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Gaze cueing (i.e., the shifting of person B's attention by following person A's gaze) is closely linked with human interaction and learning. To make the most of this connection, researchers need to investigate possible moderators enhancing or reducing the extent of this attentional shifting. In this study we used a gaze cueing paradigm to demonstrate that the perceived trustworthiness of a cueing person constitutes such a moderator for female participants. Our results show a significant interaction between perceived trustworthiness and the response time trade-off between valid and invalid gaze cues (gaze cueing effect), as manifested in greater following of a person's gaze if this person was trustworthy as opposed to the following of an untrustworthy person's gaze. An additional exploratory analysis showed potentially moderating influences of trait-anxiety on this interaction ($p = .057$). The affective background of the experiment (i.e., using positive or negative target stimuli) had no influence.

Keywords: gaze cueing, trustworthiness, anxiety, affective background, moderator

Not afraid to trust you: Trustworthiness moderates gaze cueing but not in highly anxious participants.

Humans have a reflexive impulse to follow other people's eye gaze in order to detect what they are attending to. This mechanism can be used as a tool for doing good (e.g., helping a peer by indicating a potential food source) but also for deceit. For example, a pickpocket could use his eye gaze to avert his victim's attention while stealing this person's wallet. This way of a sender's (person A) gaze shifting a receiver's (person B) visual attention to a specific location, object or person has been coined *gaze cueing* or gaze following (e.g., Bayliss & Tipper, 2006; Frischen, Bayliss, & Tipper, 2007). It constitutes a fundamental mechanism of *shared* and *joint attention* (e.g., Driver et al., 1999) and thus plays an important role in human learning and interaction processes (see Frischen et al., 2007, for an overview).

Most of the research investigating gaze cues employs a so called gaze cueing paradigm (Driver et al., 1999; Friesen & Kingstone, 1998), an adaptation of the spatial cueing paradigm by Posner (1980). In this paradigm, participants are presented a face on a screen which first looks straight ahead and then turns its gaze either to the left or to the right side. Shortly after this gaze shifting, a target either appears on the side congruent to the gaze direction, or on the other, incongruent, side. Despite being instructed to ignore the gaze, participants respond faster to targets that appear on the congruent side than on the incongruent side. It was reasoned that this *gaze cueing effect* (GCE) is due to a reflexive attentional shift towards the cued direction (Frischen et al., 2007).

This GCE was initially proposed to be reflexive and automatic and thus encapsulated

in a largely independent neural network (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Hoffmann & Haxby, 2000). However, this view has recently been questioned as evidence accumulates that social information can influence gaze cueing. GCEs have been found to be moderated by social factors such as the sender face's familiarity (Deaner, Shepherd, & Platt, 2007), perceived dominance (Jones et al., 2010) and social status (Dalmaso, Pavan, Castelli, & Galfano, 2012). Another line of research could show that the sender's facial expression can also modulate GCEs under certain circumstances, for example, happy faces when embedded in a positive context (Bayliss, Schuch, & Tipper, 2010). Moreover, several studies reported enhanced gaze following in highly anxious participants but only when following the gaze of angry (Holmes, Richards, & Green, 2006) or fearful sender faces (Fox, Calder, Mathews, & Yiend, 2007; Mathews, Fox, Yiend, & Calder, 2003; Putman, Hermans, & Van Honk, 2006; Tipples, 2006), compared to following neutral faces. As gaze following plays an important role in many forms of human interaction (Frischen et al., 2007) it is crucial to detect moderators that enhance or reduce positive outcomes of these interactions. Thus, in our study we propose a further moderating social factor, as we assume that the perceived trustworthiness of a neutrally-looking sender person influences GCEs. More precisely, we hypothesize a relative reduction in GCEs when following the gaze of an untrustworthy face as compared to a trustworthy face. Furthermore - when following an untrustworthy person's gaze - we propose an enhanced GCE in highly anxious participants compared to middle and low anxious participants. Finally, we propose an enhanced GCE for a trustworthy face when it is embedded in a positive context.

The first two hypotheses are derived from two mechanisms, which we assume to underlie gaze following of (un)trustworthy faces. The first mechanism is based on an evolutionary adaption. Since a trustworthy person should not use his gaze deceitfully,

following it should be beneficial or at least not harmful at all times. In contrast, following the gaze of an untrustworthy face could be either beneficial (e.g., if this person draws someone's attention towards a potential threat) or very dangerous (e.g., if this person deceitfully draws someone's attention away from a potential threat). Since results of following an untrustworthy face can be so ambiguous, the adaptive strategy should be to rather follow a trustworthy person's gaze than an untrustworthy person's gaze. The second mechanism is based on an interaction between the perceived threat coming from an untrustworthy person and the anxiety level of the perceiver. Arguably, an untrustworthy and neutrally-looking person A is not necessarily threatening to person B. However, as long as person B can attribute a potential danger to person A, the very fact that person A is untrustworthy prohibits person B from ever feeling fully secure in person A's presence. In contrast, a potentially dangerous person (e.g., a person doing martial arts) might not be perceived as threatening as long as one trusts this person. Therefore we argue that the perceived threat coming from a neutrally-looking face arises from a combination of attributed potential danger and perceived untrustworthiness. The vast literature on attentional biases towards threatening stimuli reports an increased attendance towards threatening stimuli, which only seems to affect highly anxious persons (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007, for a review). This attentional bias appears to also play a role in several of the aforementioned studies, which reported enhanced GCEs in highly anxious participants when following the gaze of angry or fearful faces (e.g., Holmes et al., 2006; Mathews et al., 2003). Therefore, we predict enhanced gaze following of an untrustworthy face in highly anxious participants when compared to middle and low anxious participants. However, as this second mechanism competes with the first mechanism in the group of highly anxious participants, we have no clear prediction whether one mechanism has a stronger effect than the other or whether this leads to equal GCEs for the trustworthy and untrustworthy face in the group of highly anxious

participants.

Regarding the affective background, Bayliss et al. (2010) found that following the gaze of happy faces was enhanced in a setting where participants only responded to positively valenced target stimuli. They argued that the combination of a happy face cueing positive target stimuli constitutes a positive and affiliative social situation that fits to the collaborative nature of gaze following. Moreover, they suggested that gaze following is only enhanced in these positive and affiliative social situations. We propose that responding to positively valenced target stimuli cued by a trustworthy person constitutes a similar affiliative situation. Therefore, we hypothesize that following the gaze of a trustworthy, though not smiling person, is enhanced in a positive background.

Method

Participants. Statistical power analyses revealed that 53 participants would be needed to detect a small-sized within-subjects interaction ($f = 0.10$, $\alpha = .05$, $\beta = .95$, $r = .75$). We rounded that number up and collected sixty female participants, all undergraduate students at the LMU Munich, were recruited in return for course credit (mean age = 25.4, $SD = 8.6$ years). Only female participants were acquired for this study to reduce potential variance restriction that could have resulted from the inclusion of male participants (Alwall, Johansson, & Hansen, 2010; Bayliss, di Pellegrino, & Tipper, 2005). Only participants who stated that they had watched *The Silence of the Lambs* were invited into the lab¹.

Stimuli. Stimuli were presented on a 19-inch computer screen 60 cm away from participants and controlled with E-Prime software. Sender faces were two unfamiliar, neutrally-looking male faces, taken from the NimStim Face Set (Tottenham et al., 2009), as well as the faces of Aragorn and Hannibal Lecter (see footnote). We only used male faces to

avoid potential confounds of gender-specific trustworthiness ratings (e.g., Buchan, Croson, & Solnick, 2008). The unfamiliar faces were selected by the authors on the grounds of appearing equally trustworthy. Each face was edited to produce straight and averted gazes, align different illumination, as well as face, eye, and pupil sizes. Face sizes were 7-8 cm x 11.5 cm, eye sizes 1.1-1.3 cm x 0.5 cm and pupil sizes were 4 mm in diameter. We displayed the same target stimuli, taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), as used by Bayliss et al. (2010; see Appendix of Bayliss et al. for a detailed description of the pictures). These were 6 neutral target stimuli used for the practice trials, 80 positive target stimuli (flowers, landscapes, food) and 80 negative target stimuli (snakes, spiders, weapons). Target stimuli were presented in a 9.5 cm x 7.5 cm frame 7.5 cm away from the central point of fixation which was indicated by a 1 cm x 1 cm fixation cross.

Design & Procedure. The trait anxiety of participants was measured with the German version of the State-Trait-Anxiety Inventory (STAI-G: Laux, Glanzmann, Schaffner, & Spielberger, 1981) prior to starting the experimental program. After conducting 6 practice trials, each of the 4 character faces was presented for 25 seconds accompanied with a vignette reading a short personality description to prime them either trustworthy or untrustworthy. These vignettes as well as all instructions and questionnaire items were originally in German (see online supplementary). The character Markus was depicted as a Good Samaritan, putting a lot of effort into helping his friends. The character Peter was depicted as violent thief, exploiting his well-meaning parents. Note that these vignettes and corresponding unfamiliar faces were counterbalanced. As manipulation check, trustworthiness ratings were obtained prior and after experimental trials by asking “How trustworthy do you think XXX is?” and “I would trust XXX with a secret.” on a 7-point Likert scale. Before starting the experimental trials, all characters and names were presented together for another 8 seconds.

Concerning the localisation task, participants were instructed to respond as quickly and as accurately as possible to the position of pictures appearing next to the cueing face. They were told to press the “c” key on a standard German keyboard if the picture appeared left of the face and the “m” key if the picture appeared to the right. They were informed that the only relevant feature was the location of the pictures. Furthermore, they were instructed to ignore the face’s gaze, content of the pictures and to focus on the centre of the screen, indicated by a fixation cross. A single trial (see Figure 1) started with a fixation cross in the centre of the screen for 600 ms; after this a face appeared at the same place with eyes gazing straight ahead. After 1000 ms, the eyes moved to either the right or the left side. After 450 ms, a target stimulus appeared to the right or left of the face and remained there for 2000 ms. Subsequently, a blank screen was presented for another 2000 ms before the next trial started. Target stimuli were counterbalanced across participants as either being only positive or only negative and presented randomly within blocks of 40 pictures. There were 4 blocks in sequential order, leading to a total of 160 trials, so every participant saw every picture twice. In line with the study of Bayliss et al. (2010) every picture was presented for the full 2000 ms, unaffected by when the participant responded. This was in order to produce an equally strong affective background between participants. Each block of 40 pictures was followed by a short break of 30 seconds. The appearance of the characters, congruency and gaze directions were counterbalanced over all trials in each block. That means a participant randomly saw each face in 5 congruent and 5 incongruent trials per block, looking twice right and twice left, respectively, and twice completely randomly left or right.

Figure 1. Illustration of a single congruent trial. Stimulus face (Tottenham et al., 2009) and target are similar to the original stimuli which were not allowed to be published.

Results

Data was analysed with the *R Environment for Statistical Computing* (R Development Core Team, 2008). Prior to analysis, missed trials (1.1%), error trials (0.3%) and trials with response times slower than 1000 ms or faster than 200 ms (together 0.6%) were removed from the data. One participant had to be excluded due to missing anxiety data, leaving a total of 59 participants. Ratings of trustworthiness between the two faces (i.e., characters) differed

significantly. The trustworthy primed character was rated higher than the untrustworthy one before, $t(58) = 12.39, p < .001$, difference = 2.70, as well as after the experimental trials $t(58) = 7.23, p < .001$, difference = 1.86. Welch's t -tests indicated that pre- and post-experimental trustworthiness ratings of the two characters were not influenced by specific stimulus faces ($ps > .08$) with the exception of post-experimental ratings of the untrustworthy character, which varied slightly between the two stimulus faces, $t(55) = 2.24, p = .029$, difference = 0.60. Nonetheless this difference of trustworthiness scores between stimulus faces was 3 times smaller than the difference in trust scores between the two characters.

Table 1

Number and age of participants in three groups based on trait anxiety scores (STAI-G) as well as the number of participants per target condition. Standard deviation in parantheses.

Group	STAI-trait	Age	n	Participants per target condition	
				Positive	Negative
Low-anxious	31.06 (3.06)	27.88 (10.39)	18	10	8
Middle-anxious	38.40 (1.19)	24.70 (6.71)	20	10	10
High-anxious	49.52 (5.37)	23.76 (8.79)	21	10	11

We conducted a single 2 x 2 x 2 x 3 mixed measures ANOVA with congruency (congruent vs. incongruent) and trustworthiness (trustworthy vs. untrustworthy) as within-subjects factors and target valence (positive vs. negative) and anxiety level (low, middle and high) as between-subjects factors. Participants were divided into 3 anxiety groups according to the 33% and 66% percentile of the STAI-G score (see Table 1). Effect sizes are reported as generalized eta-square (η^2_G), where typical guidelines suggest that .26 is a large, .13 a medium, and .02 a small effect (Bakeman, 2005). The main effect of congruency was significant, $F(1, 53) = 17.95$, $MSE = 20391$, $p < .001$, $\eta^2_G = .019$, showing that participants responded faster when the sender face looked towards the location of the target than when it looked away. The predicted interaction between congruency and trustworthiness reached significance as well, $F(1, 53) = 5.49$, $MSE = 1825$, $p = .023$, $\eta^2_G = .002$. Hence, participants produced a greater GCE (see Figure 2) when the sender face was trustworthy, $t(58) = 4.67$, $p < .001$, difference = 24.21 ms, than when it was untrustworthy, $t(58) = 2.90$, $p = .005$, difference = 13.92 ms. Further post-hoc t -tests revealed that participants showed marginal significantly slower response times for trustworthy faces in incongruent trials, $t(58) = -1.92$, $p = .059$, difference = -6.04 ms, but not significantly faster response times for trustworthy sender faces in congruent trials, $t(58) = 1.46$, difference = 4.25 ms. The GCE produced by trustworthy or untrustworthy sender faces was not influenced by the target valence, $F(1, 53) = 0.03$, $MSE = 10$. That means it did not matter whether participants responded only to positive or only to negative target stimuli. Finally, the variation of GCEs between trustworthy and untrustworthy sender faces and across different levels of trait anxiety turned out to be just short of being significant, $F(2, 53) = 3.03$, $MSE = 2017$, $p = .057$, $\eta^2_G = .002$. No other main effects or interactions attained significance. To summarize, the untrustworthy face – compared to the trustworthy face – led to a smaller response time difference between congruent and incongruent trials. This was not influenced by the affective background.

Figure 2. Mean response times in milliseconds in congruent and incongruent trials for the trustworthy and the untrustworthy sender face. Error bars represent 95% confidence intervals of mean.

Influence of anxiety-levels and trustworthiness. Although the 3-way interaction between congruency, trustworthiness and anxiety level only attained marginal significance ($p = .057$), we wanted to further explore this effect. Thus, we conducted a $2 \times 2 \times 2$ mixed measures ANOVA with congruency and trustworthiness as within-subjects factors and target valence as between-subjects factor at each level of anxiety. We did not have any specific hypotheses about target valence and its interactions at any level of anxiety but we kept it in the analysis for exploratory reasons. By coincidence, participants were evenly distributed between target valences across anxiety groups (see Table 1). In the group of low trait-anxious participants the interaction between trustworthiness and congruency attained significance, $F(1, 16) = 4.73$, $MSE = 2216$, $p = .045$, $\eta^2_G = .008$ (see Figure 3a). This interaction was due to a

significant GCE for trustworthy faces, $t(17) = 2.11$, $p = .050$, difference = 24.40 ms, and a non-significant GCE for untrustworthy faces, $t(17) = 0.26$, difference = 12.50 ms. The main effect for congruency failed to reach significance, $F(1, 16) = 2.03$, $MSE = 3223$. In the group of middle trait-anxious participants both the main effect for congruency, $F(1, 18) = 8.42$, $MSE = 9704$, $p = .010$, $\eta^2_G = .035$, and the interaction between congruency and trustworthiness, $F(1, 18) = 4.61$, $MSE = 1293$, $p = .046$, $\eta^2_G = .005$, (see Figure 3b) reached significance. Again, this interaction was due to a non-significant GCE for untrustworthy faces, $t(19) = 1.67$, difference = 13.99, and a significant GCE for trustworthy faces, $t(19) = 3.24$, $p = .004$, difference = 30.07 ms, which also seems to have driven the main effect of congruency. An unpredicted interaction between congruency and target valence attained marginal significance, $F(1, 18) = 3.32$, $MSE = 3827$, $p = .085$, $\eta^2_G = .014$. In the group of high trait-anxious participants only the main effect of congruency attained significance, $F(1, 19) = 12.35$, $MSE = 9156$, $p = .002$, $\eta^2_G = .018$, whereas the interaction between trustworthiness and congruency, $F(1, 19) = .47$, $MSE = 125$, (see Figure 3c) was not significant. As the significant congruency effect suggests, GCEs were significant for both untrustworthy faces, $t(20) = 3.23$, $p = .004$, difference = 23.77 ms, and trustworthy faces, $t(20) = 2.89$, $p = .009$, difference = 18.47 ms. No other main effects or interactions were significant in any of these 3 ANOVAs. To summarize, low trait-anxious participants followed the gaze of trustworthy person while barely following the gaze of an untrustworthy person. Middle trait-anxious participants followed the gaze of a trustworthy person more than they followed the gaze of an untrustworthy person. High trait-anxious participants showed the same gaze following behaviour for gazes by trustworthy and untrustworthy faces.

Figure 3. Mean response times in milliseconds in congruent and incongruent trials for trustworthy and untrustworthy sender faces in groups of participants with a) low trait-anxiety b) middle trait-anxiety c) high trait-anxiety. Error bars represent 95% confidence intervals of mean.

Discussion

Using a gaze cueing paradigm (Driver et al., 1999; Friesen & Kingstone, 1998), we showed that the difference between response times to congruently and incongruently cued targets (i.e., the GCE) was greater when the cueing person was perceived trustworthy as opposed to untrustworthy. In other words, participants had a greater tendency to follow a trustworthy person's than an untrustworthy person's gaze. Furthermore, we found no significant difference in the modulation of GCEs due to trustworthiness whether the experimental setting was negative or positive. This casts doubt upon Bayliss et al.'s (2010) notion that "gaze cueing can only be selectively modulated in a positive context" (p. 1229), however does not mean we failed to replicate Bayliss and colleagues' study as their smiling and our neutrally looking sender face do not share the same properties.

Exploring the effect of trait-anxiety on gaze cueing, we found that little anxious participants followed the gaze of a trustworthy person but hardly – or not at all – the gaze of

an untrustworthy one. Moderately anxious participants followed both gazes, but they followed the trustworthy person's gaze to a larger extent. Highly anxious participants followed both gazes to the same extent (see Figure 3). In other words, the more anxious the participant the smaller was the difference between following a trustworthy person's gaze and following an untrustworthy person's gaze. The finding that - in the group of highly anxious participants - GCEs for trustworthy and untrustworthy faces did not significantly differ may seem odd at first; however it can be accounted for by a combination of the two proposed mechanisms underlying gaze following of (un)trustworthy faces. The first mechanism assumes a general relative reduction of gaze following for untrustworthy faces compared to trustworthy faces. The second mechanism assumes a relative increased gaze following for a threatening, untrustworthy face that is unique to highly anxious persons (e.g., Bar-Haim et al., 2007; Holmes et al., 2006; Mathews et al., 2003). The almost complete suppression of following an untrustworthy person's gaze - leading to a non-significant congruency effect - in the group of low anxious participants was surprising. Nonetheless, this could be explained by findings showing that low-anxious persons have a tendency to attentionally disengage with mildly threatening stimuli (e.g., Bar-Haim et al., 2007; MacLeod, Mathews, & Tata, 1986), and might therefore be not as susceptible to gaze cues coming from an untrustworthy face. However, as we did not control for the amount of threat participants perceived from the stimulus faces and since the effects of this specific attention-withdrawal are not reported consistently across all kinds of stimuli (Bar-Haim et al., 2007), this hypothesis needs more in-depth validation.

One could argue that the effect of relative reduced gaze following for untrustworthy faces is solely driven by the higher order interaction between trustworthiness and anxiety, but this seems unlikely as the effect was also found in the group of middle anxious participants. Nonetheless, the relative contribution of threat and untrustworthiness that led to our results

cannot be obtained from this study and should be the focus of subsequent research. It is also important to note that these findings concerning the interaction between anxiety levels of participants and trustworthiness have to be treated with caution. First of all, the initial interaction between congruency, trustworthiness and anxiety was only marginally significant ($p = .057$). Second, as we did not hypothesize a linear effect of anxiety on gaze cueing, we divided participants into groups instead of testing anxiety as a covariate; even though that generally is the recommended method. Consequently, this exploratory result awaits cross-validation and can only be regarded as a first attempt to investigate the joint relation of trait-anxiety and trustworthiness on gaze cueing.

An important aspect of our results is that they give further evidence (e.g., Bayliss et al., 2010; Dalmasso et al., 2012; Deaner et al., 2007; Holmes et al., 2006; Jones et al., 2010; Mathews et al., 2003) that social information can moderate gaze cueing, which is contrary to the notion that gaze cueing is solely controlled by an independent neural network (e.g. Driver et al., 1999; Friesen & Kingstone, 1998). It should be noted, that this was not the first study examining a potential influence of trustworthiness on gaze cueing, however these studies yielded inconsistent results. Although some studies - implicitly (Bayliss & Tipper, 2006) or explicitly (King et al., 2011) investigating the effects of trustworthiness on gaze cueing - could not find any moderating effect, other studies found effects of trustworthiness (e.g., Petrican et al., 2013) at least in specific populations. Particular strengths of our study might account for the different results compared to King et al. (2011) and Bayliss and Tipper (2006). However, our study also has its limitations.

Strengths and limitations. The first strength of our study is that we, unlike King et al. (2011), checked the trustworthy priming right before and after experimental trials. Second, we

controlled for anxiety-levels of participants which are known to have a moderating impact on gaze following (e.g., Holmes et al., 2006; Mathews et al., 2003). Third, we had a bigger sample size ($n = 59$) than King et al. (2011, $n = 24$) or Bayliss and Tipper (2006, $n = 40$), which increased the power in our study.

Following Bayliss et al. (2010), we only assessed female participants to reduce variance restriction in our data (see also Alwall et al., 2010). Therefore, our findings are limited to the understanding of females following the gaze of males. Other combinations of gender could reveal different results. It should be also noted that the effects described here might be more due to the pronounced lack of trustworthiness of character A than to the trustworthiness of character B. The supposed-to-be trustworthy character differed significantly from the scale mean = 4, indicating neutrality, before experimental trials, $t(58) = 2.17$, $p = .034$, difference = .41, but not after experimental trials, $t(58) = -.08$, difference = -.02. A stronger trustworthy primed character as well as a third neutrally primed one could have revealed if the effect is really driven by trustworthiness or lack of trustworthiness or both. Finally, findings regarding the influence of trait-anxiety and trustworthiness on gaze following await replication. Further studies should control for the amount of threat and untrustworthiness of sender faces to explore the unique contribution of the two proposed mechanisms underlying gaze following of (un)trustworthy faces.

Conclusion. In a gaze cueing paradigm we demonstrated that the trustworthiness of a person affected the extent of following this person's gaze. This effect was not further influenced by the affective background in which it took place. In a first exploratory investigation, we found that trait-anxiety levels influenced the gaze following of an untrustworthy person's gaze. These findings compliment previous research that has shown that social information is able to influence the neural network underlying gaze following even

on a higher processing level (i.e., the moderation is not due to certain facial expressions of the sender person; e.g., Deaner et al., 2007). To have a greater benefit from the many processes in which gaze cueing plays an important role (e.g., Frischen et al., 2007) it is crucial to detect underlying moderators to enhance positive and reduce negative effects. At least for females, trustworthiness appears to be one of those moderators.

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Footnotes:

¹This requirement was due to an additional hypothesis in which we predicted that two familiar faces (*Aragorn* from *The Lord of the Rings* and *Hannibal Lecter* from *The Silence of the Lambs*) would be naturally and more strongly primed trustworthy or untrustworthy, respectively, and thus participants should show an even bigger difference in GCEs when following – or not following - the gaze of these faces. As we had problems finding enough participants that had seen both movies and as this was just an additional exploratory hypothesis we relaxed this requirement. Thus, we ended up with 48 out of 60 participants who had seen both movies. However, results regarding these characters are not reported here, as they can only be regarded exploratory since these character's faces could neither be counterbalanced with their corresponding trustworthiness nor could we efficiently control for effects of different degrees of familiarity, which might have had an effect (Deaner et al., 2007). Nonetheless, the interested reader finds all the obtained results and our complete dataset in the online supplementary material.