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# Influence of computer feedback on attentional biases to emotional faces in children

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ABSTRACT

We examined which type of corrective feedback in a computerized task produces an optimal balance between performance and emotional reactions in children. To that end, we conducted an emotional dot-probe task. We employed three types of corrective feedback (negative, positive, or mixed) along with a control, non-feedback condition. We tested the effect of feedback on: (i) task performance; (ii) immediate emotional reactions in terms of attentional preferences toward emotional faces (happy, sad, and angry); and (iii) self-reported affective experience after the task. Results showed that children committed more errors in the non-feedback group than in the mixed and negative feedback groups. Furthermore, the mixed feedback and the positive feedback groups showed an attentional bias away from sad faces. In contrast, the negative feedback group showed an attentional bias toward angry faces and felt unhappy after the task. Thus, the preferred type of feedback in children, in terms of better performance and a positive emotional reaction in a computerized task, is mixed feedback.



## 1. Introduction

Computerized tasks are increasingly used in educational settings: they allow controlling the presentation of materials, registering the responses, and providing immediate corrective feedback (Jaehnig & Miller, 2007). This latter component is the main focus of the current research. As Pekrun, Goetz, Titz, and Perry (2002) indicated, computer feedback occurs both instantly and systematically—note that these are key factors in its positive reception by students (see Hattie, 2009). Computers can be programmed to track the students' responses and to redirect students to focus on correct responses (i.e., positive feedback), error responses (i.e., negative feedback) or both (i.e., mixed feedback). Although most research on feedback has examined its effect on behavior (i.e., task performance), feedback also elicits emotional reactions (see Belschak & Den Hartog, 2009, for review).

### 1.1. The influence of feedback on emotional processing

It has been suggested that emotional reactions can act as mediators in the relationship between feedback and performance (Ilies & Judge, 2005). Given that corrective feedback elicits emotional reactions, attention may be primarily focused on emotions rather than on elements such as task achievement (Lazarus, 1991). Therefore, an examination of how different types of feedback (positive, negative, and mixed) influence emotional reactions as well as performance in computerized tasks is important at both theoretical and applied levels.

At the theoretical level, the affective events model (Weiss & Cropanzano, 1996) proposes that corrective feedback is an event that induces emotional reactions during the task. This model assumes that feedback has a significant psychological impact both on performance and on the attitude towards the task (see Fig. 1, for a schematic depiction of the model). That is, feedback can elicit immediate emotional reactions (e.g., anger after an "ERROR" message) and these emotional reactions may affect both task performance and the self-reported affective experience after finishing the task.

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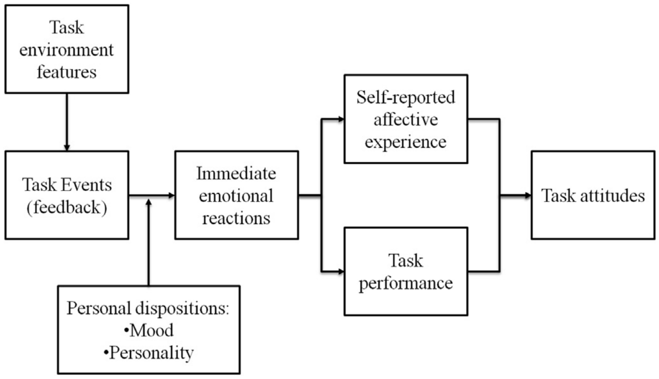


**Fig. 1.** Schematic depiction of the affective events model (adapted from Weiss & Cropanzano, 1996).

### 1.2. How to study emotional responses after feedback

While the affective experience after finishing a given task can be analyzed and verbalized in a questionnaire (i.e., a self-reported measurement), immediate emotional reactions after each response typically escape consciousness (see Reingold & Ray, 2006). An excellent strategy to capture these reactions is to examine how emotional information biases attention during the task. For instance, individuals with depression respond to faster to sad information than to happy information (i.e., a mood-congruent bias; see García-Blanco, Perea, & Livianos, 2013; Murphy et al., 1999). Importantly, immediate emotional reactions do not necessarily go hand in hand with self-reported affective experience. For example, an individual can feel anger as an immediate reaction to incorrect response but, after finishing the task, s/he may self-report a positive experience because feedback could have helped to improve her/his performance (Podsakoff & Farh, 1989).

To examine how feedback modulates both immediate emotional reactions and more sustained affective experiences. In the present research, we combined self-reported affective experience with the response times to emotional information in a computerized task with children. The sample was composed of children rather than adults because children regularly receive feedback from their teachers and parents. Furthermore, children are often unable to report affective experience and their descriptions may not always correspond with the adults' appreciations. The difficulty to quantify children's mood makes it difficult to choose the best corrective feedback to maintain an appropriate attitude toward the task.

### 1.3. Previous research on feedback and emotions in children

The influence of feedback on emotional reactions in children has received little attention in the literature. Prior research can be classified in two groups: (i) studies with contingent feedback (i.e., children receive accurate positive feedback ['Good!'] or negative feedback ['Wrong!'], depending on their performance); and (ii) studies with non-contingent feedback (i.e., children may receive positive feedback ['Good!'] or manipulated negative feedback ['Wrong!'] for correct responses, while all incorrect responses receive negative feedback). While prior contingent feedback studies have been carried out in a naturalistic context, non-contingent feedback studies have been carried out in an experimental context.

In a study with contingent feedback, Mouratidis, Vansteenkiste, Lens, and Sideridis (2008) found that when positive feedback is provided, students persisted in an activity during physical education lessons and self-report positive affective experience; however, their performance did not change. In another study with contingent feedback, Ball, Hoyle, and Towse (2010) reported that when negative feedback was provided to children during an analogical reasoning task, performance improved, but it had a negative impact on self-reported affective experience. Although these studies offer relevant information on how feedback may have positive or negative consequences on children' performance and self-reported affective experience, the influence of feedback on immediate emotional reactions is less well known (see He et al., 2013).

Prior experiments on non-contingent computer feedback in children have focused on its impact on emotions by the assessment of attentional bias with a reaction-time task together with self-reported affective experience (e.g., Beck et al., 2011). Beck et al. (2011) administered a manipulated computer game to children with and without functional abdominal pain. In each group, the participants were assigned to a negative non-contingent feedback condition or a positive non-contingent feedback condition in the computer game. An emotional dot-probe task and a self-report on their somatic symptoms were applied before and after the computer game to assess the resulting emotional reactions. (Note that, in the current experiment, we also employed a dot-probe task because it is an excellent technique for examining how emotionally relevant stimuli capture attentional resources [see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007, for a meta-analysis]). In the dot-probe task used by Beck et al. (2011), two cued words (neutral vs. emotional, i.e., pain-related) were presented simultaneously above and below on the computer screen, either at 20 ms or 1250 presentation rate (i.e., automatic vs. controlled attentional processing, respectively; see Yiend, 2010, for a review). Immediately after the words disappeared, a dot probe (target) replaced one of the two cued words. This trial could be: (i) an emotion trial (i.e., the target replaced the emotional word) or (ii) a neutral trial (i.e., the target replaced the neutral word). The participant's task was to press a button to indicate the position in which the target appeared. Faster responses in emotion trials would signal an attentional bias towards emotional words, whereas faster responses to neutral trials would signal an attentional bias away from emotional words. The results in the Beck et al. (2011) experiment indicated that, at a controlled rate, children with abdominal pain showed an attentional bias toward pain stimuli both before and after non-contingent feedback (positive or negative). However, only after non-contingent feedback (positive or negative), children with abdominal pain only showed an attentional bias toward pain stimuli at an automatic rate and self-reported higher somatic symptoms. Therefore, feedback elicited emotional reactions even at an automatic processing stage. Although healthy children did not show any attentional bias, they showed higher somatic symptoms after negative, non-contingent feedback. Thus, attentional biases and self-reported affective experience do not necessarily go together. Other studies with non-contingent feedback have also assessed their influence on self-reported affective experience (e.g., Deveney et al., 2013). Using a 9-point Likert scale, Deveney et al. (2013) compared the influence of non-contingent feedback and contingent feedback on self-reported valence, arousal, and frustration in healthy and chronically irritable children. Both groups of children felt unhappier, more frustrated, and performed less accurately during non-contingent than contingent feedback, but no differences emerged from arousal self-reporting. Therefore, valence and arousal should be considered as two different aspect of affective experience.

Although non-contingent feedback experiments offer valuable information on affective/cognitive processes, it is unclear whether the increase in unhappy mood (Deveney et al., 2013) or pain-related biases and self-reported symptoms (Beck et al., 2011) were due to the negative feedback or to the frustration caused by non-contingent feedback. More important, the contingent feedback represents a more typical corrective event in the school environment than non-contingent feedback. Furthermore, what we should note here is that Beck et al. (2011) assessed attentional biases before and after the manipulated computer game with non-contingent feedback —note that these biases do not necessarily capture the immediate emotional reactions to feedback. To capture immediate emotional reactions, feedback should be provided in the dot-probe task.

### 1.4. Rationale of the experiment

The main goal of the current research is to determine the type of corrective feedback in a computerized task that elicits an optimal balance between performance and emotional reactions in children. We do so by displaying emotional faces (i.e., happy, sad, and angry) in a dot-probe task in which we employed three different types of feedback (positive feedback, negative feedback, and mixed feedback) to different age- and sex-matched children groups. A group with no feedback served as a control. We examined the children's performance in terms of errors and emotions, covering self-reported affective experience (i.e., positive vs. negative valence and high vs. low arousal measures before and after task) and immediate emotional reactions (i.e., attentional biases in terms of reaction time toward emotional stimuli along the task).

According to the affective events model (Weiss & Cropanzano, 1996), feedback should have an influence on immediate emotional reactions (i.e., in terms of an attentional bias toward emotional faces), self-reported affective experience, and performance. First, as in prior naturalistic research on contingent feedback, we expect performance to improve (relative to a no-feedback condition) when negative feedback is provided (Ball et al., 2010), but not when positive feedback is provided (Mouratidis et al., 2008). Second, the different types of feedback should affect mood differently: (i) positive feedback would elicit a positive attentional bias (i.e., toward happy stimuli or away from negative stimuli) and pleasant mood (see Mouratidis et al., 2008), and (ii) negative feedback would elicit a negative attentional bias (i.e., toward negative stimuli or away from happy faces) and unpleasant mood (see Ball et al., 2010). Finally, we also examined whether attentional biases are modified by feedback at an automatic and/or at a controlled level: we expect attentional biases at both automatic and controlled presentation rates (see Beck et al., 2011).

## 2. Material and methods

### 2.1. Participants

Eighty children between six and twelve years of age (39 girls and 41 boys; 20 s grade, 20 third grade, 20 fourth grade, and 20 fifth grade) took part in the experiment. Children were recruited from a local primary school in Albacete (Spain). Participants were allocated to the groups randomly while keeping sex and gender approximately constant for all groups (see Table 1). The board of directors from the school authorized this research and parental informed consent was obtained for all participants. The school counselor verified that none of the participants had a history of intellectual impairment, learning disorders or any psychiatric diagnoses based on Diagnostic and Statistical Manual of Mental Disorders Text Revision (DSM-IV-TR) criteria (American Psychiatric Association, 2000). In addition, in order to guarantee the absence of current subclinical symptomatology, every parent had to fill out the Child Behavior Check List (CBCL; Achenbach, 1991; children could not have a T-score greater than 64 in any index). Eighteen children were excluded according to the exclusion criteria. The demographic and clinical data for the final sample are presented in Table 1.

### 2.2. Materials

The emotional stimuli, which served as cues, were 84 facial expressions (half female) taken from the FACES database (Ebner, Riediger, & Lindenberger, 2010). A total of 12 happy, 12 angry, 12 sad faces, and 48 neutral images (36 control and 12 filler) were chosen. Each emotional face was matched with the neutral control faces of the same actor. Thus, in each trial, two pictures appeared as cues, namely, an emotional face (happy, angry, or sad) and a neutral face. This resulted in the following three groups of experimental trials: 12 happy-neutral, 12 angry-neutral, and 12 sad-neutral cues. In addition, six pairs of neutral faces were presented before the experimental trials as a practice block.

### 2.3. Procedure

Children were randomly assigned to one of this experimental feedback conditions: (i) no feedback; (ii) negative feedback (children only receive negative feedback for errors, i.e., 'Wrong!', and no feedback for correct responses); (iii) positive feedback (children only receive positive feedback for correct responses, i.e., 'Right!', and no feedback for errors); or (iv) mixed feedback (children received both negative and positive feedback depending on the subject's response). Twenty children took part in each group.

Children were assessed in groups of four in a silent room. Presentation of stimuli and recording of responses were controlled by DMDX software (Forster & Forster, 2003). The experimental session began once six practice trials had been completed. In each trial, a fixation point (+) was presented for 500 ms at the center of the screen. Then, two cued stimuli with different emotional valences (e.g., one neutral and one happy) were presented simultaneously at different screen locations (above and below) for 500 ms or 1500 ms. Immediately after the cues disappeared, a dot probe (i.e., a green or a red square) replaced one of the two stimuli, either the emotional (i.e., congruent trial) or the neutral one (i.e., incongruent trial). Participants were instructed to press a button to indicate the color of the square. The target square was presented until the participant responded or until 3000 ms had elapsed (see Fig. 2). According to previous studies, which have demonstrated that the effect of immediate feedback after individuals' responses is likely more powerful (e.g., Clariana, Wagner, & Roher Murphy, 2000), children received trial-to-trial feedback on their task performance. The participants self-reported valence and arousal before task and after task was measured using 9-point Likert scales (Deveney et al., 2013).

The task comprised one practice block followed by nine test blocks composed of 12 experimental trials (four happy-neutral, four angry-neutral, and four sad-neutral), which were randomly displayed within each block. Each pair of cued faces was presented three times during the experiment. Thus, a total of 114 trials (108 study + six filler) were presented. The vertical location and the type of face (emotional or neutral or replaced by the square), were balanced across trials, with the constraint that each type of face appeared in each of the two positions 50% of the time and the square replaced the emotional cues 50% of the time. The presentation order of the images was randomized across participants. The variation in the image locations and the randomization of trials guaranteed that the participants were not able to use any predetermined scanning strategy. The whole session lasted approximately 25–30 min.

**Table 1**
Demographic and clinical data from no-feedback group, negative, positive and mixed feedback groups. Data shown are averages and standard errors.

| | No (n = 20) | Mixed (n = 20) | Negative (n = 20) | Positive (n = 20) | p |
|---|---|---|---|---|---|
| Age | 8.65 (0.34) | 9.30 (0.28) | 8.95 (0.26) | 8.95 (0.29) | 0.48 |
| Female:Male ratio | 8:12 | 13:7 | 9:11 | 9:11 | 0.34 |
| CBCL scores | | | | | |
| Anxious/Depressed | 55.95 (1.21) | 53.53 (0.91) | 53.33 (0.93) | 55.50 (1.01) | 0.37 |
| Withdrawn/Depressed | 52.05 (1.02) | 51.12 (0.39) | 51.14 (0.29) | 50.40 (0.22) | 0.26 |
| Somatic Complains | 55.19 (0.47) | 54.24 (0.60) | 53.38 (0.53) | 55.05 (0.77) | 0.12 |
| Social Problem | 52.67 (0.53) | 51.94 (0.44) | 52.29 (0.44) | 51.60 (0.35) | 0.36 |
| Thought Problems | 54.24 (1.29) | 54.29 (1.19) | 54.33 (1.29) | 56.40 (1.38) | 0.58 |
| Attention Problems | 52.81 (0.46) | 52.00 (0.19) | 52.57 (0.43) | 52.25 (0.37) | 0.57 |
| Rule-Breaking Behavior | 53.19 (1.01) | 52.53 (0.63) | 52.52 (0.67) | 53.15 (0.74) | 0.88 |
| Aggressive Behavior | 52.29 (0.53) | 53.06 (0.61) | 52.71 (0.43) | 53.30 (0.52) | 0.55 |

Note: the p values correspond to the omnibus test for all groups.

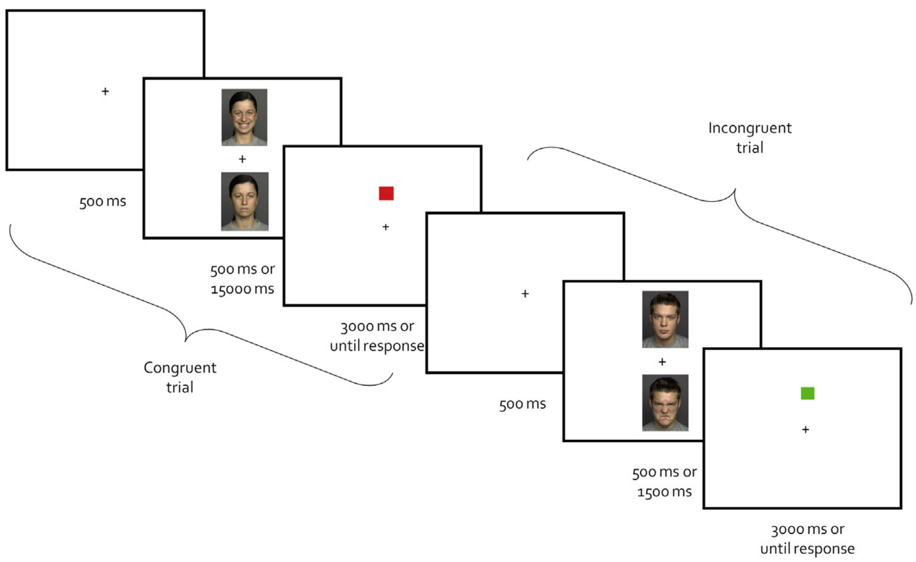


**Fig. 2.** Stimulus presentation sequence across a congruent trial and an incongruent trial.

## 3. Calculation

To compute bias scores, correct RTs on congruent trials (i.e., in which the probe replaced an emotional face) were subtracted from the correct RTs on incongruent trials (i.e., in which the probe replaced and neutral face). Thus, positive bias scores indicated an attentional bias toward an emotional face, while negative bias scores represented an attentional bias away from an emotional face (see Mogg, Bradley, & Williams, 1995, for a similar procedure). Additionally, we computed the percentage of wrong trials across task (i.e., the probability of errors to indicate the color of the square) in order to assess the children's task performance.

The RT differences (as a measure of attentional biases) and the percentage of errors (as a measure of performance) were analyzed in 4 (Group: non-feedback, mixed feedback, negative feedback, positive feedback) x 3 (Valence: happy, angry, sad) x 2 (Duration: 500 ms, 1500 ms) omnibus analysis of variance (ANOVA) in which Group was a between-subjects factor and Valence and Duration were within-subject factors. In addition, one-sample *t*-test for each group was conducted under each condition in order to examine if attentional bias scores differed from zero. Additionally, to examine the effects of feedback on subjective affect, group differences on perceived valence and arousal were assessed using an ANOVA in which Group was a between-subjects factor and Time (before and after task) was within-subject factor. To control for type-I error, Dunnett *t*-tests were used to compare each feedback group (mixed, negative, and positive) relative to the non-feedback control group (i.e., between-groups comparisons). In addition, Bonferroni tests were used to analyze the effect of Valence and Duration (i.e., within-group comparisons; see García-Blanco, Salmerón, Perea, & Livianos, 2014, for a similar procedure).

## 4. Results

To ensure that responses were based on actual responses to probe location, very short response rimes (RTs < 100 ms) were excluded, as were trials with correct RTs that exceeded 2.0 standard deviations beyond the participant's mean. We calculated the mean correct RT under each condition (for happy, angry and sad faces at 500 and 1500 ms) for each participant. The descriptive data for each condition are presented in Table 2. The mean RTs (and their corresponding SEs) for each condition are shown in Table 2 and the percentage of errors (and their corresponding SEs) for each condition is shown in Table 3.

**Table 2**
The mean RTs (with SE) for each condition in no-, mixed-, positive-, and negative-feedback groups.

| | | | No (n = 20) | Mixed (n = 20) | Negative (n = 20) | Positive (n = 20) |
|---|---|---|---|---|---|---|
| Threat | Congruent | Short | 619 (28) | 523 (28) | 604 (33) | 581 (29) |
| | | Long | 681 (31) | 563 (30) | 659 (41) | 630 (33) |
| | Incongruent | Short | 617 (25) | 511 (25) | 620 (32) | 578 (32) |
| | | Long | 681 (33) | 569 (31) | 688 (41) | 619 (33) |
| Sad | Congruent | Short | 602 (23) | 519 (23) | 608 (23) | 591 (39) |
| | | Long | 660 (27) | 554 (30) | 680 (37) | 639 (34) |
| | Incongruent | Short | 604 (23) | 497 (24) | 606 (23) | 569 (35) |
| | | Long | 649 (30) | 536 (27) | 678 (26) | 621 (35) |
| Happy | Congruent | Short | 622 (28) | 512 (27) | 608 (29) | 574 (30) |
| | | Long | 673 (29) | 561 (28) | 648 (25) | 628 (38) |
| | Incongruent | Short | 622 (29) | 515 (28) | 590 (30) | 593 (34) |
| | | Long | 655 (28) | 555 (31) | 649 (28) | 643 (35) |

**Table 3**
The percentage of errors (with SE) for each condition in no-, mixed-, positive-, and negative-feedback groups.

| | | | No (n = 20) | Mixed (n = 20) | Negative (n = 20) | Positive (n = 20) |
|---|---|---|---|---|---|---|
| Threat | Congruent | Short | 10.80 (2.36) | 3.59 (1.22) | 2.68 (1.25) | 8.06 (2.07) |
| | | Long | 12.02 (2.55) | 3.07 (1.10) | 3.09 (1.02) | 4.76 (0.96) |
| | Incongruent | Short | 9.25 (2.57) | 6.15 (1.86) | 6.84 (2.03) | 11.11 (1.50) |
| | | Long | 6.68 (1.62) | 2.17 (1.01) | 4.19 (1.34) | 4.41 (1.41) |
| Sad | Congruent | Short | 7.27 (1.89) | 4.34 (1.30) | 5.43 (1.70) | 10.62 (2.43) |
| | | Long | 5.70 (2.03) | 5.18 (1.84) | 2.72 (0.96) | 5.99 (1.51) |
| | Incongruent | Short | 9.01 (1.83) | 3.78 (0.88) | 5.81 (1.65) | 13.46 (2.54) |
| | | Long | 5.76 (2.15) | 2.62 (0.85) | 3.29 (1.05) | 5.94 (1.60) |
| Happy | Congruent | Short | 6.54 (1.52) | 2.36 (0.76) | 3.02 (1.45) | 7.52 (2.00) |
| | | Long | 6.33 (1.85) | 4.33 (1.70) | 3.15 (1.75) | 9.16 (1.65) |
| | Incongruent | Short | 7.76 (1.90) | 5.27 (1.13) | 4.64 (1.20) | 11.00 (2.51) |
| | | Long | 8.31 (2.78) | 3.67 (1.26) | 1.72 (1.00) | 6.19 (1.85) |

### 4.1. Behavioral data

#### 4.1.1. Response times

The ANOVA on the latency data showed a significant main effect of Valence, $F(2,76) = 5.72$, $p = 0.004$, $\eta^2 = 0.07$, whereas the effect of Group approached significance, $F(3,76) = 2.37$, $p = 0.077$, $\eta^2 = 0.09$. More important, the interaction of Valence x Group was significant, $F(6,152) = 4.14$, $p = 0.001$, $\eta^2 = 0.14$. Neither the effect of Duration nor the other interactions approached significance (all $ps > 0.36$).

To examine the Valence × Group interaction, we conducted simple test effects on Group for each Valence (see Fig. 3). For angry faces, the effect of Group was significant, $F(3,76) = 4.75$, $p = 0.004$, $\eta^2 = 0.16$. Dunnett *t*-tests showed significant differences between the negative feedback group and the non-feedback group ($p = 0.019$): Children who received negative feedback showed larger bias score than the non-feedback group for angry faces (22 ms vs. −2 ms, respectively). No other differences were found for the mixed or positive feedback groups relative to the non-feedback group (all $ps > 0.89$). For sad faces, the effect of Group approached significance, $F(3,76) = 2.56$, $p = 0.061$, $\eta^2 = 0.09$—note however, that Dunnett *t*-tests failed to show significant differences between the non-feedback group and the rest (all $ps > 0.17$). For happy faces, the effect of Group was significant, $F(3,76) = 3.63$, $p = 0.016$, $\eta^2 = 0.13$. Dunnett *t*-tests showed that children who received positive feedback showed larger bias score than the non-feedback group for happy faces (17 ms vs. −9 ms, respectively $p = 0.013$). No other differences were found between the non-feedback groups and the mixed or negative feedback groups (all $ps > 0.70$).

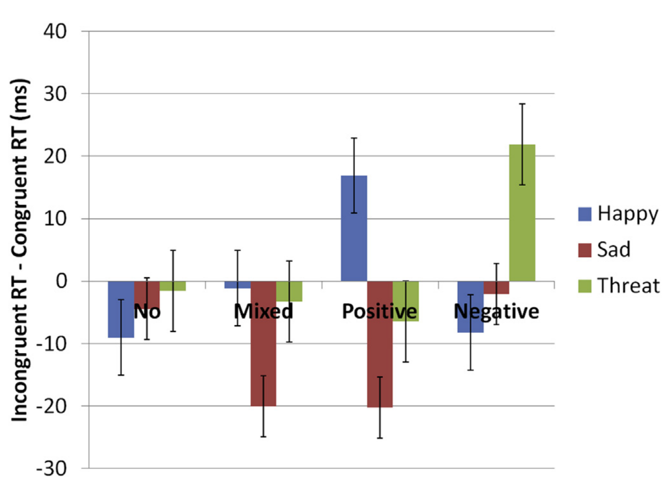


**Fig. 3.** Difference in Response Time between Incongruent and Congruent conditions on each Valence for all Groups.

To study the presence of attentional biases, the bias score under each condition was tested for the difference from zero using one-sample *t*-test for each group. Duration was not considered in one-sample *t*-tests because neither the main effect of Duration nor its interactions with Group or Valence were significant in an omnibus ANOVA. For the mixed feedback group, *t*-tests showed that the bias score were significantly smaller than zero under the sad condition, $t(19) = -3.58$, $p = 0.002$. That is, the mixed feedback group showed an attentional bias away from sad faces. For the positive feedback group, the bias score was significantly smaller than zero under the sad condition, $t(19) = -3.80$, $p = 0.001$. In addition, the bias score was significantly larger than zero for happy faces, $t(19) = 2.48$, $p = 0.022$. In other words, the positive feedback group showed an attentional bias away from sad faces together with an attentional bias toward happy faces. Finally, for the non-feedback group, no bias scores were significantly different from zero under any valence (all $p > 0.28$).

#### 4.1.2. Percentage of errors

The ANOVA on the percentage of errors showed a main effect of Group, $F(1,76) = 5.25$, $p = 0.002$, $\eta^2 = 0.17$, and a main effect of Duration, $F(1,76) = 21.42$, $p < 0.001$, $\eta^2 = 0.22$, which were qualified by Duration × Group interaction, $F(1,76) = 3.73$, $p = 0.015$, $\eta^2 = 0.13$. Neither the effect of Valence nor other interactions were significant (all $ps > 0.07$).

To examine the Duration × Group interaction, we conducted simple test effects on Group for each Duration. For the short cue duration, the effect of Group was significant, $F(3,76) = 5.76$, $p = 0.001$, $\eta^2 = 0.19$. Dunnett *t*-tests showed that children who received mixed feedback committed fewer errors than the non-feedback group at the short rate (4.74% vs. 8.44%, respectively; $p = 0.046$). No other differences were found for the negative or positive feedback groups relative to the non-feedback group (all $ps > 0.09$). For the long cue duration, the effect of Group was also significant, $F(3,76) = 4.08$, $p = 0.010$, $\eta^2 = 0.14$. Dunnett *t*-tests revealed significant differences between the mixed feedback group and the non-feedback group ($p = 0.025$) and between the negative feedback group and the non-feedback group ($p = 0.010$): Children who received mixed feedback or negative feedback committed fewer errors than the non-feedback group for long condition (3.51% and 3.03% vs. 7.47%, respectively). No other differences were found for the positive feedback group relative to the non-feedback group ($p = 0.67$).

### 4.2. Self-report mood

To determine the group differences in self-report mood, we conducted separate ANOVAs on arousal and valence as dependent variables.

The ANOVAs on arousal showed that the effect of Time was significant, $F(1,76) = 4.09$, $p = 0.001$, $\eta^2 = 0.19$. Children were more excited after the task (M = 5.41, SD = 0.52) than before the task (M = 5.20, SD = 0.72). Neither the effect of Group nor the interaction approached significance (all $F < 1$).

The ANOVAs on valence showed that effect of Time approached significance, $F(1,76) = 3.02$, $p = 0.09$, and the effect of Group was significant, $F(3,76) = 4.67$, $p = 0.005$, $\eta^2 = 0.16$. Furthermore, there was a significant Time × Group interaction, $F(3,76) = 4.95$, $p = 0.003$, $\eta^2 = 0.16$. This interaction showed that while were no signs of a difference between groups before task ($F < 1$), there was a robust effect of Group after the task, $F(3,76) = 2.25$, $p < 0.001$, $\eta^2 = 0.25$. Dunnett *t*-tests showed that the negative feedback group (M = 5.60, SD = 0.50) felt unhappier than the non-feedback group (M = 5.35, SD = 0.59; $p = 0.003$). The differences between the mixed or positive feedback groups versus the non-feedback group were not significant (all $ps > 0.47$).

## 5. Discussion

The present dot-probe experiment was designed to examine the effect of feedback on performance (i.e., percentage of errors in a dot-probe task) and emotional reactions in children—this included both immediate emotional reactions (i.e., attentional biases toward or away from emotional faces: happy, sad, and angry) and self-reported affective experience after finishing the task. The main findings can be summarized as follows. First, performance improved when mixed feedback or negative feedback was provided. Second, mixed feedback and positive feedback elicited a positive attentional bias (i.e., a bias away from sad faces), while negative feedback elicited a negative attentional bias (i.e., a bias towards angry faces). Third, when only negative feedback was provided, children felt unhappy after the experiment.

The decrease in the percentage of errors when mixed or negative feedback was provided suggests that both types of feedback improve performance. This finding offers empirical support for the following claims: (i) when positive feedback is accompanied by negative feedback (i.e., mixed feedback), individuals may became more motivated to avoid negative reinforcement and to obtain positive reinforcement (see Hattie & Timperley, 2007); and (ii) upon receiving only negative feedback, individuals may become angrier with their previous performance, and they would set higher performance goals for their future performance—note that as a result they would perform at a higher level than those who receive no feedback (Podsakoff & Farh, 1989).

The current dot-probe experiment also showed that feedback affects immediate emotional reactions. In particular, mixed and positive feedback elicited a positive emotional reaction (in terms of an avoidance bias away from sad faces). Instead, negative feedback produced an attentional bias towards angry faces rather than towards sad faces—note that negative feedback may elicit an annoying mood rather than sadness in children (see Podsakoff & Farh, 1989). As indicated in the Introduction, prior naturalistic studies (e.g., see Ball et al., 2010; Mouratidis et al., 2008) showed that negative feedback had a positive effect on performance, but it decreased motivation and increased negative affect. These attentional biases may play an important role in children's attitude on subsequent tasks (Hattie & Timperley, 2007). Importantly, the effect of feedback on attentional biases for emotional faces in healthy children occurred at both short (500 ms) and long (1500 ms) presentation rates (see also Beck et al., 2011). In addition, while positive feedback alone does not seem to have an effect on performance, it can increase persistence and interest in the task, as it provides information on what to do or how to respond the next time.

Another important finding in the current experiment is that the children in the negative feedback group felt unhappier than the children in the non-feedback group. This suggests that negative feedback elicited not only immediate negative emotional reactions (i.e., an attentional bias towards angry faces) but also produced a negative affective experience, as deduced from the self-report affective experience once the dot-probe task was finished (Compton, 2003).

Taken together, these findings are consistent with the affective events model (Weiss & Cropanzano, 1996): feedback is an affective task event that improves performance and elicits emotional reactions, as deduced from immediate attentional biases and the self-reported affective experiences. Finally, it is important to stress that emotional reactions elicited by feedback may be more complex than those that can be subjectively analyzed in self-report questionnaire (Reingold & Ray, 2006). Indeed, mixed and positive feedback groups showed a positive attentional bias, but there were no parallel differences in self-reported affective experience.

A limitation of this study is that the differences in the percentage of feedback information across groups (100% for the mixed feedback group, 91% for the positive feedback group, and 4% for the negative feedback group) reduced experimental control. However, this cannot explain the feedback effect on mood in the negative feedback group—note that this was the group with the lowest percentage of feedback information. In addition, our findings may not necessarily generalize to adolescents or adults. Therefore, further experimentation should examine whether age modulate the influence of feedback on attentional biases.

## 6. Conclusions

The current emotional dot-probe experiment in children demonstrated that the preferred type of feedback, in terms of better performance and a positive emotional reaction in a computerized task, is mixed feedback (i.e., feedback on both correct and error responses). In addition, the computerized tasks that assess attentional biases are a promising tool to capture emotional reactions. From an educational perspective, future research should examine whether mixed feedback in computerized tasks is also the preferred choice in a learning scenario.

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