive psychology to indicate an association between different stimuli or between different stimulus dimensions (see e.g., Piekema et al., 2010), and in this context it describes well a combination between gaze direction and facial expression within a face. Specifically, the binding between gaze direction and emotional facial expressions is what determines the social meaning and value of a seen face, and this is what seems to have an impact on the different memory processes. According to the shared signal hypothesis (Adams & Kleck, 2003; 2005), in fact, the specific combination of gaze direction and emotional expression (i.e., the binding between these two facial dimensions) is what enhances face processing. That is, cues relevant to threat (e.g., direct gaze and angry expression) share the same signal value which facilitate processing when emotion and eye gaze are combined in a congruent manner (e.g., both signalling approach) relative to an incongruent manner (e.g., one signalling approach and the other avoidance). Therefore, not all the combinations have the same power or strength to influence processing: a congruency of meaning between eye-gaze and emotion would denote a stronger binding between these two dimensions, and this in turn would exert a stronger effect on stimulus processing and WM processes. Interestingly, Artuso, Palladino and Ricciardelli (2012) found that an observer's self-meaningful associations between gaze direction and facial expression (such as joyful faces displaying direct gaze) were updated faster in memory than less self-meaningful associations (such as joyful faces displaying averted gaze) suggesting that WM is sensitive to the gaze-emotion binding. Specifically, the bindings that convey the same social and adaptive meaning exert a stronger influence on updating. Artuso and colleagues defined strong bindings as those associations between gaze direction and facial expression which were demonstrated to have interactive and congruent effects, i.e., as both signalling approach such as joy-direct gaze or fear-averted gaze. Weak bindings were instead defined as those associations between gaze direction and facial expression which were less meaningful for the perceiver since they did not share the same communicative value (thus, weakly bound together), such as joy-averted gaze or fear-direct gaze (see Adams & Kleck, 2003; 2005).

Interestingly, in Artuso and colleagues' work the experimental procedure took into account the accuracy rate (see e.g., Morris & Jones, 1990) and the step-by-step response latencies allowing isolation of the specific processing phases involved in encoding, maintenance and updating of information. Participants had to firstly study the visual appearance of a face (i.e., encode it) and then to retain the information about that face, rehearsing it in memory (i.e., maintaining and rehearsing that face, at the maintenance stage) or substituting part of that information (i.e., updating it). This experimental procedure has been successfully employed using letters as stimuli (see Artuso & Palladino, 2011; 2014) and was extended to study the updating of different combinations of gaze direction and facial expression (Artuso et al., 2012). To specifically favour the updating, the task required the creation of couples involving consecutive gaze direction (or facial expression) and replace them as the task went on. Through this procedure, the updating was explicitly encouraged, and such a fine-grained approach appears to be preferable to the mere accuracy measure (for a comparison between the tasks see Artuso & Palladino, 2014). Therefore, in addition to recall accuracy we also recorded response latencies.

In their study Artuso and colleagues (2012) found that both in encoding and in updating, strong bindings (e.g., joy-direct gaze), were advantaged (i.e., showed shorter response latencies) relative to weak bindings (e.g., joy-averted gaze). This advantage for strong bindings was accounted for by the fact that faces are important stimuli for social and interpersonal behaviour; therefore, these stimuli need to be updated quickly in order to be beneficial to our social behaviour. Further, it was found that the updating of strong bindings was more difficult compared to its encoding; this was interpreted as due to the higher number of operations needed during updating. For example, the substitution of information has been identified as a unique updating operation especially in terms of removal of outdated information. However, a possible ecological limitation of the study was that in the updating task face identity continuously changed during the same trial.

In every-day situations the identity of the face we are looking at (or interacting with) rarely changes in a very short period of time (within a second). In fact, the most highly relevant social interactions which can strongly impact our social environment are those which take place in dyads or couples where people and their face identity remain the same for a certain period of time, e.g., mother-son; friend-friend; professor-student. Interestingly however, while identity remains the same, the changeable aspects of gaze direction and/or facial expression may vary. For example, in a discussion it is highly important to recognize changes in gaze direction in order to understand the reactions and intentions of the other person. This is not trivial, rather is an essential part of the social interaction and communication process. If during the relationship we miss this aspect of non-verbal communication, either gaze direction or facial expression, sometimes the verbal medium is not enough and can even be poor or not thorough (e.g. Hall, Coats & LeBeau, 2005). On the contrary, in situations where face identity changes continuously such as in groups or crowds, the individual is presumably less involved, and therefore the interaction is less relevant for him/her.

The purpose of the present study was therefore to investigate the process of updating gaze direction-facial expression associations in situations more similar to a dyadic relationship, by using a task where face identity did not change in the same trial. Participants were required to encode, memorize or update gaze direction since it has been shown that it has a primary role in specifying the context of emotion and thus in determining the consequent social appraisal of the seen face (e.g., Milders et al., 2011).

In the first experiment we aimed to extend Artuso et al.'s study by making the task more ecologically valid using the same face identity throughout the trial in both experiments; thus, the only change within the same trial could be either in the gaze direction or in the emotional expression. In our view, this is more similar to everyday situations in which the most relevant situations are those in which someone is interacting with the same people. In both experiments we used the same stimuli but in Experiment 2 we contrasted the updating process to the memory process, to test the specificity of any gaze direction-facial expression binding effect. To this end, we instructed participants to memorize gaze direction only in one case or to update gaze direction in the other case.

Experiment 1

In the first experiment we studied how different combinations of gaze direction and facial expression within the same face identity were updated in WM. Specifically, we were interested in the updating of gaze direction when facial expression context was either strongly or weakly associated with it (see Adams & Kleck, 2003). Specific facial expressions and their social meaning (face appraisal), in fact, depend upon the direction of gaze displayed by the face. For example, an angry face displaying a direct gaze is more meaningful for the observer than the same face with the gaze averted, since the former indicates that the target of the anger expressed by the face is the observer him/herself. Moreover, the gaze direction itself communicates where the attention of the other person is directed, thus indicating her/his interests and future social intent. Given these premises and the importance of gaze direction in determining the social meaning of faces, in the present experiment we focused only on the updating of gaze direction; in our previous study (Artuso et al., 2012) we found that the updating of facial expression was less relevant in determining social appraisal. To provide a direct comparison with previous findings we employed the same task used in 2012; the only difference being that in the present study the face identity remained the same during the trial. This was done in order to increase both the ecological validity and the social relevance of the task. On the basis of our previous findings we expected to find shorter response times in the updating of strongly bound associations between gaze direction and facial expression (e.g., joy-direct gaze) compared to weakly bound associations (e.g., joy-averted gaze). Second, we expected that ecological validity would interact with memory processes so boosting orfacilitating the most meaningful and adaptive ones, i.e. strong bindings.

Method

Participants

The participants (N= 25; mean age = 23.48 years; two males) were undergraduates from the University of Pavia. All volunteered in exchange for partial course credits, gave their informed consent and were naïve as to the purpose of the experiment. The study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki, and fulfilled the ethical standard procedures recommended by the Italian Association of Psychology (AIP).

Apparatus and Stimuli

The computerized updating task used in Artuso et al.'s paper (2012) was employed. Stimuli were presented on a 17" monitor driven by an Asus computer, located about 60 cm from the observer. Stimulus presentation and response time (RT) registration were controlled by SuperLab software.

The stimuli were colour photographs of faces selected from the Radboud Faces Database by Langner and colleagues (2010) and measured 5.6˚ x 6.8˚. Ten individuals were selected (five females and five males) and multiple versions of each photograph were used, showing joyful, fearful or neutral facial emotional expressions. A central face with the neutral facial expression was always presented at the start of the trial to allow participants to adapt (stimulus adaptation; see also below). At this phase, the eyes were occluded by uniform pink colored regions that matched the eye region area. The occlusions were removed as the task started. Each face expression was taken with either direct or averted gaze. Gaze direction and facial expression combinations were counterbalanced within faces.

Procedure and Design

The participants were presented with trials composed of three photos each; they were told that the same face identity was presented throughout the same trial, but with different facial expression or gaze direction combinations.

The participants were instructed to encode the displayed photos and, when necessary, to replace (i.e., update) the information about two consecutive faces, in terms of gaze direction. At the end of the trial they were asked to recall the gaze direction of the last or next-to-last face. Therefore, in order to correctly perform the task they had to keep in mind two consecutive photos (i.e., first and second, or second and third). Participants received the specific instruction to focus on and memorize gaze direction, disregarding facial expression.

All the trials started with an initial stimulus adaptation phase in which a neutral face with covered eyes was presented. Then, participants had to press the spacebar to start the experimental trial which comprised a trial of three photos. At the end of it a recall test was displayed. The fixed sequence is exemplified in Figure 1 and was as follows: an encoding phase in which a first photo was presented; a maintenance phase in which a second photo was presented and the participants had to keep in mind the first couple of photos; an updating phase in which a third photo was presented and the participant was required to disregard the first, keep in mind the second, and add the third photo. Thus the previous two photos had to be remembered in order (i.e., the first and the second). This process represented the updating function in terms of keeping in mind and substituting irrelevant information (see Palladino et al., 2001). On presentation of the third photo since the task required keeping in mind the last couple of photos presented, the participant had to keep in mind the second and the third, (thus substituting the first with the third and removing the first from WM).

At the encoding, maintenance or updating phases the presented photographs could differ in a critical dimension (gaze direction or facial expression). Each trial could represent strong or weak binding. If strong, the binding was represented by the following combinations: joy-direct gaze; fear-averted gaze. If weak, the binding was represented by the following combinations: joy-averted gaze; fear-direct gaze.

At the end of each trial, participants were asked to recall the gaze direction of one of the last studied couple of photos. The prompt for recall (which face had to be recalled, i.e., the last or the next-to-last face) was displayed in the centre of the screen in writing: either "last" or "next-to-last". Participants responded by pressing keys on the computer keyboard : key "M" for direct gaze, key "Z" for averted gaze (regardless of whether the gaze was averted to the left or to the right).

The variables of interest were Binding and Phase. Binding was manipulated through the strength of the specific association between gaze direction and facial expression within faces (see also Introduction). Thus, strong bindings were the associations between gaze direction and facial expression previously demonstrated to have interactive effects as both signalled approach, i.e. joy-direct gaze and fear-averted gaze; weak bindings were instead defined as those associations between gaze direction and facial expression which are less meaningful for the perceiver since they do not share the same communicative value, i.e. joy-averted gaze and fear-direct gaze.

The Phase variable had three levels corresponding to each specific phase of the task: encoding, maintenance and updating, each engaging the participant with a specific request (as previously explained).

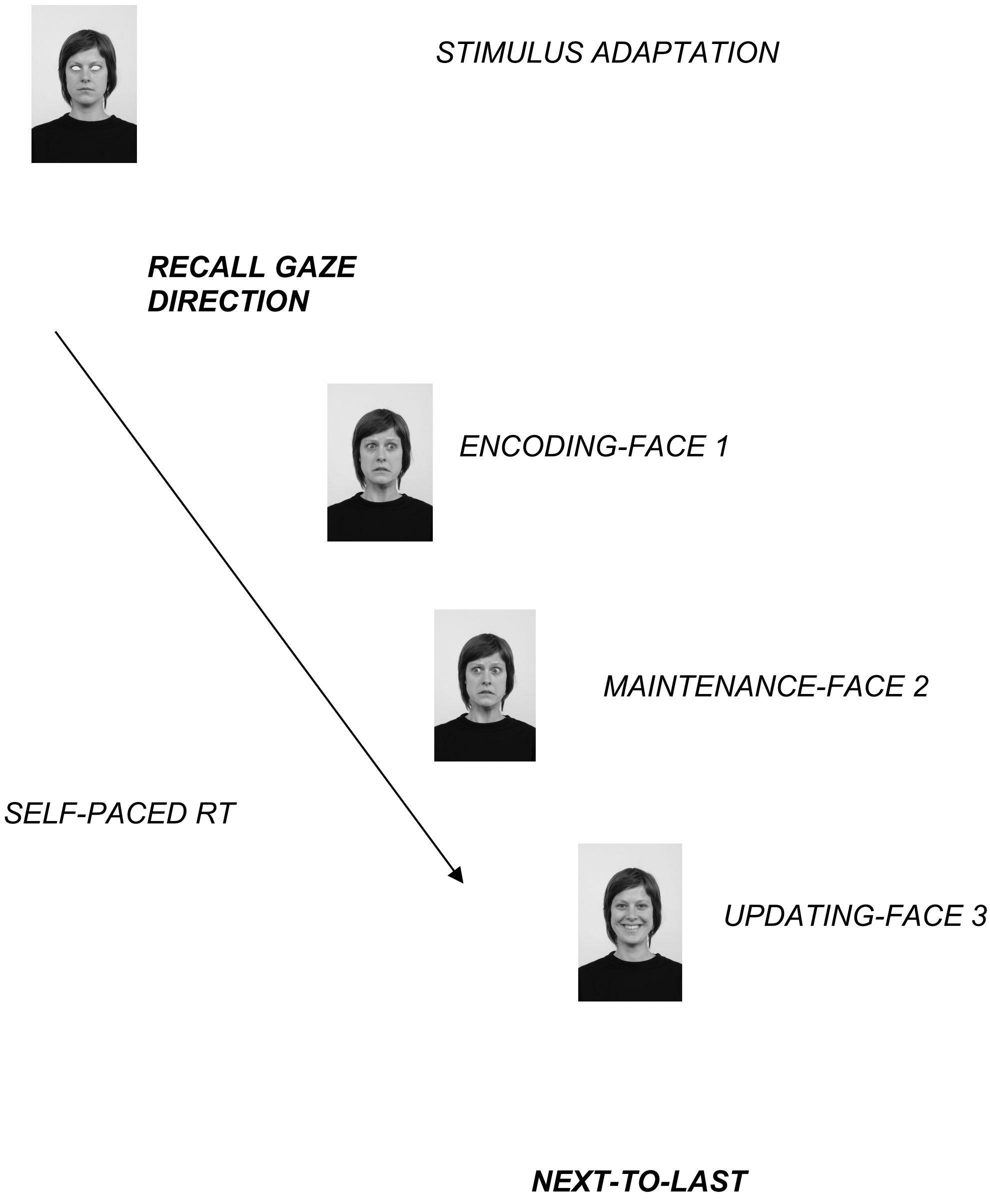
The task was self-paced, that is, the participants pressed the spacebar to start each trial and again after each phase of the trial, in order to carry on with the task. The RTs for each of the study and updating phases were collected as dependent variables. In addition, accuracy rate at the final recall test was measured.

After sixteen practice trials, a total of one-hundred and forty-four trials, divided into four experimental blocks, were presented individually to the participants.

Results

Only trials in which the recall was correct were analyzed (94.62 %). We focused our analysis only on task self-paced RTs, which have been shown to be much more sensitive to the updating process (see e.g., Artuso & Palladino, 2011).

Figure 1


STIMULUS ADAPTATION
RECALL GAZE DIRECTION
ENCODING-FACE 1
MAINTENANCE-FACE 2
SELF-PACED RT
UPDATING-FACE 3
NEXT-TO-LAST

Data treatment

RTs faster than 150 ms or exceeding individual participant means for each condition by more than three intra-individual standard deviations were considered outliers and therefore excluded from the analyses (5.83%). The RTs for the encoding, maintenance and updating phase were calculated as follows. The RT was computed starting from the onset of the first photo until the participants (having encoded, maintained or updated the photo) pressed the spacebar to continue the task. Then, the mean RTs were computed for each specific phase. The mean RTs of the encoding phase were computed by averaging the RTs of all the encoding phases of each condition for each participant. An analogous procedure was used to calculate the mean RTs for the maintenance and the updating phases.

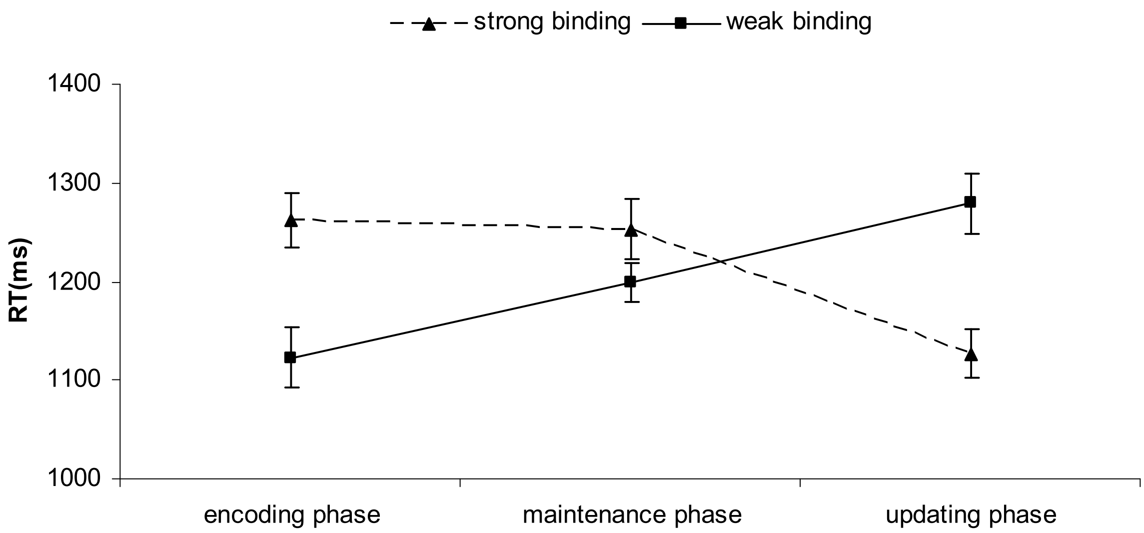
Analysis

The response times (RTs) were then entered in an ANOVA with Binding (strong, weak) x Phase (encoding, maintenance, updating) as within-subjects factors.

Neither Binding, $F(1, 24) = .49$, partial $\eta^2 = .02$, $p = .491$, nor Phase, $F(2, 48) = 1.31$, partial $\eta^2 = .05$, $p = .28$, reached significance. However, the two-way interaction between Binding and Phase reached significance, $F(2, 48) = 28.06$, partial $\eta^2 = .54$, $p < .001$. See Figure 2.

Simple effects showed longer RTs at the encoding phase for strong bindings compared to weak bindings ($p < .001$); the opposite pattern was found at the updating phase, with faster RTs for strong bindings relative to weak bindings ($p < .001$). At the maintenance phase, strong and weak binding response times did not differ ($p = .12$).

Figure 2.



Discussion

Our results showed that the encoding of gaze direction in strong bindings was more difficult than in weak bindings. Second, we found that the updating of gaze direction was faster (thus easier) in strong bindings than in weak bindings.

Intriguingly, the results obtained for the strong binding conditions seem to be contradictory to the ones reported in our previous study (Artuso et al., 2012) and counterintuitive. At the updating phase, the present results support previous findings, with shorter response latencies for the strongly bound combinations; the fact that strongly bound combinations such as joy-direct gaze were updated faster than weakly bound ones can be accounted for by the social and interpersonal importance of faces; for example, these associations need to be updated quickly in order to be beneficial to our social behaviour.

On the contrary, at the encoding phase, the present results show longer response times for strongly bound associations than for weakly bound ones. However, it should be noted that the additional time needed to encode such faces could be due to the additional encoding of face identity. Since it did not change within trials face identity onlyneeded to be encoded at the beginning of each trial; this additional facial information resulted in a lengthening of the encoding phase, .

However, an alternative explanation of the fact that we found shorter updating RTs for strong binding conditions (relative to the encoding phase) could be due to the fact that participants had already maintained in memory all the information from the faces, thus there was no need to update it. In fact, since the same face identity was presented in the trial, participants could just have maintained in WM the presented photos as a trial of three single items with no need to group them into couples and update the memory content. Therefore, in this case the advantage found for strong binding conditions could be a consequence of their preferential processing and memorization and not due to the fast updating of the face appraisal.

For this reason and in order to better investigate the effect of gaze direction and facial expression bindings on the updating of photos of the same individual, we ran a second experiment, identical to Experiment 1, in which we directly compared an update task to a memory task. The comparison between Experiment 1 and 2 would allow us to demonstrate that in Experiment 1 participants were really updating their memory contents and not simply maintaining all the presented information as a chunk. To this end, in Experiment 2, we compared the same updating task used in Experiment 1 with a condition in which participants had to perform a memory task. That is, participants were simply instructed to keep in mind all the presented faces as in standard short-term memory tasks (e.g., Palladino & Jarrold, 2008).

Furthermore, in Experiment 1 we only had trials composed of three photos and this could have been a problem as the trial length was too predictable and participants could have used strategies to perform the task or could have stayed less alert. In fact, they always knew that three photos would be displayed and that an update was requested. Therefore, in Experiment 2 we varied the number of photos displayed so that they ranged from two to three. Adding the new two-photo trials served as a control since it made the task less predictable, prevented participants from using strategies, and made them more alert.

Experiment 2

This experiment aimed to demonstrate that the participants in Experiment 1 were actually doing a gaze direction update task and not simply maintaining in memory all the information presented during the trial. Specifically, our main aim was to compare a memory task with an update task, to show that the advantage found for strong binding conditions is specific to updating and absent in memory.

We then expected to replicate the results found in Experiment 1 for the update task and to find differences between the two tasks in terms of RTs (i.e., longer RTs for updating relative to recall due to the increase in the cognitive operations required in updating - see also Experiment 1 rationale). In order to compare updating and memory, we manipulated the instruction given to participants. To test memory, participants were instructed to encode and maintain (to remember) all the information they saw (i.e., all the gaze direction of the faces they saw as a serial order, either two or three). To test updating, they were instructed to maintain couples of faces and replace the first when a third was displayed (as explained in Experiment 1). By comparing the two instruction types, we evaluated whether the advantage for strong bindings was due specifically to updating, or to a general/unspecific memory effect.

In addition, to make the task less predictable we used a control and an experimental task. The control task consisted of two photo trials and the experimental task consisted of three photo trials (as in Experiment 1). See below for details.

Method

Participants

The participants (N= 34; mean age = 23.26 years; four males) were undergraduates from the University of Pavia. None of them had taken part to Experiment 1. In Experiment 2 there were two different main tasks: a memory task and an update task. Two subgroups of participants were randomly created and assigned to either the memory task or the updating task. Within each main task, all of the participants then performed a control task consisting of two-phase trials and an experimental task consisting of three-phase trials (see next section). All volunteered in exchange for partial course credits, gave informed consent and were naïve as to the purpose of the experiment. The study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and fulfilled the ethical standard procedure recommended by the Italian Association of Psychology (AIP).

Procedure and Design for the main tasks

The apparatus, material and procedure were the same as for Experiment 1, except for the instructions.

The control task (two-phase trial task) consisted of trials which required only two phases (encoding of the face, maintenance of the face). The variables of interest were Instruction (memory, updating), which was manipulated between-participants, and Binding (strong, weak) and Phase (encoding, maintenance) which were manipulated within-participants. The Instruction could request either a memory procedure or an updating one. From a procedural point of view, the memory and updating trials were identical, except for the instructions which were expected to produce different processes: in the case of memory, participants had to keep in mind the two presented faces with no substitution of information; whereas in the case of updating they had to keep in mind a couple of faces and replace the first one with the third/last one that was presented (see Experiment 1 procedure). It should be noted that in the control task the updating instruction still asked the participants to update the faces (see also below) but actually they always saw a two-face length trial and they could not predict whether the trial ended after two faces of whether a third face would be presented. This was done in order to make the task less predictable.

The experimental task (three-phase trial task) was made up of trials which required three phases (encoding of the face, maintenance of the face and its updating) and was identical to the task used in Experiment 1. The variables of interest were Instruction (memory, update), which was manipulated between-participants, Binding (strong, weak) and Phase (encoding, maintenance, updating) which were manipulated within-participants. Again, from a procedural point of view, the memory and updating trials were identical, except for the instructions which were expected to produce different processes: in the case of memory, participants had to keep in mind the three presented faces with no substitution of information to be performed; whereas in the case of updating they had to keep in mind a couple of faces, i.e., disregarding the first, keeping the second in mind and adding the third, thus keeping in mind the prior two photos in consecutive order (see also Experiment 1 procedure).

Note that not all the participants were instructed to update and memorize; half of them had to perform an update task and the other half a memory task. All of them were given both the control and the experimental task.

For both tasks, at the end of each trial (either memory or updating) participants were asked to recall the gaze direction of the last or the next-to-last face. The prompt for recall was the same as for experiment 1 (i.e., the word “last” or “next-to-last) and was displayed in the centre of the screen.

In order to contrast performance in the main memory and updating tasks we performed data analysis separately for the control and experimental tasks.

Results

Only trials in which the recall was correct were analyzed (95.83 %). As we obtained high accuracy at recall, we focused our analysis only on task self-paced RTs (see also Experiment 1).

Data treatment

RTs faster than 150 ms, or exceeding individual participant means for each condition by more than three intra-individual standard deviations were considered to be outliers and therefore excluded from the analyses (4.72 %). Thus, for control task trials we computed RTs for both the encoding and maintenance phases. Similarly, for experimental task trials we calculated RTs for the encoding, maintenance and updating phases. The RTs were computed starting from the onset of the presented face until the participants (having memorized/updated the face) pressed the spacebar to continue the task and see the next face.

Given that the control and experimental tasks differed in the number of phases (i.e., two phases in the control and three phases in the experimental condition) and followed different experimental designs, we ran two different analyses.

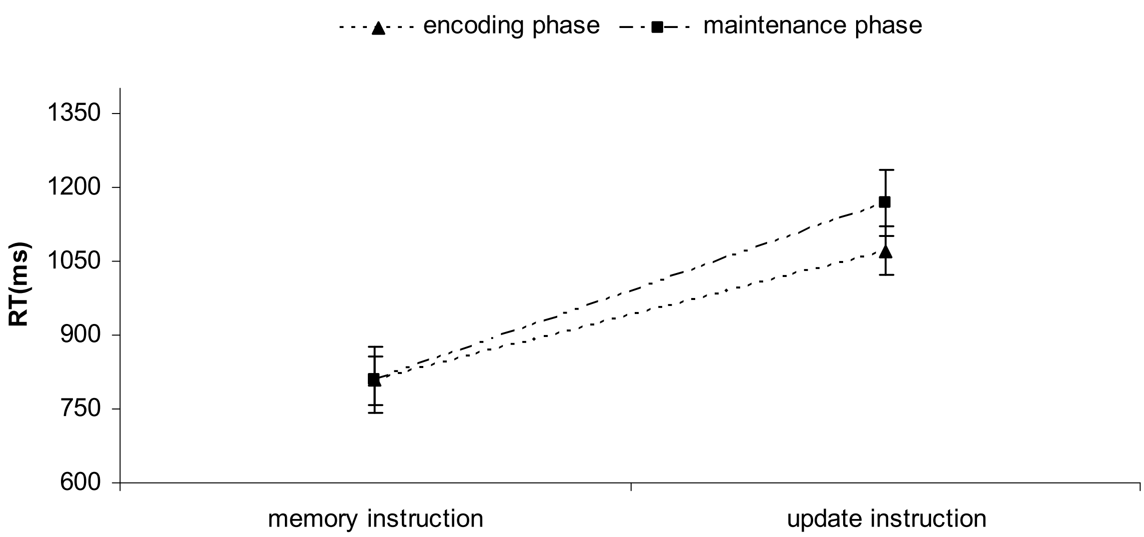
Control task analysis

An ANOVA with Binding (strong, weak) x Phase (encoding, maintenance) as within-subjects factors and Instruction (memory, update) as a between-subjects factor was run on self-paced RTs.

The Instruction main factor reached significance, $F(1, 32) = 7.83$, partial $\eta^2 = .20$, $p < .001$. This showed faster response times for trials where participants were instructed to memorize, compared to those where they had to update information.

The two-way interaction between Instruction and Phase reached significance as well, $F(1, 32) = 7.36$, partial $\eta^2 = .19$, $p = .011$. Simple effects analyses showed that overall response times were slower when an update instruction was given to participants. Moreover, when the memory instruction was given, the encoding and maintenance phases did not differ ($p = .974$); in contrast, when the update instruction was given, the maintenance phase took longer than the encoding phase ($p < .001$). See Figure 3.

Figure 3.



Experimental Task analysis

An ANOVA with Binding (strong, weak) x Phase (encoding, maintenance, updating) as within-subjects factors and Instruction (memory, update) as a between-subjects factor was run on self-paced RTs.

The Instruction reached significance, $F(1, 32) = 13.21$, partial $\eta^2 = .29$, $p < .001$. This showed an advantage for trials where participants were instructed to memorize, compared to those where they had to update information.

The three-way interaction between Binding, Instruction and Phase was significant too, $F(2, 64) = 5.61$, partial $\eta^2 = .15$, $p = .005$. Simple effects analyses showed that overall response times were slower when an update instruction was given to participants.

In strong bindings, when the memory instruction was given, the phases of encoding, maintenance and updating did not differ ($p = .92$); by contrast, when the update instruction was given, the updating phase was faster than the encoding and maintenance phases ($p < .001$), as shown in Figure 4a (Figure 4 has been split into two different graphs, one for strong bindings and one for weak bindings).

In weak bindings, when the memory instruction was given, the phases of encoding, maintenance and updating did not differ ($p = .10$); in contrast, when the update instruction was given, the updating phase was slower than the encoding and maintenance phases ($p < .001$) as shown in Figure 4b.

Figure 4a

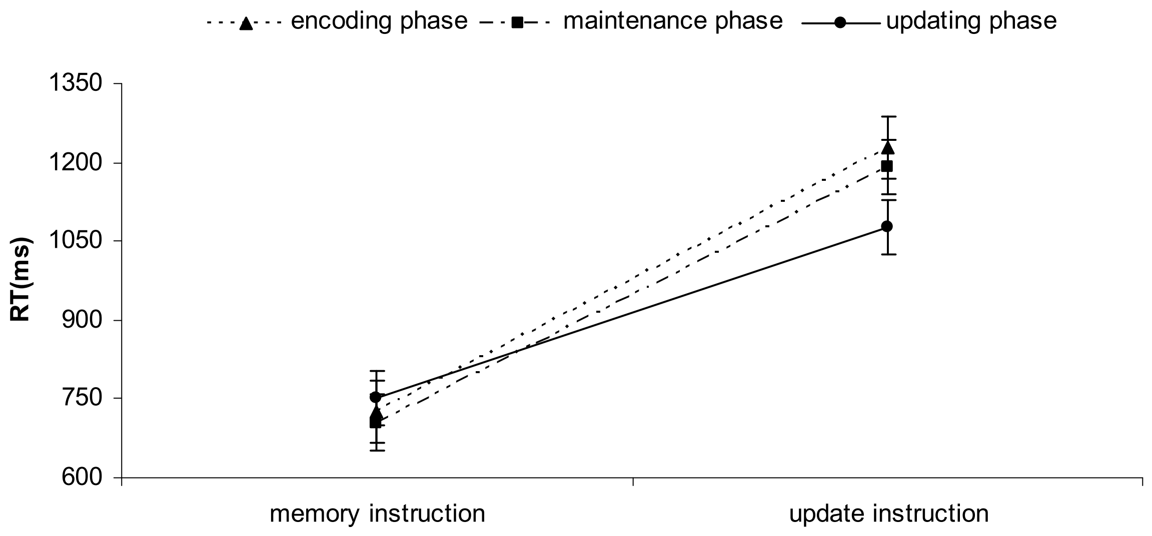
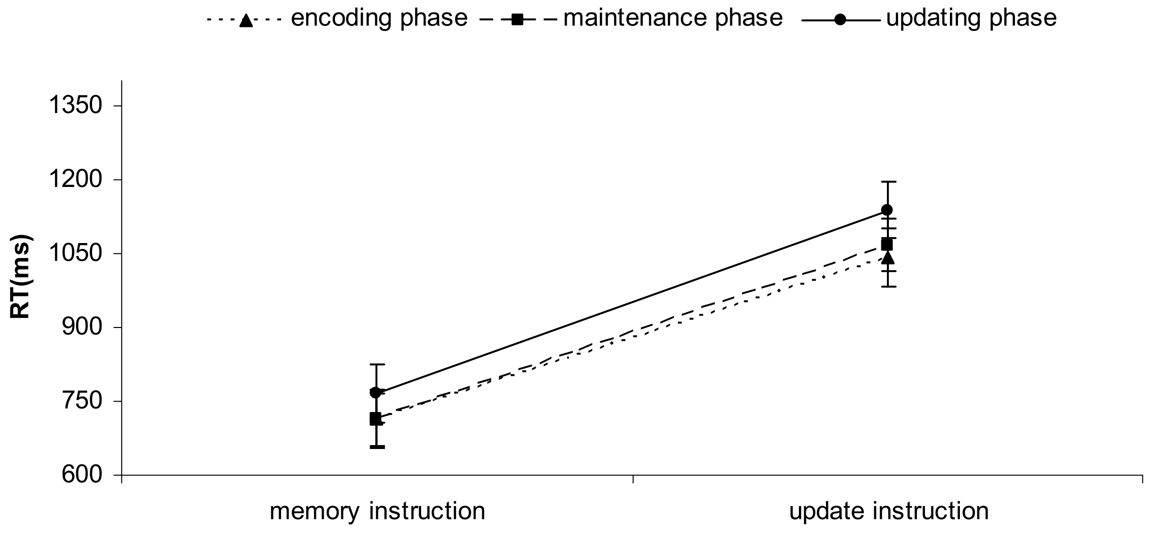


Figure 4b



Discussion

The results from Experiment 2 replicated and extended the findings from Experiment 1 since they showed that the update task was more demanding/difficult than the memory task. Moreover, when participants were instructed to update (but not when instructed to memorize) we observed a different pattern of response between strong and weak binding conditions at different phases. At the updating phase, strong binding trials showed shorter RTs (relative to weak bindings); at the encoding phase, strong bindings showed longer RTs than weak bindings.

Interestingly, the difference between memory and update trials instruction was observed not only in the experimental task (which is more obvious) but also in the control task where no updating actually took place. This indicates that our manipulation was effective. As previously said in fact, the control task was designed to make the task less predictable and to prevent participants from using strategies and keeping them more alert. As participants did not know the length of each trial they were less likely to use strategies and they were ready to respond.

General discussion

The aim of the present study was to extend the investigation of how gaze direction, strongly or weakly associated with a facial expression in terms of meaning and motivational behaviors (approach and avoidance), modulates specific memory processes, such as memorizing and updating. This was done by using a task where face identity did not change within the same trial, in order to focus on socially meaningful and ecologically valid situations. Among social cognition processes, one of the most important abilities is to interact face-to-face with other people in relevant and frequent communication (e.g., professor-student). In order to achieve this, a primary role is played by the capacity to memorize, (self-) represent the gaze direction of others, and update this representation as the communication unfolds. These memory functions extend to other social cognition abilities such as for example real-time person perception which relies on continuous, flexible updating of our initial impressions based on new information (Mende-Siedlecki, Cai, & Todorov, 2013). In the present study we asked participants either to update or memorize gaze direction of the same face which was combined with different facial expressions in order to provide different social information.

Our first finding was that the updating of strongly bound associations between gaze direction and facial expression was faster than the updating of weakly bound associations. On the contrary, at the encoding stage we found the opposite pattern, since strong bindings took longer to be encoded than weak ones. Thus, only at the updating stage did we replicate a pattern of advantage for strongly bound associations, similar to that obtained in our previous study (Artuso et al., 2012). Of major interest for every day social interaction is that in the present study the advantage was obtained by using the same face identity throughout the trial (see also Levens & Gotlib, 2012).

In addition, we found that this pattern of results was observed in both experiments even when controlling for possible task bias effects such as the use of strategies (by comparing a control and an experimental task in Experiment 2). Crucially, we instructed participants to update or to memorize sequences of faces and we found that even in the control task, where updating was only a possibility it did not occur (see analyses of control condition of Experiment 2), and participants took longer to perform the task. Longer RTs in the control task where no updating was actually required can be due to the fact that the trial length was unknown to participants who had to get prepared either to perform or not perform the updating. As previously described, in fact, participants, by not being aware of the trial length and trial end, always had to be alert and ready to respond (quickly and accurately). This finding is interesting since it is in line with studies using traditional stimuli, such as digits or letters, and may be considered as a marker of the updating task (see e.g., Palladino & Jarrold, 2008). In addition, the result is interesting from a social perception point of view. In fact, every time we see a face, we are actually in a condition of uncertainty since in a short time it will be difficult to forecast if the face of the person we are talking to, or interacting with, will gaze away or will change facial expression.

It’s worth noting that the advantage (i.e., shorter RTs) for updating compared to encoding found in the strong binding conditions differs from what we found in our previous study, where the updating of strong bindings required longer RTs than encoding (see Artuso et al., 2012). However, in our previous study new face identities were always presented within the same trial and the cost incurred in updating strongly bound combinations of gaze direction and facial expression (slower RTs) was interpreted as due to both the updating of the binding between two consecutive faces who changed in identity and the updating of the appraisal of the gaze/expression binding of the new face. Weakly bound combinations of gaze direction and facial expressions have very little meaning for the observer therefore its updating either does not occur or requires less effort than the updating of the meaning of strongly bound gaze direction-facial expression combinations.

By contrast, in the present study, we did not find a cost in updating strongly bound associations relative to encoding, but rather we observed an advantage. This might be a consequence of the fact that when people first see the face, they have to encode a new face identity, as well as gaze direction and facial expression. In the present study, the face identity did not change during the trial, so people could carry on with the task without needing to take identity into consideration any more. In addition, we believe that the updating was faster here also because the process required by the task was more ecological and matched better the usual memory and updating processes required in a dyadic communication (Hall et al., 2005; Tronick, 1989). In fact, having to encode, memorize and update the gaze direction within the same face, is something that is more similar to what is required in a daily activity in which a new face does not change at each phase.

Also, it's worth noting that the effect was specific for updating memory trials and not just due to a general memory process, as it was absent in the memory trials. The results, in fact, can be better understood if we assume that in the process of memorizing information usually the observer does not need to update face information (i.e., to replace irrelevant information by removing it from memory); consequently, he/she does not have to update the face appraisal either. In such a task the participants are likely to simply learn a sequence and keep in mind all the stimuli, as in traditional memory tasks, e.g. letter span tasks, where a sequence of stimuli has to be memorized serially.

In addition, there was evidence of the validity and reliability of our updating task as we found longer RTs in updating trials vs. memory trials also in the control condition, where no updating actually took place. This can, in fact, be interpreted as a preparatory or anticipation effect, due to the fact that the trial length was unknown to the participants who had to be prepared either to perform or not perform the updating. This finding is also interesting since it is in line with studies using traditional stimuli, such as digits or letters and may be considered as a marker of the updating task (see e.g., Palladino & Jarrold, 2008).

Taken together, these results represent an original way to study a cognitive single process, such as memory updating, and its impacts on social cognition processing. . We showed that a dimension of a social stimulus (i.e., gaze direction of a human face) and possibly the appraisal processes involved in person perception exert different effects on the processes of updating and memorizing. This is interesting since it provides new knowledge about social WM (Meyer et al.,2012). Namely, the ability to maintain and manipulate information about other people: a process needed for successful social interaction. In every day life, in fact, the face of others is not a static image but rather a constantly shifting stream of expressions that convey different mental states and behavioural intentions which we need to track in order to adapt in our social environment.

The advantage observed in updating strongly bound stimuli could represent also an adaptive approach to highly changeable social stimuli like faces. Studies of attention (e.g., Gabay & Henik, 2008; Sapir, Soroker, Berger & Henik, 1999) have shown that people are more likely to re-orient their attention to new stimuli or non-explored portions of space. Similarly, in our study, participants may simulate a communicative socially meaningful condition where faces change continuously and frequently. In fact, they were expected to be ready to code and memorize the changes in gaze direction of the face they were observing. Therefore, the ability to detect any change in the face with which we are interacting could be part of a more general adaptive ability, allowing us to orient to novel stimuli or novel dimensions of a stimulus.

Future research is needed to explore the role or possible impairments of memory updating for social stimuli, such as faces in populations where it has been shown that there is a scarce comprehension and appraisal of social stimuli, such as in psychopathological disorders (see Keltner & Kring, 1998) as well as to test for possible interesting gender[1] or cross-race effects (see Adams, Pauker & Weisbuch, 2010). Moreover, it would be useful to investigate the functional brain networks and the neural dynamics underlying face updating which may involve the same regions associated with the updating of person impression (Mende-Siedlecki et al., 2013).

In conclusion, our study represents an original contribution to the investigation of how the direction of gaze, when strongly or weakly associated with a facial expression, impacts differentially on distinct processes of updating and memorizing.

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Footnote

[1] We acknowledge that that participants' gender could matter. However, in the current work we did not analyze a possible effect of gender due to the reduced number of males in the sample.

Figure caption

Figure 1. An example of a trial with gaze direction and facial expression strongly bound together presented in Experiment 1. After the initial stimulus adaptation phase, in this example the participants were instructed to focus on and memorize the direction of the gaze of the face, disregarding the facial expression. After reading the instruction, they had to press the spacebar to see each face of the trial sequence. The self-paced experimental part of the trial started when the first face (Face 1, displaying here an averted gaze) appeared. Since the task was to recall at the end of the trial the direction of the gaze of either the last or the next-to-last of the seen faces, the participants had to memorize the direction of the gaze of Face 1 and to keep it in mind along with the that of the following face presented. Then, when the participants pressed the spacebar, the second face (Face 2) was presented. Here again, the face showed an averted gaze. At that point, participants had to keep in mind the gaze direction of the first two faces (Face 1: averted–Face 2: averted). Next, when the third face appeared with a direct gaze, an updating phase took place. In it the participants had to replace the direction of the gaze of the first memorized face (averted) with the most recent one (direct). Namely, they had to replace the direction of gaze of Face 1 with the direction of gaze of Face 3, thus updating their representation. They now had in mind the new association of gaze direction (Face 2: averted-Face 3: direct). Finally, at the end of the trial, at the recall test phase, in this example they had to recall the next-to-last memorized gaze by pressing the key corresponding to direct gaze on the keyboard. The stimuli are reproduced in gray scale.

Figure 2. Experiment 1: Mean RTs of strong and weak Binding trials as a function of Phase (encoding, updating). Error bars represent 95% CIs.

Figure 3: Experiment 2 Control task: Mean RTs of memory and update instruction as a function of Phase (encoding, maintenance). Error bars represent 95% CIs.

Figure 4a: Experimental task strong binding: Mean RTs of memory and update instruction as a function of Phase (encoding, maintenance , updating). Error bars represent 95% CIs.

Figure 4b: Experimental task weak binding: Mean RTs of memory and update instruction as a function of Phase (encoding, maintenance, updating). Error bars represent 95% CIs.