The Effect of Facial Emotion and Action Depiction on Situated Language Processing

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Abstract

Two visual world eye-tracking studies investigated the effect of emotions and actions on sentence processing. Positively emotionally valenced German non-canonical object-verb-subject (OVS) sentences were paired with a scene depicting three characters (agent-patient-distractor) as either performing the action described by the sentence, or not performing any actions. These scene-sentence pairs were preceded by a positive prime in the form of a happy looking smiley (vs. no smiley) in experiment 1 and in the form of a natural positive facial expression (vs. a negative facial expression) in experiment 2. Previous research has demonstrated the effect of action depiction on sentence processing of German OVS sentences (Knoeferle, Crocker, Scheepers, & Pickering, 2005). Moreover, emotional priming facilitates sentence processing for older and younger adults (Carminati & Knoeferle, 2013). However, up to date there is no evidence as to whether schematic faces such as smileys are as effective as natural faces in facilitating sentence processing. These insights lead to the hypotheses that participants would not only profit from depicted events, but that processing of OVS sentences might also be positively affected by emotional cues. Plus, we assessed the degree of naturalness the emotional face needs to possess to affect sentence processing. Results replicate the predicted effect of action depiction (vs. no action depiction). The expected facilitatory effect of emotional prime is trending in both experiments. However, the effect is more pronounced in the natural face version (exp. 2) than in the smiley version (exp. 1).

Keywords: Sentence Processing; Visual World Paradigm; visually situated language comprehension; eye movements; emotional priming; iconic, natural facial expression.

Introduction

Monitoring people's gaze behavior in a visual context provides a unique opportunity for examining the incremental integration of visual and linguistic information (Tanenhaus et al., 1995). Non-linguistic visual information can rapidly guide visual attention during on-line language processing in adults (e.g., Chambers, Tanenhaus, & Magnuson, 2004; Knoeferle et al., 2005; Sedivy et al., 1999; Spivey et al., 2002). However, existing research has focused mostly on assessing how object- and action-related visual information influences spoken language comprehension.

By contrast, the integration and role of social contextual cues into language processing, such as emotional facial expressions is still under-examined, and we do not know which degree of naturalness (and corresponding degree of detail) is needed for comprehenders to exploit them. Yet, in natural conversation such social cues are highly relevant for interpretation and the extent to which they rapidly impact language comprehension deserves attention.

Additionally, we do not know to which extent the portrayal of facial emotions and action events *relative* to one another modulates visual attention and language comprehension. The link between social cues (e.g., a smile) and their associated scene aspects (other smiles or a positively valenced action) is naturally more subtle than the link between an action and its corresponding verb.

We therefore assessed whether adults can make use of direct action-related visual information on the one hand, and contextual social information of varying degree of naturalness on the other hand for sentence comprehension of non-canonical German object-verb-subject (OVS) sentences. We used OVS sentences since these are grammatical but non-canonical in German. They permit us to assess to which extent their associated processing difficulty is alleviated by the two manipulated cues. To motivate our studies in more detail, we first review relevant literature on the use of visual referential context of depicted actions in sentence comprehension, on the effect of extralinguistic social cues on sentence comprehension and on the difference between schematic versus natural facial expression depictions.

Sentence Comprehension and the Visual Context

Adults can rapidly use visual referential context for disambiguating structurally ambiguous sentences. In a real-world study, the context showed an apple, an apple on a towel, an empty towel and a box and participants

listened to related sentences (e.g., *Put the apple on the towel in the box*). They immediately fixated the apple located on the towel upon hearing the ambiguous phrase "on the towel". They thus used the visual context to interpret "on the towel" as the modifier of "the apple", specifying its location (Tanenhaus et al., 1995). Adults can further use depicted actions to facilitate role assignments in non-canonical OVS sentences (Knoeferle et al., 2005). In a visual world eye-tracking study, clipart scenes depicted agent – action – patient events; as participants inspected the scene, they listened to sentence-initial ambiguous German SVO and OVS sentences describing the events (e.g., a princess was depicted and described as being painted by a fencer). Results demonstrated that participants used the depicted action events to rapidly anticipate role relations and resolve the initial ambiguity.

Effects of Extralinguistic Social Cues (Faces)

Can other aspects of the visual context such as extralinguistic social cues likewise modulate and facilitate the processing of structurally difficult sentences, i.e., facilitate role assignment in non-canonical OVS sentences? Emotions and emotional facial expressions are essential for social interactions. They are extensively exploited when interpreting an interlocutor's utterances and feelings (cf. Nummenmaa, Hyönä, & Calvo, 2006). Moreover, using emotional priming in a visual world paradigm, Münster, Carminati and Knoeferle (2014) showed that videos of dynamically unfolding emotional facial expressions of real faces facilitated the processing of emotionally valenced canonical *SVO sentences* when the emotional valence between prime face and target sentence matched. Dynamic emotions are further recognized faster and more accurately and elicit enhanced and prolonged cortical responses vs. static counterparts (see e.g., Harwood, Hall, & Shrinkfield, 1999 and Recio, Sommer, & Schacht, 2011 for ERP evidence). Despite this, the processing of emotional sentences was equally facilitated by natural dynamic and static faces in Münster et al., (2014; see also Carminati & Knoeferle, 2013).

In summary, the findings by Münster et al. (2014) and by Carminati and Knoeferle (2013) showed for the first time that facial expressions can incrementally modulate adults' processing of emotional sentences. Yet, the referential integration of emotional valence was purely semantic. However, using non-canonical *OVS sentences*, the present study focuses on the facilitation of compositional integration, i.e., the anticipation of a target agent prior to it being mentioned in a sentence-initial role ambiguous situation.

Degree of Naturalness: Real vs. Schematic Faces

For interpreting utterances in natural social situations, we can rely on the full range of facial features and motions used to denote an emotional expression. However, whether the degree of naturalness of the facial expression matters (in modulating emotional effects on sentence processing) remains to be seen. For instance, research on emotional face recognition has also used computer-generated schematic faces; generally the evidence suggests that these are recognized as well as natural faces (e.g., Ruffman, Ng, & Jenkin, 2009, Öhman, Lundqvist, & Esteves, 2001; Chang, 2006).

We do not yet know, however, whether schematic or real facial expressions are equally facilitating cues during sentence processing. Is a schematic expression where emotion is stripped down to its bare essential (e.g., in smileys) sufficient, or do we need more detailed and *natural* emotional information to elicit emotional priming effects on online sentence comprehension? The present research addressed this question while building on the reviewed results.

The Present Research

In two visual world eye-tracking experiments we investigated how the processing of non-canonical German OVS sentences is influenced by two cues, i.e., (a) the presence (vs. absence) of an emotional prime (a "smiley" in exp.1; a natural facial expression in exp. 2, Fig. 1), and (b) the presence (vs. absence) of depicted action events. Participants saw either an emotionally positive prime (smiley in exp. 1 or positive natural expression in exp. 2, see Fig. 1) or an incongruent prime (a star in exp 1 and a sad natural expression in exp. 2) followed by a clipart scene depicting three characters (agent – patient – distractor, Fig. 2). Shortly after the onset of the scene, participants listened to a positively emotionally valenced OVS sentence describing the scene in a "who-does-what-to-whom" fashion (*Den Marienkäfer kitzelt vergnügt der Kater*, transl.: 'The ladybug (patient) tickles happily the cat (agent)'). In half of the trials the action mentioned in the sentence (e.g., tickling) was performed by the characters and depicted as an object on the screen (i.e., a feather, see Fig. 2); in the other half of the trials, the characters did not perform any actions i.e., no objects were depicted (Table 1). Participants orally answered a comprehension question in the active or passive voice asking for the agent or the patient of the action (exp. 1) or a passive comprehension question asking for the patient of the action (exp. 2) after each sentence.

Regarding the processing advantage for depicted actions (Knoeferle et al., 2005), we predicted facilitation in processing the OVS sentence when an action (vs. no action) was depicted. This should manifest itself in more fixations towards the agent of the sentence (vs. the distractor) in the depicted-action condition than in the no-action condition. Importantly, in the depicted-action conditions we expect fixations to the agent to be anticipatory (i.e., appearing before the mention of the agent), if listeners are able to use the actions proactively while they process the sentence (Knoeferle et al., 2005). Additionally, we predict more looks (anticipatory or not) towards the agent (vs. distractor) in the positive (vs. incongruent) prime condition, if the positive emotional prime facilitates processing of positive non-canonical (OVS) sentences.


Figure 1: Positive emotional primes for exp. 1 (smiley) and exp. 2 (happy natural facial expression)

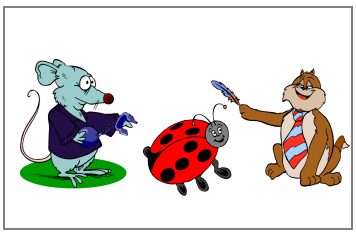

Figure 2: Example scene of an experimental trial with depicted actions associated with the OVS sentence *Den Marienkäfer kitzelt vergnügt der Kater*.

Table 1: Experimental Conditions

a)	positive prime	action depiction	*Den Marienkäfer kitzelt vergnügt der Kater* . Transl.: 'The ladybug (patient) tickles happily the cat (agent)'
b)	positive prime	no action	*Den Marienkäfer kitzelt vergnügt der Kater* .
c)	incongruent prime	action depiction	*Den Marienkäfer kitzelt vergnügt der Kater* .
d)	incongruent prime	no action	*Den Marienkäfer kitzelt vergnügt der Kater* .

Concerning the prime manipulation, we predict more pronounced effects with the real face (exp. 2) than the smiley (exp. 1) if the natural facial expression is a stronger cue than the iconic smiley. A stronger effect of the natural face should manifest itself in more fixations towards the agent in the positive (vs. incongruent) prime condition compared to the smiley version. Regarding the interaction between the depicted action and the positive prime, we predicted more looks towards the agent (vs. distractor) in the condition where both cues are present (vs. single cue or no cue conditions) if both cues can be integrated and used to facilitate role assignment at the same time. If, however, the different cues interfere with each other, we should see more fixations towards the agent (vs. distractor) in the single cue conditions (vs. the two-cue condition).

Offline, a processing advantage for the depicted-action condition (vs. no-action) should manifest itself also in higher accuracy for the comprehension questions. Likewise we predict higher accuracy for the prime (vs. incongruent prime) condition, if the positive emotional prime facilitates the comprehension of the non-canonical OVS sentences. Regarding a possible interaction of cues, we predict higher accuracy for the two-cue condition (vs. single-cue) if both cues additively facilitate answering the comprehension question. If, however, the cues interfere with each other, the single-cue conditions should show higher accuracy.

Experiment

Participants

40 adults (ages 18-30) participated in experiment 1 and 40 different adults in the same age range participated in experiment 2. All had German as their only mother tongue and normal or corrected-to-normal vision.

Materials and Design

Materials and design were identical for both experiments, except that exp.1 used a happy smiley (vs. a star), while exp. 2 used a happy (vs. unhappy) natural facial expression as a prime (Fig. 1).

We created 16 experimental positively valenced German OVS sentences in the form 'The [agent $_{\text{accusative case}}$] [Verb] [positive Adverb] the [patient$_{\text{nominative case}}$].' and 28 filler sentences (thereof 24 SVO sentences). Filler sentences were balanced for neutral and positive valence. For each sentence we created a clipart scene. The 16 experimental scenes each consisted of three characters (agent – patient – distractor). The sentential patient was always the middle character. Both agent and distractor character were facing the patient. The patient always faced the agent of the sentence (see Fig. 2). The characters were balanced for left and right positioning, across items and the different experimental lists. The scenes for the 28 filler sentences depicted either 2 or 3 characters, balancing out the number of characters in a scene across all 44 trials. In addition, in exp 2 we changed the positioning of filler characters, so that agent and patient did not always face each other and/or were positioned next to each other. This was done to prevent strategy development as to who is interacting with whom. To match the positive sentence valence, the agent portrayed a happy facial expression in all experimental scenes. The patient always portrayed a neutral expression and the distractor character a slightly negative one.

For each experimental scene we created two versions of the same picture. One version where the action verb mentioned in the sentence was depicted (i.e., the characters are performing the action of the sentence), and one version where the characters were not performing any action, i.e., they simply stand next to each other. If actions were depicted, both the agent and the distractor character performed an action towards the patient (middle character, see Fig. 2). In the filler pictures, action depiction was balanced, so that in half of all 44 trials an action was depicted.

We crossed the depicted-action vs. no-action scenes with the positive prime vs. incongruent prime condition. In exp. 1 the prime consisted of a happy looking smiley; the incongruent prime condition consisted of a star. In exp. 2 the prime condition consisted of a woman's facial expression showing a broad and open smile, the incongruent prime condition had the same woman

portraying a sad expression. As only the positive emotional expression matches in valence with the sentence and the facial expression of the target agent, we call the positive facial expression the prime. We will refer to the star (exp. 1) and the negative facial expression (exp. 2) as the incongruent prime condition.

Procedure

An Eyelink 1000 Desktop Mounted System with remote setup monitored participants' eye movements. Only the right eye was tracked, but viewing was binocular. Each trial started with a prime (happy smiley for exp. 1 or positive natural facial expression for exp. 2) or incongruent prime (star for exp. 1 or negative facial expression for exp. 2). The prime in exp. 1 was presented for 1750 ms, the prime in exp. 2 was presented for 5500 ms. Both prime versions were accompanied by the spoken phrase "Look!" to catch participants' attention and direct it to the following scene. 2000 ms after the onset of the target screen the sentence was presented. 500 ms after the end of the sentence, all depicted actions (if present) were removed from the scene and the comprehension question was heard. After participants had responded to the question, the experimenter proceeded to the next trial. Each experiment took approximately 30 minutes.

Analysis

We divided the sentence into individual word regions and a long region encompassing the whole sentence. We will focus on our critical regions (the Verb and Adverb). The Verb region is the first region where the agent of the sentence can be anticipated if an action is depicted on the screen. The Adverb region gives away the valence of the sentence and thus matches in positive valence with the prime in the prime condition. For each region (and a combined Verb-Adverb region), we computed the mean log gaze probability ratio according to the formula: *Ln* (*p*(agent)/*p*(distractor)). *Ln* refers to the logarithm and *p* refers to probability. This ratio expresses the bias of inspecting the agent relative to the distractor. The ratio does not violate the independence and homogeneity of variance assumptions, which makes it suitable for comparing looks to two scene regions with parametric tests such as Analyses of Variance (ANOVAs, see, e.g., Arai, Van Gompel, & Scheepers, 2007). More looks to the agent (vs. distractor) are indexed by a positive log ratio. More looks to the distractor (vs. agent) are indexed by a negative log ratio.

We computed mean log gaze probability ratios for each region separately by participants and items. These means were then subjected to ANOVAs with participants and items as random effects. Accuracy scores were computed for each experiment by condition.

Results

Main results for the accuracy analysis in exp. 1. Only experimental trials were included in the analyses. Participants answered 95.93% of all trials correctly. We did not find main effects of prime or action depiction. The interaction between prime and action depiction was also not significant. However, we saw a main effect of voice ($p<.05$). Subjects' answers were significantly more accurate when the comprehension question was posed in the active than in the passive voice. Moreover, we found an unexpected significant voice x prime interaction in the item analysis ($p<.05$). This interaction shows that the presence of the emotional prime proves helpful for answering the comprehension question but only with the questions in the passive voice (Fig. 3).

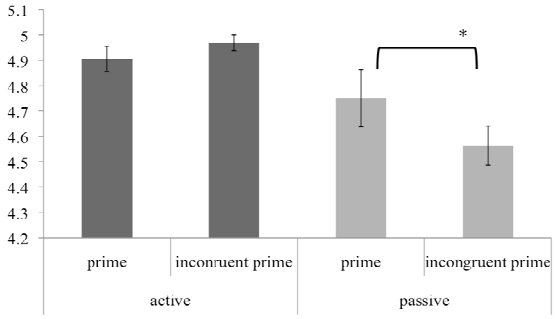

Figure 3: Voice x prime interaction in the accuracy results (exp. 1)

Main results for the accuracy analysis in exp. 2. Participants answered 95.6% of the comprehension question correctly. Results yielded a significant effect of action depiction ($p<.05$) and a marginal effect of prime. When an action was (vs. wasn't) depicted, participants were significantly more accurate in answering the question. Moreover, they were more accurate when the valence of the prime was positive (i.e., congruent) than when it was incongruent.

Main results for the eye-movement analysis in exp. 1. Results revealed a significant effect of action depiction in all analyzed regions (all $ps<.05$), indicating a strong preference to look more at the agent (vs. distractor) when the mentioned action was (vs. wasn't) depicted. Although we did not find a significant effect of the emotional prime, nor any interactions, the means of the interactions of all analyzed regions show that participants look more at the agent, i.e., the subject of the sentence (vs. the distractor) when the emotional prime is positive (vs. incongruent), but only in the condition for which an action is also present (Fig. 4).

Main results for the eye-movement analysis in exp. 2. Results revealed a significant effect of action depiction in all analyzed regions (all $ps <.05$), indicating a strong preference to look more at the agent than the distractor when the mentioned action was (vs. wasn't) depicted. Moreover, we found a marginal effect of prime for the Adverb, Verb-Adverb (Fig. 5) and the long region. While the interactions were not significant, the means of all analyzed regions clearly show that participants look more at the agent (vs. the distractor) when the emotional prime

(happy face) is presented (vs. incongruent prime), but only when actions are also depicted.

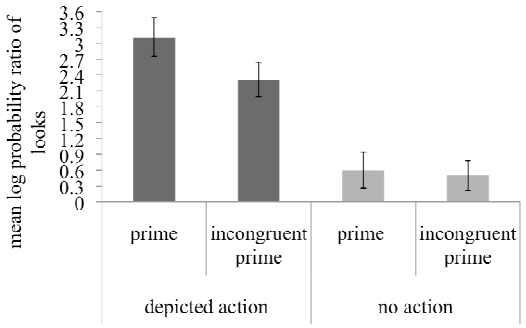

Figure 4: Prime x action interaction for the adverb region (exp. 1)

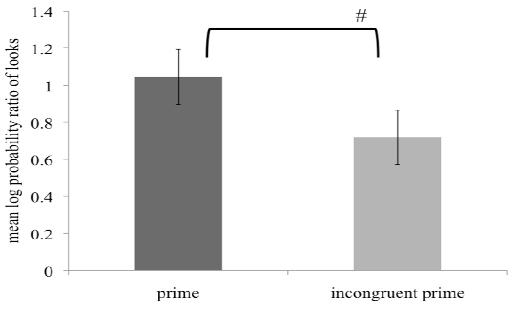

Figure 5: Marginal effect of prime for verb-adverb region (exp. 2)

Discussion

In two visual-world eye-tracking experiments, we assessed to which extent adults can use depicted actions and positive facial emotions for understanding non-canonical OVS sentences. Moreover, we investigated whether the form of the prime face (schematic vs. real face) modulates potential facilitative effects of the emotional primes on sentence processing.

Our results show that participants make extensive use of depicted action events (vs. no actions) in identifying the agent of the sentence when processing the OVS sentences. More interestingly, adults also seem to make use of the non-linguistic social cue, i.e., the positive emotional facial prime in processing the OVS sentences. Crucially, the means of the action x prime interactions indicate that the emotional cue is only used in combination with a depicted action being also present, irrespective of its schematic or natural appearance. One possibility is that the facial expression is merely used for reassurance purposes, i.e., because it corroborates the already powerful cue provided by the depicted action. In fact, the action object depicted on the screen referentially links to the linguistic input (the verb). On the other hand, when the positive face prime appears without the action, the link between the prime, the agent's positive facial expression and the positive valence of the sentence is much less direct, perhaps also because the valence of the prime is not explicitly mentioned in the sentence. The listener arguably must infer the relationship between these different kinds of cues (facial prime, the target agent's facial expression and sentence valence) to integrate them during sentence comprehension. It appears that this integration does not happen on the fly, unlike establishing a direct link between the depicted actions and the verb. Thus, the emotional cue may only be used to re-confirm the role relations that are assigned by "direct" reference to the visual context when the action is depicted.

As regards the facial prime manipulation, we observed essentially the same prime x action interaction pattern (Fig. 4) with the schematic smiley (exp. 1) as with the natural facial expression (exp. 2). These results are broadly in line with findings that viewers recognize schematic and natural faces equally well (Ruffman et al., 2009; Öhman et al., 2001; Chang, 2006, but see Prazak & Burgund, 2014, for evidence that processing of real faces may be more holistic than that of schematic ones).

However, our analyses revealed a marginal effect of prime on sentence processing with natural face primes (but not with the smileys). The natural facial expression appears to be used to a greater extent during sentence interpretation and thematic role assignment than the smiley. A further reason for this difference could be a design feature of our experiments. In exp. 2 the incongruent prime condition was a sad face while in exp. 1 this condition was a neutral star symbol (i.e., not a sad smiley). This may have contributed to enhancing attention to the positive face (i.e., because it appeared in contrast to a sad one in exp. 2). In turn this may have contributed to a greater effect of the natural happy faces on sentence processing in exp 2 than for the happy smiley in exp 1. In addition, the natural faces were presented longer, arguably enabling more in-depth interpretation of the emotions and thus stronger effects on visual attention.

Another factor that may have contributed to a better integration of the natural face prime into the processing of the sentence (in combination with the design factor mentioned above) is that in exp. 2 the natural prime face 'fitted' better with the experimental context, in the sense that this face was more readily perceived to be the face of the speaker of the following sentence (which was spoken by a female voice). This arguably contributed to rendering the experimental scenario of exp. 2 more naturalistic, i.e., more similar to everyday situations in which we can use non-linguistic information such as the facial expression of our interlocutor to help us interpret the linguistic input within its (non-)linguistic context. Moreover, as in exp. 2 we also ruled out possible strategic effects regarding the facing of agent and patient characters, the effects cannot be due to an inspection of the pictures alone. In order to reliably assign thematic roles, visual cues have to be integrated into the processing of the linguistic input.

From clues such as facial expressions we attribute mental states to others ("Theory of mind", Premack & Woodruff, 1978) and we expect human interlocutors to behave coherently. Thus we expect a person with a happy face to say something positive. In exp. 2 the happy face

prime set up this expectation, and this may have enhanced looks to the target agent. By contrast, we do not usually interact with smileys and thus a smiley as a "speaker" may not elicit the same kind of expectation. The subtle effects of the emotional prime vs. e.g., results by Carminati & Knoeferle (2013) and Münster et al. (2014) could also be due to the different processing types investigated. Thematic role assignment is arguably a cognitively more challenging task than semantic-referential processing, and thus may result in weaker integration of the social cue since attentional resources needed are higher.

To conclude, although a schematic smiley provides sufficient information to facilitate sentence processing in combination with depicted actions, our results provide some evidence for the view that a natural facial emotional expression can lead to a subtly stronger priming effect and thus is better integrated into the interpretation of emotionally valenced OVS sentences.

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