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The Influence of Prosody and Case Marking on Thematic Role Assignment in Ambiguous Action Scenes: Adults versus Children

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Abstract

In two visual word eye tracking studies, we investigated the influence of prosody and case marking on children's and adults' thematic role assignment. We assigned an SVO/OVS-biasing (vs. neutral) prosodic contour to unambiguously case marked German subject-verb-object (SVO) and object-verb-subject (OVS) sentences respectively. Scenes depicted ambiguous action events (e.g., donkey-paints->elephant-paints->cheetah) but case marking and prosody could, in principle, disambiguate. In adults, case marking but not prosody rapidly guided thematic role assignment. Children did not rely on case marking but exploited the biasing prosody to enhance their agent-first interpretation of the sentences. These results suggest that in scenes depicting fully ambiguous role relations, children's understanding of case marking at the age of five is not yet robust enough to enable thematic role assignment. Prosody did not overwrite the SVO preference, it rather enhanced it.

Keywords: Visual World Paradigm, eye movements; prosody; action scenes; age differences; language processing; thematic role assignment; case marking.

Introduction

In rich contexts, listeners can rapidly exploit a range of different cues (e.g., prosody, non-linguistic information, case marking) during language comprehension. Such cues can, for instance, help them to efficiently identify the thematic roles of a sentence. Thematic roles distinguish the role an argument carries with regards to the predicate of the sentence (Carnie, 2002). Although children rapidly acquire language during the first years of their life, a full command of their native language takes, not surprisingly, time to develop. One aspect that is particularly challenging is the correct assignment of thematic roles. In German, for example, a transitive sentence typically includes a subject, a verb, and an object but speakers can arrange these constituents in more than one way, yielding, among others, subject-verb-object (SVO) or object-verb-subject (OVS) orders. To determine who is doing what to whom, comprehenders can rely on the case-marked determiners of the sentential noun phrases. Accusative case marks a sentence-initial noun phrase as the object (patient), and nominative case marks it as the subject (agent) of the sentence. But case marking can be

ambiguous in German (feminine and neuter nouns have the same form in the nominative / subject and the accusative / object case), resulting in temporary ambiguity as to who-does-what-to-whom. The resolution of this ambiguity can be difficult for children, not only because of their strong SVO word order bias. The following section describes a range of studies on how adults rapidly exploit visual, case, and prosodic cues for thematic role assignment while children sometimes struggle to exploit these cues.

Visual Information

In rich contexts, non-linguistic information like the visual referential context, contrast between objects, depicted actions, or events can all rapidly influence the interpretation, syntactic structuring, and thematic role assignment of spoken utterances (e.g., Chambers, Magnuson, & Tanenhaus, 2004; Knoeferle, Crocker, Sheepers & Pickering, 2005; Sedivy et al., 1999; Tanenhaus et al., 1995). Tanenhaus and colleagues (1995) found that adults use referential context to disambiguate sentences (e.g., *Put the apple on the towel in the box*). The visual display contained either one or two referents (one referent: an apple on a towel, two referents: one apple on a towel and another apple on a napkin). Participants' gaze pattern suggested structural disambiguation in that they interpreted the towel as a destination (VP-analysis) for the apple in the one-referent context and as the location of the apple (NP modifier analysis) in the two-referent context (see Sedivy et al., 1999 for related effects of contrastive adjectives in establishing reference to objects).

Event relations depicted in the visual context can help listeners with anticipating thematic role relations. In Knoeferle et al. (2005), participants listened to locally ambiguous German SVO and OVS sentences (transl: 'the princess (agent/patient) washes/paints apparently the pirate (patient)/ the fencer (agent)'). The sentences did not provide information about who is the agent or the patient prior to disambiguation by case marking on the determiner of the second noun phrase. Scenes depicted the princess in both an agent and a patient role (the fencer was acting upon the princess while the princess was acting upon a pirate). During the verb ('washes / paints'), participants successfully anticipated the patient or the

agent role filler respectively in SVO and OVS sentences. Thus, the depicted event information resolved the ambiguity in the linguistic input.

Children, much like the adults, can rapidly exploit depicted actions to correctly identify thematic roles in German SVO and OVS sentences. Shortly after the verb had identified the action (and its associated role relations), the children anticipated the patient (vs. agent) in the scene for SVO sentences (Zhang & Knoeferle, 2012) and the depicted agent (vs. patient) for OVS sentences (Münster, 2016; Zhang & Knoeferle, 2012). However, children, unlike adults, did not exploit a referential context for disambiguating a VP-/NP-attachment ambiguity. When hearing *Put the frog on the napkin...* they interpreted the napkin as the frog's destination in both the one- and the two-referent context even though the latter biased towards a location interpretation (Trueswell et al., 1999). However, in the absence of real-time measures these results do not provide insight into children's online sentence processing.

Case Marking

When it comes to linguistic information, case marking is believed to be a very strong cue for thematic role assignment with adult participants (e.g., Matzke, Mai, Nager, Rösseler & Münte, 2002). However, studies in five-year old children report conflicting results. Dittmar et al., (2008), found that five-year-olds struggled to exploit case marking for thematic role assignment. The results of an act-out task revealed that children relied on (SVO) word order instead of case marking for interpreting ambiguous and unambiguous German SVO and OVS sentences. They interpreted the first noun phrase as the subject/agent even if it was case-marked as the object/patient of the sentence (agent-first/SVO bias). However, more recent evidence suggests that children at the age of four to five *can* rely on case marking for correct thematic role assignment in unambiguous German SVO and OVS sentences (e.g., Özge et al., 2015).

In Özge et al., (2015), information from the visual display likely supported the interpretation of the linguistic input. The scenes were created on the basis of world knowledge about who is the most likely agent and the most likely patient (typically the fox eats the hare and the hare eats the cabbage). The scenes thus showed animals (a hare, a fox, and a cabbage) between which stereotypical role relations exist, but they did not disambiguate who-does-what-to-whom (case marking did).

Even clearer effects of the visual context emerged in Zhang et al. (2012) and Münster (2016). Here, depicted actions (e.g., a bear painting a worm) disambiguated the role relations (only one animal performed the action mentioned in the linguistic input) but scenes did not depict stereotypical role relations; when the actions were absent, unambiguous case marking alone (i.e., in the absence of stereotypical role relations between bear and worm) was insufficient to disambiguate the role relations. Thus, the visual context seems to matter. By contrast, the effects of case marking alone on children's thematic role

assignment (i.e., when scenes do not support thematic role assignment through either stereotypical world knowledge associated with the characters or disambiguating action depictions) remain unclear.

Prosody

Supra-sentential information can also be useful for establishing a link between the linguistic input and the visual world. Among others, prosody assigns focus to sentence constituents (e.g., via accentuation). Prosody can moreover rapidly disambiguate syntactic structure. In a visual world eye tracking study, participants rapidly exploited prosody to identify grammatical functions when the scene depicted role fillers such as a cat, a bird, and a dog, for which world knowledge implicated stereotypical thematic relations (e.g., cats chase birds and dogs chase cats, Weber et al, 2006). But the scenes did not otherwise disambiguate the upcoming thematic role relations. Feminine case marking (identical in nominative and accusative case) on the determiner of the first noun phrase created locally structurally ambiguous sentences: *Die Katze (amb.) jagt womöglich den Vogel (acc/obj)/der Hund (nom/subj)*– ‘The cat (amb.) chases possibly the bird (obj/patient)/the dog (subj/agent)’. Biasing prosodic contours prompted listeners to make more anticipatory eye movements towards the agent (vs. patient) in the scene for ambiguous OVS sentences and towards the patient (vs. agent) in the scene for ambiguous SVO sentences. Prosody was the only information available for the correct anticipation of thematic roles prior to the disambiguating case marking on the second noun phrase; but at the same time, world knowledge associated with the scene may have provided a supportive background.

Children also exploited prosody for thematic role assignment (Grünloh et al., 2011). Two short videos showed thematic role relations in two orders, permitting a direct contrast of agent-patient and patient-agent events. However, prosodic effects (of an accentuated first noun phrase in OVS sentences) emerged only when case marking was also present. When case marking was absent (ambiguous OVS sentences) children relied on their (SVO) word order bias instead of prosody and thus interpreted the OVS sentences as agent-first sentences.

The Present Research

This paper investigates the effects of prosody (biasing towards either the SVO or the OVS order as in Weber et al., 2006 vs. neutral) and case marking (SVO vs. OVS) in ambiguous action scenes. The actions were depicted but did not give away the specific role relations of the sentences (two characters performed identical actions and could both function as possible agents of the verb, Fig. 1, the elephant; the donkey, see Table 1 for sentences). Our scenes did not include stereotypical knowledge about who does what to whom. If a supportive context is necessary for children to exploit case marking, then we should see no effects of case marking on thematic role assignment in the present study (i.e., no anticipation of the agent / the

donkey in OVS but of the patient, the cheetah, in SVO and OVS sentences, Table 1 and Fig. 1, portraying an SVO bias). This prediction is based on the literature that revealed conflicting results regarding children's reliance on case marking (Dittmar et al., 2008; Özge et al., 2015). Alternatively, seeing event relations depicted could be helpful even if the characters perform identical actions (i.e., seeing a donkey as the patient in a painting event might help to integrate object case marking). If so, we should see effects of case marking.

If prosodic effects do not depend on a supportive scene context, then we should see effects of prosody on children's thematic role assignment and anticipation of role fillers in the scene. Alternatively, we may observe the effects of an SVO bias (more looks to the patient / the cheetah during the verb) independent of case marking and prosody in children.

Adults can rapidly use case marking for thematic role assignment (Matzke et al., 2002) and should thus anticipate the correct patient / agent depending on case marking. Prosody should also influence the timing and amount of anticipatory eye movements towards the target role filler during the time course of the sentence.

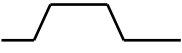

Participants further responded post-trial to questions about who-does-what-to-whom. Adults should answer these questions correctly in almost all cases since case marking was unambiguous (further effects of prosody may or may not emerge). For children, case-marking may affect the accuracy (reduced for OVS sentences). We also expected more correct responses for sentences assigned a biasing (vs. neutral) prosodic contour if children benefit from prosody for thematic role assignment.

Experiments

Participants. 24 five-year old children (age range 4.5 to 5.10 years) and 24 young adult (mean age=25.5) monolingual (i.e., no acquisition of a second language before the age of 6) native speakers of German participated in this study. Children came from different kindergartens in the area of Bielefeld and the experiment was conducted at the kindergartens. Each child received a toy for participation. Young adults were students from Bielefeld University and were paid to participate. Participants had normal or corrected vision and hearing and all gave informed consent. The Bielefeld University ethics committee approved the experiments.

Materials. A linguistically trained female native speaker of German recorded 24 unambiguous transitive German subject-verb-object (SVO) and 24 unambiguous transitive German object-verb-subject (OVS) sentences. She was instructed to use the prosodic structure displayed in Table 1 for each sentence structure respectively. The sentences were all unambiguously case marked on the first noun phrase of the sentence. We emulated the prosodic contours reported by Weber et al. (2006) and these were either present or sentence intonation was even. In SVO sentences the main stress was on the verb (L*+H accent on NP1, H* accent on the verb) and in OVS sentences on the first noun phrase (L+H* accent on NP1; Table 1).

Table 1. Overview of experimental conditions (ag=agent, pat=patient, subj=subject, obj=object).

Sentence Structure	Prosodic Structure	Example
SVO	 L*+H (NP1), H* (verb)	Der Elefant (subj/ag) zeichnet sogleich den Gepard (obj/pat). <i>The elephant (subj/ag) draws immediately the cheetah obj/pat).</i>
SVO	neutral	Der Elefant (subj/ag) zeichnet sogleich den Gepard (obj/pat). <i>The elephant (subj/ag) draws immediately the cheetah obj/pat).</i>
OVS	 L+H* (NP1)	Den Elefanten (obj/pat) zeichnet sogleich der Esel (subj/ag). <i>The elephant (obj/pat) draws immediately the cheetah (subj/ag).</i>
OVS	neutral	Den Elefanten (obj/pat) zeichnet sogleich der Esel (subj/ag). <i>The elephant (obj/pat) draws immediately the cheetah (subj/ag).</i>

For each of the 24 SVO and OVS sentences we created scenes depicting three clipart animal characters (Fig.1). The direction in which these characters were looking was the same for all three of them, either left or right. The middle character and one of the adjacent characters were depicted as performing the same action (e.g., for the verb 'draw', *zeichnen*, the two characters were depicted as holding a pencil on a canvas). The third character did not perform an action. Thus, the actions provided a context but did not permit comprehenders to unambiguously identify the correct thematic role relations upon hearing the verb.

The middle character was always role ambiguous because it could be the agent or the patient of the scene. We dub the other character depicted as performing an action the 'true agent' of the scene and the character not performing an action the 'true patient' of the scene. Each animal character filled both roles (that of a true agent and a true patient). The cheetah, for instance, is the true patient in the image shown in Figure 1. In a counterbalancing scene, the cheetah is the true agent. The elephant is depicted as drawing in the example scene (true agent); in a counterbalancing scene, the elephant is the true patient. Across all lists, each scene occurred once in each condition with all characters facing right and once

with all characters facing left. We added 8 fillers to the experiments. The number of filler was kept constant for the two experiments to maximize similarity in the materials across age groups. Post experiment questionnaires revealed no recognition of the experimental goal. After each trial participants were asked a comprehension question which was either presented in active or in passive voice (e.g., *Who paints here? Or who is being painted here?*). Prior to the actual experiment three practice trials familiarised the participants with the scenes and the task. The design of these items was identical to the experimental items. The sentences were structured either in SVO or OVS order and prosody was either biasing or neutral. All scenes were pre-tested with 20 five-year old children and the results confirmed that all depicted characters were correctly identified. Out of the 24 different depicted actions, only one was not correctly identified and was exchanged.

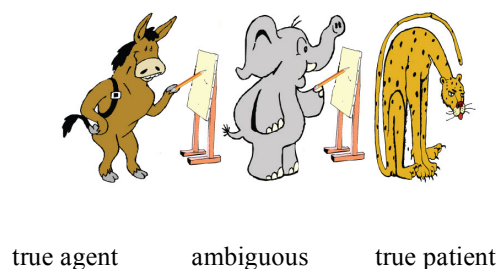


Figure 1. Example picture of a scene.

Procedure. Participants' eye movements were monitored with an EyeLink 1000 eye tracker with a sampling rate of 500 Hz Monocular, and an average accuracy of 0.5° in the remote setup. Images were presented on a Dell laptop with a screen resolution of 1920x1080. Before starting the experiment, the experimenter manually calibrated the eye tracker using a five-dot calibration scheme. For each trial, the scene was presented for 2000 ms, followed by the auditory sentence. 1500 ms after sentence offset the question followed (Fig. 2). A drift correct point separated the trials to ensure calibration of the eye tracker and the same starting point for each trial. Participants first saw the practice trials. Next, the experimenter re-calibrated before starting the experiment. Each testing session lasted approximately 20 minutes.

Analysis. We defined two word regions for the analysis: verb and adverb (beginning of verb onset to adverb onset for the verb and beginning of adverb onset to NP2 onset for the adverb). These two regions were defined on the basis of the prosodic structure of the sentences. We focused on the verb region because this is where the prosodic structures can be distinguished. Whenever there is a main stress on the first noun phrase, the verb experiences a fall in stress. Otherwise the main stress is on the verb. We were further interested in the adverb region to examine post-verbal eye movements.

Visual input: 2000ms

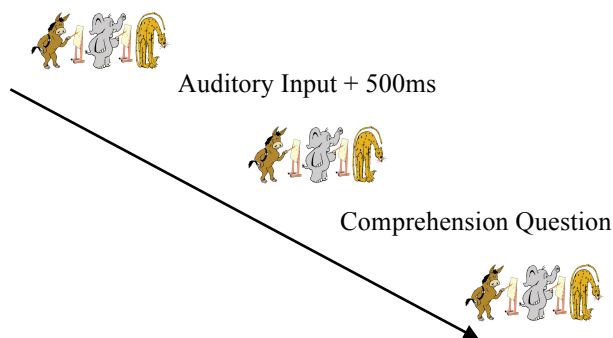


Figure 2. Example for the time course of an experimental trial.

In the scenes, we defined two role fillers (the donkey, the true agent; the cheetah, the true patient) as areas of interest. The middle role filler was always mentioned at the beginning of each sentence and was thus not used for the analysis of anticipatory eye movements. We computed mean log-ratios of looks towards the agent and the patient of the scene (see Arai, van Gompel & Sheepers, 2007; Carminati & Knoefeler, 2013). Log-ratios are a relative measure that represents the looks towards one character over the other. On the basis of these mean log-ratios we conducted an Analysis of Variance (ANOVA) following a 2 (word order) x 2 (prosody) design by subject and by item for all word regions of the sentence (NP1, verb, adverb, NP2). All positive numbers in the log-ratios represent a preference of looking at the agent (vs. patient) in the scene and all negative numbers a preference towards the patient (vs. agent) in the scene. The post-sentence questions show the number of correctly answered questions. We calculated percentages of correct answers of all possible answers and analysed the accuracy data using generalised linear mixed effects models (Bates, Mächler, & Walker, 2015).

Eye movement results. The data for both age groups showed no significant effects of prosody in the verb and adverb regions (Figs 3 and 4). For the adults (only), the analyses revealed a main effect of word order for the verb and adverb (Fig. 3: adverb). The adults were more likely to inspect the patient (vs. agent) in SVO sentences (negative numbers) and the agent (vs. patient) in OVS sentences (positive numbers) during the adverb region (word order effect: $p < .001$).

The child data showed more looks towards the patient (vs. agent) in all four conditions (intercept $p < .05$). The preference to inspect the patient over the agent is only slightly higher in the biasing compared to the neutral prosody conditions (Fig. 4).

Accuracy Results. Adult's post-sentence answers revealed a high percentage of correct answers (99%), with no difference between the conditions (Fig. 5). The child data revealed an overall accuracy of 71%. The analyses revealed no clear difference between the two prosodic

conditions but a main effect of word order ($p < .001$, Fig. 6).

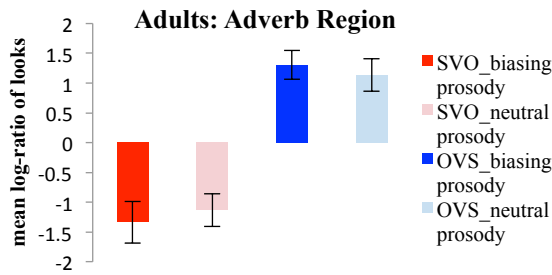


Figure 3. Mean log-ratio of looks of agent over patient during the adverb region per condition in adults (Analysis by subjects).

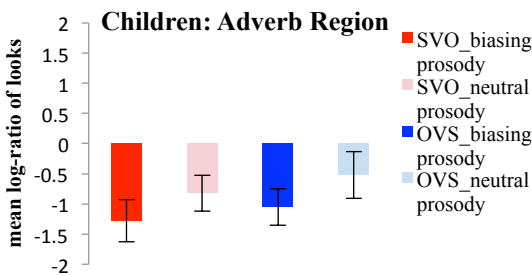


Figure 4. Mean log-ratio of looks (agent over patient) during the adverb region per condition in children (Analysis by subjects).

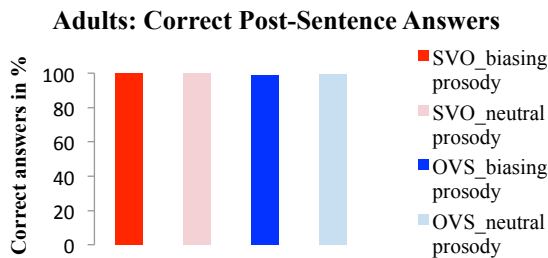


Figure 5. Accuracy results: percentage of correct post-sentence answers per condition in adults.

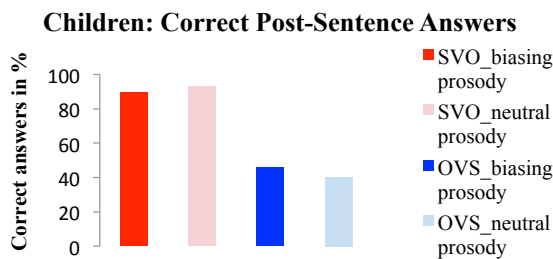


Figure 6. Accuracy results: percentage of correct post-sentence answers per condition in children.

Discussion

We investigated children's and adults' thematic role assignment in unambiguously case marked German SVO and OVS sentences using scenes in which two role fillers performed identical actions. Thus, as participants heard the verb, it was unclear which of two events (one depicting the NP1 referent as the agent, the other depicting him as a patient) to rely on for anticipating upcoming role fillers. In brief, the scene did not disambiguate the thematic roles relations. But case marking and prosodic cues could, in principle, permit anticipatory thematic role assignment. We recorded participants' eye movements to the agent and patient in the scene while they inspected scenes and listened to related German SVO and OVS sentences (Table 1).

Previous research has reported effects of prosody on thematic role assignment in German children and adults (Grünloh et al., 2011; Weber et al., 2006). Unlike these previous findings, our results revealed no significant effect of prosody. Previous research further revealed that adults rapidly use case marking for thematic role assignment (Matzke et al., 2002). Results for children were, however, contradictory (Dittmar et al., 2008; Münster, 2016; Özge et al., 2016; Zhang & Knoeferle, 2012). In line with previous findings, the adults in our study exploited case marking for real-time thematic role assignment. They directed more anticipatory looks towards the true patient (vs. agent) in SVO sentences and towards the true agent (vs. patient) in OVS sentences. Children, by contrast, did not exploit case marking for such visual anticipation. In both SVO and OVS sentences, they directed more anticipatory looks towards the true patient during the adverb. They thus seem to have interpreted OVS sentences as agent-first sentences, disregarding the unambiguous object case marking on the sentence-initial noun phrase.

In adults, the null effect of prosody might be explained by the fact that morpho-syntactic (case) information has stronger links to thematic role assignment than supra-sentential information. Similar arguments have been made for prosodic marking and object color contrast (Sedivy et al., 1999). Sedivy et al. argued that color contrast effects enable a strongly contrastive interpretation already, eliminating further contrastive intonation effects. A similar argument might hold for case marking and prosody. Case marking in adults fully disambiguated thematic role assignment and prosody had no additional beneficial effects. Relatedly, adults in Grünloh et al. (2011, Exp. 1) failed to exploit prosody but used case marking for thematic role assignment.

Concerning the children, our prosody results differed from those by Grünloh and colleagues (2011) who reported that a contrastive OVS-biasing intonation in unambiguous sentences facilitated children's identification of patient-agent events. One reason for this might be that we used different scenes. In our study, participants saw one ambiguous scene that included both possible interpretations (e.g., true patient <-action ambiguous <-action true agent). In Grünloh and

colleagues (2011), by contrast, children selected one event picture from two adjacent ones (in which agent and patient roles appeared in reversed order, agent-patient vs. patient-agent). This direct contrast may have facilitated identifying the correct event by means of prosody (and case marking). In addition, in our scenes participants – including children – inspected the NP1 referent when it was named. The verb then linked to a matching action of that referent and likely reaffirmed this was the correct agent. It is possible that the verb-action match and additional posture of the NP1 referent (facing the true patient), may have led children in particular to interpret an L+H* accent on NP1 as highlighting the NP1 as the agent rather than as the patient, even if case-marking indicated it was the object and patient.

In previous studies on children's use of case marking (Münster 2016; Özge et al., 2015; Zhang & Knoeferle 2012), *visual* information likely provided a supportive background for exploiting case marking. Unlike prior research, our scenes did not constrain thematic role relations by means of stereotypical knowledge (Özge et al., 2016) or action depictions that – once the verb became available – permitted children to distinguish SVO and OVS sentences (Münster, 2016; Zhang & Knoeferle, 2012). One of the reasons for why children in our study did not use case marking in real time might thus be the lack of supportive contextual information.

Children's comprehension mechanisms develop throughout the first years of their life. They learn from their immediate environment and from observing who interacts with whom. Perhaps they need an unambiguous visual background to exploit case for syntactic structuring. Without that, they fail to correctly interpret more demanding OVS sentences and fall back on default structures (e.g., SVO). Further research could examine when children start to abstract away from the visual display and begin to use case marking in an adult-like manner for syntactic structuring.

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