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German Children's Comprehension of Word Order and Case Marking in Causative Sentences

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Two comprehension experiments were conducted to investigate whether German children are able to use the grammatical cues of word order and word endings (case markers) to identify agents and patients in a causative sentence and whether they weigh these two cues differently across development. Two-year-olds correctly understood only sentences with both cues supporting each other—the prototypical form. Five-year-olds were able to use word order by itself but not case markers. Only 7-year-olds behaved like adults by relying on case markers over word order when the two cues conflicted. These findings suggest that prototypical instances of linguistic constructions with redundant grammatical marking play a special role in early acquisition, and only later do children isolate and weigh individual grammatical cues appropriately.

One of the important tasks of early childhood is mastering a conventional language. Languages differ not only in their words but also in the grammatical constructions they employ for assembling words into meaningful utterances. Grammatical constructions are composed of multiple words, or word categories, structured into patterns in particular ways by such things as word order and grammatical markers (e.g., a different ending on a word when it is the subject rather than the direct object in a sentence—so-called case marking). In English, the sentence ''The dax mibbed the gazzer a toma'' (the ditransitive construction) implies a transfer of some kind, even though all the contentful words are meaningless (Goldberg, 1995).

One construction of particular importance in early development is the basic transitive construction, prototypically used to indicate an agent causally acting on an object, as in simply ''The dax mibbed the gazzer.'' The importance of this construction stems from the fact that it is one of the ontogenetically earliest in which it is critical to distinguish the different roles of the participants in some event. Thus, ''The toma mibbed'' creates no problems for deciding who was doing the action because there is only 1 participant. But if we hear ''The toma the gazzer mibbed,'' we must decide who is mibbing whom, and to do this we need to understand the grammatical conventions of the particular language being learned. Interestingly, in most languages, there are multiple, redundant cues for helping the listener do this in many utterances—although in other utterances, there can be just a single cue. For example, in the English sentence ''He mibs pencils,'' we identify the agent of the action as *he* based on the facts that: (a) it is said before rather than after the action word or verb (word order), (b) it is the subject pronoun *he* (and not the object pronoun *him*; case marking), (c) it agrees in number with the verb (we say ''He mib*s*'' but ''Pencils mib,'' without an -s; subject – verb agreement), and (d) it is a statistical fact that animate beings, such as male persons, are more likely to act on inanimate things, such as pencils, than the other way around (animacy). A child acquiring the English transitive construction, therefore, could on a particular occasion be using any or all these cues to determine who is mibbing whom in the utterance.

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The competition model of Bates and MacWhinney (1987, 1989) represents an attempt to assess how children acquire the different cues of different languages—especially in the transitive construction—and how they weigh these cues relative to one another when they conflict (see also Slobin & Bever, 1982). In a comprehension task in which they were asked to identify who was doing what to whom, young children heard a sentence such as ''Him kissed she.'' Case-marked pronouns indicate that the female kissed the male (she > him), but word order indicates that the male kissed the female (him > she). The finding is that from early in the preschool period English-speaking children privilege word order over all other tested cues (e.g., animacy and subject–verb agreement) in interpreting transitive sentences. Other researchers have tested English-speaking children's comprehension of word order when it is the only cue available (therefore not conflicting with any other cues) and found that even young 2-year-olds already distinguish between such things as ''X is tickling Y'' and ''Y is tickling X'' (Hirsh-Pasek & Golinkoff, 1996, with familiar verbs; Gertner, Fisher, & Eisengart, 2006, with novel verbs).

In many other languages, the grammatical cues in transitive sentences are much more evenly weighted than in word-order dominant English. For example, various languages in which all nouns are case marked for their role in the sentence (not just pronouns, as in English), have a much more flexible word order—because if a word is locally marked with a case marker indicating its role in the sentence, then word order may be used for pragmatic functions such as emphasis and perspective (as English does awkwardly in such sentences as ''**Him** I like''). Therefore, if German adults are presented with a sentence parallel to the English sentence above (''Him kissed she''), they interpret it in the opposite way to English adults, that is, they insist that the subject-marked pronoun *she* indicates the one doing the kissing even though it comes after the verb (whereas it most often comes before the verb) (MacWhinney, Bates, & Kliegl, 1984).

Importantly, in the competition model, there are methods for quantifying the strength of various cues in a particular language, for example, in the transitive construction. To do this one looks at the general dimensions of the frequency of a cue (cue availability), the consistency of a cue in indicating a function (cue reliability), and the complexity of a cue (cue cost). In English, case-marked pronouns (e.g., *I–me, he–him*) are highly reliable in transitive sentences (when they are present they indicate accurately agent and patient), but they are not always available (often there are only full nouns, which are not case marked). Word order is almost always available in German, but it is often not reliable (because sometimes transitive sentences have the agent after the verb and the patient before it—which works because they are both case marked for role). These two dimensions of cues—availability and reliability—can be combined to give an overall measure of cue validity (Kempe & MacWhinney, 1998).

With respect to acquisition, Bates and MacWhinney (1987) predicted that children should acquire first those cues with highest cue validity. In addition, because sometimes several cues may indicate the same function—providing extra information—children should find it especially easy to comprehend prototypical transitive sentences with both word order and case marking (and perhaps other cues) working in coalition: the coalitions-as-prototypes model (Bates & MacWhinney, 1987). This should be true especially if, as is often the case, the prototype occurs very frequently. An agent of a transitive action, for instance, should be identified most easily by a German child if it is not only marked by its position before the verb but also by the relevant case marker. In a study of English- and Italian-speaking children, Bates et al. (1984) provided evidence for this approach by comparing the use of word order and animacy cues (agents tend to be animate, patients inanimate) in transitive sentences. They found that the high cue validity of word order in English led English 2-year-olds to rely on word order and ignore animacy when these two cues conflicted (i.e., when they heard ''The pencil is kicking the cow'' they tried to make the pencil kick), whereas the low cue validity of word order in Italian led Italian 2-year-olds to rely on animacy and ignore word order (making the cow kick the pencil).

Some researchers have proposed that the particular aspects of cue validity that children follow change over development. In a study with Hebrew-speaking children and adults, Sokolov (1988) found that cue availability—how often a cue occurs—played a stronger role in sentence interpretation for younger children, whereas cue reliability—the proportion of relevant sentences for which a particular cue correctly indicated agent or patient—played a stronger role for older children and adults. Of special importance, children have to notice which cue adults follow when two cues conflict (conflict validity). In many cases, this may be a quite drawn-out process, as the relevant conflict situations are sometimes fairly rare in the language children experience (McDonald, 1986). Supporting this general view, Matessa and Anderson (2000) found that in adult artificial language learning cue validity predicted which cues are used early in the

learning process and conflict validity predicted which cues are used in later learning.

Cue cost (essentially, complexity) has been much less studied. Building on Slobin's (1982) local cues hypothesis, one claim is that ''local cues'' such as case marking can be processed on the spot without taking the entire sentence into account, whereas ''distributed cues'' such as word order impose a greater burden on short-term processing capacity (because sentential fragments need to be held in memory until the next relevant component is processed). Support for this hypothesis was provided by Lindner (2003), who found that early in development German children tended to rely on ''local cues'' and only later on ''distributed cues,'' although Lindner's analyses did not involve a direct comparison between conditions in which the different cues supported or conflicted with one another. Studies that have made such a direct comparison have found that German preschool children comprehend sentences in which case marking and word order conflict, more poorly than sentences in which case marking and word order collaborate (e.g., Mills, 1977; Primus & Lindner, 1994; Schaner-Wolles, 1989). However, these studies differ as to the age at which German children accurately comprehend sentences with conflicting cues, probably because the different studies used only sentences with highly familiar verbs, and exactly which verbs were used varied between studies. The use of familiar verbs makes it possible that children could respond on the basis of only verb-specific knowledge (e.g., knowing only that the hitter comes before *hit*), whereas mature grammatical knowledge is based on verb-general, abstract knowledge of grammatical constructions.

In the current study, we investigated German children's understanding of word order and case marking cues in transitive sentences, and—unlike previous studies in the competition model framework—we did this using novel verbs. Our specific question was when German children come to understand that in their language case marking is a 100% reliable cue (even if it is not always available), whereas word order is not (even though it is quite often available). In our two experimental studies, we gave children test sentences that contained various combinations of word order and case marking cues—all grammatically correct, with animacy neutralized across agent and patient. In one condition, the two cues supported one another: Case marking and word order both indicated the first noun as the agent. In a second condition, these two cues were in conflict: Word order indicated the first noun as the agent, whereas case marking indicated the second noun as agent. Finally, in a third condition, agent and patient were case-marked ambiguously and therefore the only cue children could rely on was word order. Following Bates and MacWhinney's (1987) concept of coalitions-as-prototypes, we predicted that sentences containing multiple, redundant cues (as in the first condition) should be easiest to acquire. From McDonald's (1986) findings, we predicted that sentences containing conflicting cues (as in the second condition) should be the most difficult because robust knowledge of relative cue reliabilities—from relatively rare conflict situations—is needed for adult-like comprehension. The findings from this study should be relevant not only for elucidating basic processes of language development but also for elucidating processes of children's learning more generally because it addresses such domain-general issues as the role of prototypes, the individuation of particular cues from prototypes, and children's sensitivity to more local versus more distributed cues in sequential learning.

Study 1

As a preliminary study to our two comprehension experiments, we first looked at how German adults use word order and case marking in transitive sentences addressed to young children. Because the competition model predicts that the cue validity of word order and case marking should play a key role in children's comprehension—and that cue availability and reliability might play different roles at different points in development—we computed all values for these two cues from a corpus of child-directed speech.

The German grammar relevant to the current studies is as follows. In active transitive sentences, the agent of the action is subject and is marked with nominative case marking, and the patient is direct object and is marked with accusative case marking. For both of these, the case marking is either a special form of pronoun or a noun with a special form of determiner (e.g., *a* or *the*). For example, if a dog is agent, the form is *der Hund* (the + nominative dog) or *er* (he), whereas if a dog is patient, the form is *den Hund* (the + accusative dog) or *ihn* (him). Additional complexity comes from the fact that nominative and accusative marking take different forms when applied to nouns of different genders, and in some cases, they are not distinct. For example, unlike the example of *dog* above (which is masculine), if a cat is the agent, the form is *die Katze* (the + nominative cat), but if a cat is the patient, the form is exactly the same

die Katze (the + accusative cat). This means that in some instances, case marking is not an available cue in the sense that it does not identify case role unambiguously. Finally, although in German transitive sentences agents typically come before the verb and patients after the verb, as in English, to highlight the patient pragmatically the reverse order may be used—with the case roles marked by case marking and unaffected by the reverse order. ''Den **Hund** beisst der Mann'' has the first noun, *Hund*, marked as accusative, and the second noun, *Mann*, marked as nominative and so, despite word order, the man is biting the dog.

Method

For our analysis, we used Child Language Data Exchange System (CHILDES) data of spontaneous speech by German mothers to six monolingual normally developing children (Szagun, 2004). At the time of the first recording, the children were 1.8 years old, and at the time of second recording, they were 2.5 years old. We analyzed the sample of 7,032 utterances previously examined by Stoll, Abbot-Smith, and Lieven (in press), which these authors had coded into syntactic construction types. We examined the following categories where transitives might occur—transitives, complex sentences, subject-predicate-other, and verb fragments—and extracted transitive verbs by hand. Sentences with transitive verbs were excluded when they involved idioms, such as *Hunger haben* ''to be hungry'' (literally: have hunger) and passive constructions were also excluded. First, we divided all transitive sentences into sentences with verbs that were highly causative with a volitional agent and affected patient, such as *schubsen* ''to push,'' and those with verbs that did not have any causative meaning, such as *sehen* ''to see'' (Hopper & Thompson, 1980). Then, we analyzed whether the sentence was complete, that is, with two noun phrases or whether it was a fragment, that is, subject or object was dropped.

We coded all transitive sentences for case marking in terms of whether they were unambiguous (i.e., it was clear which noun phrase was agent and which was patient) or ambiguous and for word order (subject-first or object-first). In addition, we coded which kind of case marker (i.e., which lexical form) was used. We followed Kempe and MacWhinney's (1998) formula for calculating cue availability, cue reliability, and cue validity for the case marking and word order cues that assign agent and patient. Availability of a cue was therefore defined as the number of sentences in which a cue is present, divided by the total number of transitive sentences. Reliability of a cue was defined as the ratio of sentences in which a cue correctly indicated the agent, divided by the number of sentences in which the cue was present. Finally, cue validity was defined as the product of availability and reliability. For our main analyses, we included only transitive sentences with highly causative verbs because only they contain both agent and patient. Nevertheless, we also compared these with our data for the noncausative transitive sentences and report the differences. All coding was carried out by the first author, and an additional coder coded 15% of all sentences for reliabilities. There was a high level of agreement between coders (Cohen's Kappa = 0.92).

Results and Discussion

Of our final sample of 745 transitive sentences, 410 (55%) contained highly causative verbs, and 335 (45%) were without causative meaning. Of the 410 transitive sentences with highly causative verbs, unambiguous case marking was found in 351 transitive sentences (86%) and 59 sentences (14%) contained ambiguous case marking. Fifty-five (13%) of the highly causative transitive sentences were fragments; that is, they involved either subject or object ellipsis. Of all complete highly causative sentences (with two noun phrases), 280 (79%) had a subject-first word order and 75 (21%) had an object-first word order.

To summarize, we found that in most (68%) of the complete causative transitive sentences (fragments excluded) both case marking and word order referred to the first noun as the agent. In 21% of the sentences, case marking and word order conflicted with each other because the second noun of the sentence was marked with nominative and/or the first one with accusative. In 11% of the sentences, word order was the only cue that referred to the first noun as the agent because the sentence contained ambiguous case marking. Only two sentences (less than 1%) appeared with an object-first order and ambiguous case marking.

When transitive sentences with noncausative verbs were included, similar results were found apart from the fact that object-first order appeared a bit more often (33%) and subject-first order with unambiguous case a bit less (56%). The proportion of sentences with subject-first order and ambiguous case marking was identical (11%). Of special relevance to the experiments of Study 2, we should note that marking case in German by definite determiners is not the most common way of marking (especially) agents of transitive sentences (with causative verbs) because quite often pronouns, which are always case marked, are

used. The use of definite determiners to mark agents or patients was quite rare for agents (16%) but frequent for patients (60%). Within the transitive sentences with causative verbs, 8% of the agents were marked with *der* (the + masculine + nominative), 7.5% were marked by *die* (the + feminine), and finally only 0.5% were marked with *das* (the + neuter). Patients were mostly marked with *das* (30% of all transitive sentences), followed by *die* with 17%, and the rarest was *den* (the + masculine + accusative) at 13%.

Because we were interested in the relative strength of word order and case marking as cues for identifying agents, we calculated cue availability, cue reliability, and cue validity for both following Kempe and MacWhinney (1998). But whereas it is relatively easy to determine whether the case marking cue is available or not (unambiguous nominative and accusative forms), it is difficult to know exactly how German children use the word order cue. There are two possible ways. First, the position of one argument in relation to the verb might be sufficient to decide whether this noun phrase is agent or patient (subject-verb vs. verb-object). That is, *die Frau schubst* (the + feminine woman pushes) is likely to mean ''the woman is pushing,'' whereas *schubst die Frau* (pushes the + feminine woman) is likely to mean ''is pushing the woman.'' Under this analysis, the word order cue would also be available in fragment sentences (with either the subject or object omitted). Then, we find that the word order cue is available 100% of the time and the case-marking cue in 89% of the transitive sentences. In terms of reliability, however, case marking in German, when available, always reliably indicates the agent and patient of a transitive sentence 100% of the time, whereas we find that word order does this reliably only 74% of the time (because objects can come before, and subjects after, the verb). Therefore, the cue validity for case marking is higher with 89% compared to 74% cue validity for word order.

However, there is a second possible way to calculate the availability of word order because in German the position of the verb in the sentence is relatively flexible. It can either be at the beginning of a sentence as in questions, in the middle as in main clauses, or at end in subordinate clauses. Therefore, in a sentence such as, ''. . ., *weil der Mann den Jungen schubst*'' (. . ., because the + masculine + nominative man the + masculine + accusative boy pushes) the object (patient) comes directly before the verb, although the word order still maintains the most common (canonical) subject before object order. Thus, in fragment sentences without case marking, it is very difficult to say whether a noun phrase immediately before the verb is the agent or the patient (''*hat die Frau geschubst*'' could either mean ''he has pushed the woman'' or ''the women pushed him''). If we therefore decide that the word order cue is not available in German fragment sentences, that is, those with subject or object omission because the child needs to hear the relation between two arguments in the sentence to use the word order cue, we find even stronger differences. In this case, the availability of word order drops (87%) to almost the same as that of case marking (86%) and, once validity is calculated (with 100% reliability for case marking and 79% reliability for word order), case marking is even more valid with 86% cue validity in contrast to only 68% cue validity for word order (see Figure 1). This may be the more accurate calculation because German children hear transitives with subject or object omission 13% of the time. However, we will compare our data from the following experiments with both calculations using the different definitions of word order cues.

Study 2

We use the findings from Study 1 to make various predictions about which kinds of transitive sentences German children should comprehend most readily and at the earliest ages. If what is most important from the beginning is cue reliability—as suggested by MacWhinney et al. (1984)—or cue cost—as suggested by the local cues hypothesis (Slobin, 1982)—then children should comprehend most readily sentences with unambiguous case marking regardless of the order in which the noun phrases occur (i.e., even in object-first sentences). On the other hand, if what is most important from the beginning is cue availability—based mainly on frequency in the input—then they should comprehend most readily sentences in

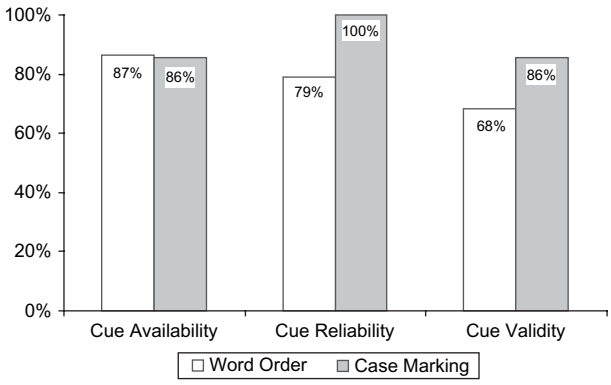

Figure 1. Availability, reliability, and validity of the grammatical cues word order and case marking for German transitive sentences in child-directed speech (Study 1).

which the agent is the first noun phrase, regardless of case marking (i.e., even in sentences with ambiguous case marking). Finally, if prototype sentences with redundant marking have a special role—as suggested by the coalitions-as-prototypes approach of Bates and MacWhinney (1987)—then children should comprehend most readily prototype sentences and might be expected to struggle when the cues conflict (i.e., in object-first sentences). Of course, it is also possible as we pointed out in the introduction and as suggested by Sokolov (1988) that cue availability, cue reliability, and prototypes play different roles at different periods of development.

In Study 2, we test these predictions experimentally using an act-out comprehension task, which is the task used most often in previous investigations of the competition model and local cues hypothesis. We adapted this task to examine how young German children perform when they hear sentences containing **novel** verbs to determine when and in which developmental order they start to use these grammatical cues productively, independent of any particular known verbs and independently of animacy cues.

Method

Participants

Sixteen monolingual German 2.7-year-old children (range = 2.6–2.8; 9 girls and 7 boys) and 16 monolingual German 4.10-year-old children (range = 4.6–5.3; 9 girls and 7 boys) were included in the study. An additional 9 children were tested but excluded from the study due to either fussiness (3), bilingualism (1), experimenter error (4), or because the child was too young (1). Children were recruited from a database of parents who volunteered to participate in psychological studies. They came from diverse social economic backgrounds. All children were tested in nursery schools in a medium-sized German city.

Materials

All verbs referred to prototypical causative-transitive actions, involving direct contact between a volitional agent and an affected patient. All actions were reversible (Hopper & Thompson, 1980). The two novel verbs *wiefen* and *tammen* were used to describe two novel transitive actions that were performed with two novel apparatuses. *Wiefen* was used to refer to an animal rocking another animal standing on a rocking-chair-like apparatus by pulling it toward itself with its head. *Tammen* referred to an animal pushing down another animal standing on a platform with a spring underneath it by jumping on its back.

Agents and patients of a particular event were pairs of animals with the same grammatical gender. Exactly which gender depended on the condition. The animals were all well known to 2-year-olds. We used the Elternfragebogen (Grimm & Doil, 2001), a much-shortened German version of the MacArthur Communicative Development Inventory (Fenson et al., 1994) to identify which animals to use. *Der Hase* ''the (+masculine) bunny,'' *der Bär* ''the (+masculine) bear,'' *der Elefant* ''the (+masculine) elephant,'' *der Hund* ''the (+masculine) dog,'' *die Katze* ''the (+feminine) cat,'' and *das Schwein* ''the (+neuter) pig'' were on the Elternfragebogen. *Der Löwe* ''the (+masculine) lion,'' *der Frosch* ''the (+masculine) frog,'' and *der Tiger* ''the (+masculine) tiger'' were on the U.S. American MacArthur. Just two animals (*das Zebra* ''the [+neuter] zebra'' and *die Ziege* ''the [+feminine] goat'') were on neither of them, but the children did not show any difficulty in identifying these animals (see the Procedure section).

All children heard the same test sentences (see Appendix A) in three conditions: In the prototype condition, they heard the novel verbs with an argument structure in which the agent was the first noun phrase and case marked with nominative, and the patient was the second noun phrase and case marked with accusative, for example, *Der Hund wieft den Löwen*. ''The (+nominative) dog is weefing the (+accusative) lion.'' In the ''word-order-only'' condition, they heard an argument structure in which the agent was the first noun phrase and the patient was the second noun phrase, but case marking was ambiguous because animals of masculine gender were not used, for example, *Die Katze wieft die Ziege*. ''The cat is weefing the goat.'' In the conflict condition, the patient was the first noun phrase and case marked with accusative and the agent was the second phrase and case marked with nominative, for example, *Den Bären wieft der Tiger*. ''The (+accusative) bear is weefing the (+nominative) tiger'' (with the meaning: it is the tiger that is weefing the bear). As a control condition, we used one familiar verb *schubsen* ''to push'' in the prototype argument structure, for example, *Der Hund schubst den Tiger*. ''The (+nominative) dog is pushing the (+accusative) tiger.'' Therefore, each child heard seven test sentences, six with novel verbs and one with a familiar verb.

Design

We tested each child with the two different novel verbs and the familiar verb in transitive

sentence structures using an act-out task. A camera in front of the children recorded their enactment. Counterbalancing was used for the agent (e.g., lion/dog) and for sides, for example, sometimes the agent was to the left and sometimes to the right of the patient. The order of the verbs and the conditions was counterbalanced by Latin squares. There were 72 possible orderings of which 16 were chosen randomly, and these were distributed evenly over the children within each age group.

Procedure

During the session, the child sat at a small children's table on which the apparatuses for the act-out task were placed. The experimenter sat next to the child. Animals and apparatuses for the act-out task were hidden in a box. The two animals for each act-out task were always placed by the experimenter in front of the child between the child and the apparatus facing the child so that it was never the case that one animal was nearer to the apparatus. We counterbalanced which animal (agent or patient) was to the left of the child both within and between subjects.

Warm-up. The children first experienced a warm-up in which they were required to imitate acting out an intransitive locative (namely: *Der Fisch springt über den Elefanten*. ''The [+nominative] fish is jumping over the [+accusative] elephant''). If they did not correctly act this out, they got a second trial with the sentence *Der Fisch klettert auf den Elefanten*. ''The (+nominative) fish is climbing onto the (+accusative) elephant.'' If the child passed one warm-up trial correctly we proceeded with the experiment.

Word learning training. Prior to all three-test conditions each child was taught the name of the novel verb in the following manner. Using animals which take German feminine gender that does not decline for nominative or accusative case (e.g., *Kuh* ''cow'' and *Ente* ''duck''), every verb (novel and familiar) was presented to each child in a live act out by the experimenter in a variety of argument structures: in the citation form with no arguments (e.g., *Das heißt wiefen*. ''That's called weefing'') as well as in transitive argument structure with two feminine pronouns (which are identical for subject and object position in German) in three different tenses (*Sie wird sie wiefen*. ''She is going to weef her''; *Sie wieft sie*. ''She is weefing her''; *Sie hat sie gewieft*. ''She weefed her''). The child was also asked to repeat the verb in the citation form (e.g., *Kannst du das sagen: wiefen*? ''Can you say this: weefing?'') and to attempt the act out with the two feminine animals.

Test trial. For the act-out trials, the experimenter placed two animals in front of the child and told the child the test sentence: *Jetzt bist du dran! Zeig mir: Der Löwe wieft den Hund*. ''Now it's your turn! Show me: The (+nominative) lion is weefing the (+accusative) dog.'' The experimenter repeated the test sentence until the child started enacting.

Vocabulary/morphology production posttest. After all test trials were over, the children took part in a language development test. The 2.7-year-olds received the vocabulary production subtest of the SETK 2 that has been standardized for German 2- to 3-year-olds (Grimm, 2000). In this, the children are shown cards with pictures of objects that they have to name. The 4.10-year-olds received the morphological production subtest of the SETK 3–5, which has been standardized for German 3- to 5-year-olds (Grimm, 2001). In this, children are shown pictures with familiar and novel objects and they had to build the correct plural form (of which there are eight possibilities in German). The 2.7-year-old children who participated in the test had a mean score of 44 (range = 36–56), and the 4.10-year-olds had a mean score of 47 (range = 36–63). The mean scores were, therefore, a bit lower than the expected ones for their age range (expected $M = 50$, $SD = 40–60$).

Coding and Reliability

For every test trial, the correct response was to choose the correct animal as agent of the action. If the child did not act out a causative scene but instead put both animals next to each other onto the apparatus we excluded those trials. We had to exclude 26 trials of 144 in the younger age group (prototypical condition [9], word-order-only condition [9], and conflict condition [8]) and none in the older age group. All children were coded by the first author, and an additional coder coded 15% of all trials for reliabilities with high agreement with the first author (Cohen's Kappa = 0.8774).

Results and Discussion

The data were analyzed using a 2 (age) × 4 (experimental condition) mixed factorial analysis of variance (ANOVA). There were main effects for both Condition, $F(3, 81) = 3.018$, $p < .05$, and Age, $F(1, 27) = 17.672$, $p < .001$, but not a significant Condition × Age interaction. Post hoc tests with a Bonferroni correction for the main effect of condition with six comparisons revealed only significant differences between the 4.10-year-old's performance with the familiar-verb control condition ($M = 94\%$) and the conflict

condition, $M = 56\%$, $t(15) = -4.392$, $p < .05$. Nonparametric tests (Wilcoxon) found the same result.

Because the chance level for our dependent variable was always 50%, we also investigated in which conditions and at which ages the children were above chance. The results show that the 2.7-year-olds were only above chance with the familiar verb, $t(15) = 2.236$, $p < .05$. In contrast, the 4.10-year-olds were above chance in the familiar-verb condition, $t(15) = 7.000$, $p < .001$, the prototypical, $t(15) = 3.576$, $p < .05$, and the word-order-only condition, $t(15) = 3.478$, $p < .05$, see Figure 2. However, we did not find any correlation between the children's performance in this task and vocabulary/morphology scores and also no group differences when comparing high and low vocabulary/morphology children.

Thus, 2.7-year-old German children were only able to comprehend transitive sentences in this act-out task with a familiar verb. One possible reason for this is that children initially form grammatical schemas around familiar verbs and are therefore only able to comprehend transitives sentences correctly with familiar verbs (Tomasello, 2003). However, a second explanation of the results is that the act-out task is particularly difficult for young children and it might be easier to carry out when asked to perform a known action than a novel action. By contrast, the German 4.10-year-olds correctly interpreted transitive sentences with novel verbs in subject-first word order, presumably because they have productive knowledge of the grammatical cue word order. But in the conflict condition, they performed at chance level. This indicates that German 4.10-year-olds have not yet acquired the use of the case-marking cue separately from subject-first word order and therefore do not interpret correctly object-first sentences.

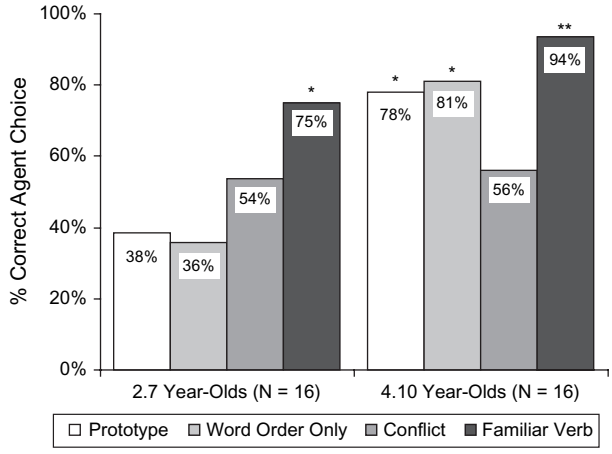

Figure 2. Mean proportion of correct agent and patient choices in the act-out task of Study 2, as a function of age and sentence type.

Study 3

It might be argued that the reason we found such late acquisition of case marking and verb-specific behavior in Study 2 is that the act-out task we used has high working memory and executive function demands. Some support for such an argument might be drawn from a previous study by Dittmar, Abbot-Smith, Lieven, and Tomasello (2008), who—contrary to the findings of the current experiment—found that German-speaking 2.6-year-olds did show productivity with novel verbs in transitive sentences in a pointing comprehension task. Therefore, in the next experiment, we adapted the pointing task to examine relative reliance on word order and case marking, using the same three novel verb conditions we used in Study 2. Furthermore, we tested a third age group of older children to try to identify a later point in language development when German children are able to comprehend object-first transitive sentences.

Method

Participants

The children were monolingual speakers of German, who were brought by a caregiver to a child lab in a medium-sized German city. Of these sixteen 2.7-year-old children (range = 2.6–2.8; 8 girls and 8 boys), sixteen 4.10-year-old children (range = 4.6–5.2; 8 girls and 8 boys), and sixteen 7.3-year-old children (range = 7.0–7.11; 8 girls and 8 boys) were included in the study. An additional 13 children were tested but excluded from the study due to either showing a side bias during the test trials (2), fussiness (7), bilingualism (2), or experimenter error (2). Children were recruited from a database of parents who volunteered to participate in psychological studies. They came from diverse social economic backgrounds.

Materials

All novel verbs referred to prototypical causative-transitive actions, involving direct contact between a volitional agent and an affected patient. Actions were reversible and involved either a caused change-of-state or change-of-location (Hopper & Thompson, 1980). The three novel verbs *wiefen*,

tammen, and *baffen* were used to describe three novel transitive actions that were performed with three novel apparatuses. *Wiefen* was identical with the action used in Study 2 except that we emphasized the causality of this new event by making the agent force the patient into a handstand with the third repetition of the action. *Tammen* was also identical with the action used in Study 2 but we emphasized the causality of this new event by making the agent force the patient to fall sideways with the third repetition of the action. The third novel verb, *baffen*, referred to an animal spinning around another animal standing on a disk, and, with the third repetition of the action, the location of the patient was changed from being next to the agent to being further away.

Agents and patients of a presented event were the same pairs of animals as in Study 2 plus three more: *das Schaf* ''the (+neuter) sheep'' and *das Pferd* ''the (+neuter) horse,'' which were on Elternfragebogen and *der Affe* ''the (+masculine) monkey'' which was on the U.S. American MacArthur-Bates Communicative Development Inventory (Fenson et al., 1994). The structural pattern of the test sentences (see Appendix B) was the same as described in Study 2. Each of the three conditions was tested with each of the three novel verbs, so that the children got nine test sentences. Unlike in Study 2, we did not test familiar verbs.

Design

We tested each child with three different novel verbs in transitive sentence structures using a pointing task. During the session, the children sat in front of a 31 × 49 cm ''Apple Cinema Display'' screen. The procedure of the pointing task was based on the Intermodal Preferential Looking (IPL) paradigm pioneered by Golinkoff, Hirsh-Pasek, Cauley, & Gordon (1987; see also Imai, Haryu, & Okada, 2005 for an adaptation of the IPL to a pointing task). For the test trials, the child saw two film scenes on the computer screen, each starting simultaneously and lasting 6 s. Both involved animals enacting the same causative event and differed only in that agent and patient roles were reversed. All children got alternating test sentences with the three different conditions and all three novel verbs were tested in one session.

For each test trial scene pair we counterbalanced which particular scene correctly matched the test sentence (e.g., for the pair ''dog weef lion'' and ''lion weef dog'' half of the children heard the German equivalent of ''the dog is weefing the lion'' and the other half heard the reverse). The order of the verbs and the conditions was counterbalanced by Latin squares. The target screen order was counterbalanced so that each side (left [L] or right [R]) was correct four or five times out of nine trials for each child (depended on counterbalancing order). The same side was never the correct choice more than twice in a row. No child experienced a condition in which the correct choice alternated regularly (e.g., LRLRLRLRL). For half of the children, the first correct side in the first trial was left and vice versa. There were 52 possible orderings for correct side of which 16 were chosen randomly and these were distributed evenly over the children within each age group. The direction of the action (from left to right or from right to left) was also counterbalanced.

Procedure

One camera from behind the children recorded their pointing behavior. Only children of the youngest age group sat on their parents' lap. When testing the older children, the parent sat behind the child on a separate chair. The parents whose children sat on their laps were asked to close their eyes during each test trial so as not to influence their child during pointing. We decided not to use headphones for the parents because we found that this distracted the children. The experimenter herself never looked at the screen during the test trials but always at the child.

Pointing practice training. To teach the children that the aim of the task was to point to one of two pictures on the computer screen, we used a very easy warm-up task with two pictures of objects, for example, ''dog'' and ''duck,'' which appeared at the screen simultaneously. Then, the children were asked to point to one of the two objects (e.g., *Zeig mir das Bild: Das ist der Hund*. ''Show me the picture: That's the dog''). The pictures were from the vocabulary comprehension subtest of the SETK-2 (Grimm, 2000). We repeated this task 10 times with different objects and all children solved it perfectly.

Word learning training. Similar to Study 2, every novel verb was presented to each child in a live act out by the experimenter in a variety of argument structures.

Film familiarization trials. Following the live enactment, for each verb the child then saw a familiarization trial in which he or she watched each of the two film scenes individually and heard the experimenter describing them in the citation form, for example, *Guck mal, das heißt wiefen*. ''Look, that's called weefing,'' whereas the other half of the screen remained blank. The side where the children saw the first

picture (left or right) was counterbalanced across and within subjects. At the end of each film scene, the experimenter pointed to each animal and asked the child "Wer ist das?" (Who's that?). The majority of the children had no problem spontaneously naming the participating animals. If a child did not name one of the animals, the experimenter told the child the name and asked him or her to repeat it, which almost all children then did.

Test trial. Following this a red dot focused the child's attention to the center of the computer screen. Then, the test trial began and the child watched the same two scenes as in the familiarization trials. But here they appeared simultaneously and were accompanied by a prerecorded linguistic stimulus with the target verb in transitive argument structure, for example, *Guck mal, der Löwe wieft den Hund*. (×2) "Look, the (+nominative) lion is weefing the (+accusative) dog." After the videos had stopped, the experimenter asked the child to point to the correct (still) picture by asking, for example, *Zeig mir das Bild: Der Löwe hat den Hund gewieft*! "Show me the picture: The (+nominative) lion weefed the (+accusative) dog!" If the child did not point the experimenter repeated the question a second time, but she never asked the child to point again once she/he had already done so.

Vocabulary/morphology production posttest. After all test trials were over, the children took part in a language development test. The 2.7-year-olds and the 4.10-year-olds received the same tests as in Study 2. The 7.3-year-olds received the morphological production subtest of the Heidelberger Sprachentwicklungstest in which children are shown pictures with familiar and novel objects and they had to form the correct plural or singular. This test has been standardized for 3- to 9-year-old Germans (Grimm & Schöler, 1998). The 2.7-year-old children achieved a mean score of 55 (range = 42–71), the 4.10-year-olds achieved a mean score of 56 (range = 38–69), and the 7.3-year-olds achieved a mean score of 49 (range = 40–59). The expected mean score is again 50 with a standard deviation between 40 and 60.

Coding and Reliability

For every test trial, the correct response was to choose the right animal as agent of the action. If the child did not choose either scene or pointed to both we excluded those trials. We had to exclude 19 trials of 144 in the youngest age group (prototypical condition [4], word-order-only condition [5], and conflict condition [10]), 1 (conflict condition) in the 4.10-year-olds, and none in the oldest age group. All children were coded by the first author, and an additional coder coded 15% of all trials for reliabilities with high agreement with the first author (Cohen's Kappa = 0.968).

Results and Discussion

The pointing behavior was analyzed using a 3 (age) × 3 (experimental condition) mixed factorial ANOVA. There were main effects for both condition, $F(2, 90) = 34.875$, $p < .001$, and age, $F(1, 45) = 19.258$, $p < .001$. However, these must be interpreted in the context of a significant Condition × Age interaction, $F(4, 90) = 5.855$, $p < .001$ (see Figure 3).

Post hoc tests with a Bonferroni correction for three comparisons revealed that the interaction was due to the 2.7-year-olds showing more correct pointing in the prototypical condition ($M = 77\%$) than in the word-order-only condition, $M = 50\%$, $t(15) = 2.595$, $p = .06$, and than in the conflict condition, $M = 46\%$, $t(15) = 3.143$, $p < .05$. No difference was found between the word-order-only condition and the conflict condition. The 4.10-year-olds also pointed correctly more often in the prototypical condition ($M = 88\%$) than in the conflict condition, $M = 35\%$, $t(15) = 4.970$, $p < .001$, and also more often in the word-order-only condition ($M = 94\%$) than in the conflict condition, $t(15) = 6.586$, $p < .001$. No difference was found between the prototypical condition and the word-order-only condition. The pattern of results for the 7.3-year-olds was generally the same as for the 4.10-year-olds—except that their performance in the conflict condition was much better (though still lower than the other conditions). That is, they pointed correctly more often in the prototypical condition ($M = 98\%$) than in the conflict condition ($M = 69\%$), $t(15) = 3.416$, $p < .05$, and more often in the word-order-only condition ($M = 100\%$) than in the conflict condition, $t(15) = 3.758$, $p < .05$,—with no difference

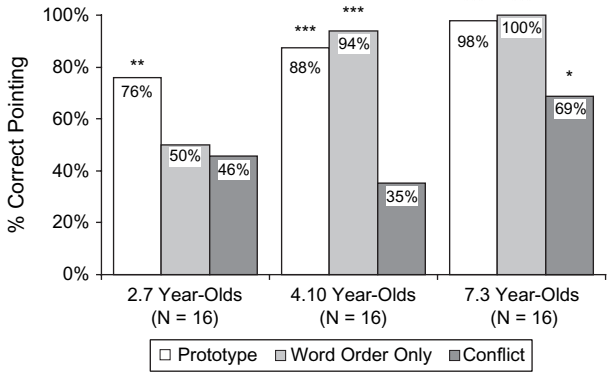

Figure 3. Mean proportion of pointing to the correct agent in Study 3, as a function of age and sentence type.

between the prototypical condition and the word-order-only condition.

Post hoc tests for the main effect of condition with Bonferroni correction revealed significant differences between all children's performance in the prototype condition (M = 87% correct pointing) and the conflict condition (M = 50% correct pointing, $t(47) = 6.601$, $p < .001$, and between the word-order-only condition (M = 81% correct pointing) and the conflict condition, $t(47) = 5.447$, $p < .001$. This indicates that conflicting cues, here word order and case marking, are especially difficult to use for children of all ages. Nonparametric tests (Wilcoxon) showed the same result.

Because the chance level for our dependent variable was always 50%, we also investigated in which conditions and at which ages the children were above chance. The results reflect the previous analyses, namely the 2.7-year-olds were only above chance in the prototypical condition, $t(15) = 4.354$, $p < .01$, whereas the 4.10-year-olds were above chance in both the prototypical, $t(15) = 9.121$, $p < .001$, and the word-order-only condition, $t(15) = 13.174$, $p < .001$, but not with the conflict condition. And finally the 7.3-year-olds reached ceiling in the prototypical and the word-order-only condition and were above chance in the conflict condition, $t(15) = 2.249$, $p < .05$. All analyses reflect a developmental trend whereby German children first acquire prototypical grammatical marking, followed by word order and only very late in age do they show an adult-like reliance on case marking when this conflicts with word order.

We were interested in what strategies young German children use to interpret transitive sentences with patients in first position. Therefore, we analyzed all children's responses to the conflicting sentences to see whether they oriented toward word order or case marking or whether they used neither strategy and avoided selecting a scene (usually through pointing to both scenes). A 3 (age) × 3 (strategy) mixed factorial ANOVA revealed main effects for both strategy, $F(2, 90) = 23.473$, $p < .001$, and age, $F(1, 45) = 21025.000$, $p < .001$. However, these must be interpreted in the context of a significant Strategy × Age interaction, $F(4, 90) = 6.362$, $p < .001$. Post hoc tests with a Bonferroni correction for three comparisons showed that 4.10-year-olds relied significantly more on word order than 7.3-year-olds, $t(30) = 2.622$, $p < .05$, and 7.3-year-olds relied more on case marking than 4.10-year-olds, $t(30) = -2.879$, $p < .05$, and 2.7-year-olds, $t(30) = -3.922$, $p < .001$ (see Figure 4).

Furthermore, we found that the performance of the 4.10-year-olds in the conflict condition was related to their state of morphological knowledge (plural morphology). Children who performed poorly on the morphological productivity posttest relied more strongly on word order in our experiment and therefore pointed incorrectly in the conflict condition (M = 17% correct pointing) than children with more robust morphological knowledge (M = 54% correct pointing), $t(14) = -2.460$, $p < .05$. The low-morphology group of children even showed below chance performance in the conflict condition, $t(7) = -5.372$, $p < .01$, which indicates a word order strategy. Similar findings come from the high-morphology group of 7.3-year-olds who showed above chance performance in the conflict condition, $t(7) = 3.122$, $p < .05$, whereas the low-morphology group of children still performed at chance. It may therefore be the case that German children pass through a stage in which they rely solely on word order and ignore case marking when these cues conflict before they learn to rely solely on case marking as adults do.

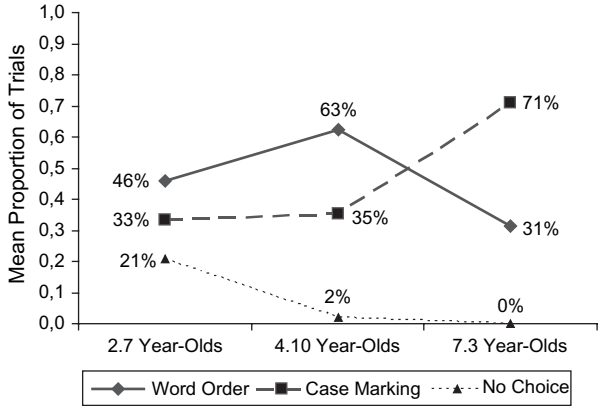

Figure 4. Strategies used (cue types relied on) during trials with conflicting cues in Study 3, as a function of age.

Our findings from Study 3 support the hypothesis that transitive sentences with a subject-first word order and with unambiguous case marking are acquired earlier by German children than are transitive sentences with a subject-first word order but ambiguous case marking. Furthermore, at age 5, German children have still problems correctly comprehending transitive sentences with object-first word order even when these are clearly case marked. By age 7, the majority of the children have solved this problem.

General Discussion

The current studies paint a fairly clear picture of how young German children come to comprehend causative transitive sentences. At around 2.6 years of age, if assessed with an act-out task (Study 2), they comprehend transitive sentences with familiar verbs but not

novel verbs. This finding is in general agreement with the production study of Wittek and Tomasello (2005) in suggesting fairly verb-specific knowledge early in development. However, when a less demanding pointing task is used (Study 3), German children at this same age show solid comprehension of prototypical transitive sentences in which both word order and case marking indicate who was doing what to whom redundantly—even with novel verbs, suggesting more verb-general knowledge at 2.6 years. That they could show their knowledge only in the experiment using a pointing task and not in the act-out experiment might be due to the memory-burdensome nature of the act-out method per se with small children (Hirsh-Pasek & Golinkoff, 1996; Munakata, McClelland, Johnsons, & Siegler, 1997).

But, importantly, these children comprehended transitive sentences only in their prototypical form with redundant marking of agent and patient. Even with the less demanding pointing measure, they did not comprehend transitive sentences for which diagnostic case marking was absent or those in which the word order was noncanonical (object-first). They could not use either cue by itself, and they suffered when either was absent. These findings suggest that in languages like German children do not begin by attending to single cues, but rather they learn to comprehend the prototype and have difficulty whenever there is deviation from it. The prototypical form in German is also the most frequent (Study 1), presumably a common pattern crosslinguistically for case-marking languages. The role of subject–verb agreement in this process (and animacy as a semantic cue) should also be investigated.

The 4.10-year-old children present us with a puzzle. In both studies, using both methods, they seem to comprehend transitive sentences mostly in terms of word order. In both Studies 2 and 3, their performance with word order only is as high as with the full prototype including case marking (both near ceiling), and they choose at random in response to sentences in which word order and case-marking conflict—with a number of children in Study 3 actually ignoring case and going with word order only. This finding is a puzzle because on the two standard measures of input in the competition model—cue availability (how often the cue is available in relevant sentences) and cue reliability (how reliable the cue is, when it is present, in indicating the correct interpretation)—word order shows no advantage in availability (87% vs. 86% for case marking), and indeed its cue reliability as standardly computed is lower (79% vs. 100% for case marking).

One possible explanation of this finding is that the way we are thinking about grammatical cues is not fully adequate. It may be that cue availability and reliability as calculated here for word order miss aspects of the input that are important for language learning children. First, as noted above, it may be that German children do not use the word order cue as the positional relation between the two nouns in the sentence (first noun = agent; second noun = patient) but as the positional relation between the noun and the inflected verb (noun before verb = agent; noun after verb = patient). That would mean that the word order cue is also available in fragment sentences and hence more often available (100%) than case marking (89%). It is also possible that German children use the word order cue as the positional relation between the two nouns but do not take fragment sentences (with subject or object omission) as part of the transitive domain.

A second possibility, also alluded to above, is that German children do not use case marking in a completely general way. Because German has three noun classes, nominative case marking, for example, has three different forms in the singular and another in the plural. If children at a particular age have not yet discovered that all these forms mark the same case, then the way that cue reliability is typically calculated is not fully adequate. That is, the children in the current studies were tested on the particular case markers *der* and *den* used as determiners (masculine nominative and accusative), which appear in only 21% of all transitive sentences, and their comprehension of these may not benefit from their experience with case marking using pronouns, in which case the cue availability of these particular forms is not particularly high. But, of course, as children learn to connect the different case-equivalent forms (e.g., the nominative forms for nouns of different genders, as well as the nominative form for personal pronouns of the same gender), the cue availability of case marking will go up (even if the input stays exactly the same). Calculating the cue availability of case marking in this more item-based way results in the availability of case marking being much lower (21%) than that of word order (87%) even when assuming that word order is not available in fragment sentences.

Both approaches to calculating the cue availability of word order and case marking result in the conclusion that availability might indeed be higher for word order than for case marking. With this prediction, it would not be unexpected anymore for our 4.10-year-old children to rely more on word order than on case marking. This suggests that young German children rely on different input parameters at different stages of development; specifically, they rely more on cue availability (basically frequency) early in

development and more on cue reliability later in development (see Sokolov, 1988, for similar findings). In agreement with this view, many studies have demonstrated the importance of frequency in early language development (see Lieven & Tomasello, 2008, for a review). Complicating matters further, many of the case markers in German are either not diagnostic within the transitive (*die* is both the nominative and accusative feminine; *das* is both the nominative and accusative neuter) or else ambiguous with forms outside the transitive (e.g., the masculine nominative form *der* is also the feminine dative and genitive). It is also important that in online sentence processing, German adults show faster reaction times when the test sentence only has a cue with high availability rather than one with high reliability (Kempe & MacWhinney, 1999)—even though in offline (less time-pressured) agent identification tasks they rely more on the cue with high reliability (see also the artificial language learning tasks of Matessa & Anderson, 2000). In all, it would seem that German word order is somehow a more straightforward cue for younger, less grammatically sophisticated children than is German case marking, which has so many different and ambiguous forms for the same grammatical function.

It must also be noted that the finding that German 4.10-year-olds rely more on word order than case marking does not accord well with Slobin's (1982) local cues hypothesis, which would predict the ''local'' case-marking cue to be easier to process than the ''distributed'' word order cue. However, German case marking differs in two ways from case marking in languages such as Turkish or Hungarian on which the local cues hypothesis was based (MacWhinney, Pleh, & Bates, 1985 for Hungarian; Slobin & Bever, 1982 for Turkish). First, whereas in Turkish and Hungarian case is marked by suffixes on the noun, in German case is marked on the determiner or adjective that precedes the noun. Therefore, one might suggest that case marking is not as local in German as in Turkish or Hungarian. Second, as just noted, the form of the German masculine nominative determiner *der* and accusative determiner *den* is ambiguous with determiner forms outside the domain of transitive sentences. Both factors, ''less locality'' and ''ambiguity,'' may influence the ease of sentence or cue processing in German transitive sentences compared to Turkish or Hungarian.

Finally, we come to the 7.3-year-olds. We ourselves were very surprised that it was only at this late age that children succeeded in the conflict condition, weighing the case marking cue over the word order cue as adults do (Study 3). However, even adults have difficulties processing noncanonical word orders, at least as measured by reaction times (Ferreira, 2003; Kaiser & Trueswell, 2004). When German adults are confronted with object-first sentences that are ambiguously marked on the first noun phrase, they initially interpret these as subject-first sentences until they hear the second noun phrase (Weber, Grice, & Crocker, 2006). Moreover, in point of fact, our current findings do not differ greatly from those of other studies that have used familiar verbs. In the studies of Primus and Lindner (1994) and Schaner-Wolles (1989), it was not until children were 5 years of age that they correctly comprehended transitive sentences with familiar verbs with conflicting word order and case marking cues. Apparently, resolving conflicting cues in sentences with novel verbs takes even longer, though how much longer is not known as we did not test children between 5 and 7 years of age.

In terms of cue availability and reliability, following the reasoning from above, children by 7 years of age should know the grammatical equivalence of all (or at least most) of the different case forms serving the same grammatical function (and should ignore ambiguities based on other information). For 7-year-olds, then, the cue reliability of case marking is something close to that computed here; therefore, they finally rely on case marking over word order, as German adults would do. They also had much more experience than the younger children with sentences containing conflicting cues. One might argue that 21% object-first sentences in the input is plenty of exemplars for learning about conflicting cues by the age of 4.10; therefore, our children at this age should have been better. However, two other factors must be taken into account. First, object-first sentences occur in pragmatically marked contexts, with stress on the initial noun—which might mark them for children as a separate construction from prototypical transitive sentences without such stress. Second, almost all the object-first sentences in German child-directed speech have pronouns, not lexical nouns with determiners, in the pre- or postverbal position (96%), and most of these (76%) are first and second person personal pronouns with which the child is highly familiar. This means that the child can comprehend the vast majority of object-first transitive sentences on the basis of well-entrenched knowledge of specific pronoun forms and meaning but need not use case marking per se. Furthermore, the majority of the remaining 4% of the object-first sentences without pronouns provided an additional animacy cue to the child, that is, an animate agent versus an inanimate patient, despite the patient appearing in sentence-initial position. Overall, only 1% of all object-first sentences were based solely on the competition

between the grammatical cues of case marking and word order. Therefore, in actual fact, young children hear very few conflict sentences in which they really are forced to decide between case marking and word order. This does not mean that the children in our experiments heard odd or ungrammatical sentences, just very infrequent ones if frequency is counted at the level of specific forms such as pronouns and particular case markers.

The overall process by which German children learn to comprehend transitive sentences in a verb-general way may therefore be summarized as follows. They begin somewhere after the second birthday by comprehending the prototypical form of such sentences (even with novel verbs) with redundant marking of agent and patient by means of word order and case marking. Between ages 2 and 4 they learn to use word order by itself, as well as a number of specific lexical forms like personal pronouns that appear in different case-marked versions. But it is only by sometime after age 5 that they become adult-like in weighing case marking over word order in sentences in which these cues conflict. Interestingly, this same process may help to explain why English-speaking children take so long to comprehend and produce sentences with novel verbs in experiments such as those summarized by Tomasello (2000). The prototypical transitive sentence in English potentially has animacy cues, a case marked subject pronoun (such as *I* or *he*), and subject–verb agreement—in addition to canonical subject-verb-object word order. In most of the experiments, all these cues were neutralized except word order. Following the reasoning of the current study, then, the prediction would be that English-speaking children should do better at an earlier age with prototypical transitive sentences including redundant cues. What this means is that all children learning all languages take time to learn the significance of individual cues when they experience those cues most often in combination with other redundant cues. This accords with the coalition model by Hirsh-Pasek and Golinkoff (1996) who suggested that children might master grammar by noting redundancies of cues for comprehension and with much recent theorizing in adult psycholinguistics in which the process of comprehension is seen as learning to integrate a great diversity of multiple probabilistic cues to language structure (the cue integration approach; see Christiansen & Monaghan, 2006).

In any case, the current study has demonstrated that even for what many researchers consider the most straightforward grammatical construction of all, the simple transitive, it can be a fairly long drawn-out process for young children to achieve adult-like mastery of the specific roles of each of the different grammatical cues instantiated in the particular sentences they hear. This mastery depends on their attention to basic aspects of their linguistic experience, such as the frequency, consistency, and complexity of those cues in particular utterances. Frequency, consistency, and complexity have also, of course, been centrally important in theories of children's nonlinguistic cognitive development and inductive learning (see Siegler, 1996). Our finding of the importance of the prototype and the long process of ''unpacking'' it into the different cues it contains, also finds resonance with much recent discussion of the relationship between prototypes and exemplar-based models in adult categorization learning (see, e.g., Anderson 1991; Chandler, 2002; Hampton, 1997; Ross & Makin, 1999). Although there is a great deal of theoretical and empirical work to be undertaken to make the links between these research fields more explicit, our results suggest to us that this aspect of children's language learning shows close parallels with essential characteristics of human learning more generally.

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Appendix A: Test Sentences Act-Out Experiment (Study 2)

(Half of the children heard the sentences with reversed agent and patient)

a. Prototype condition
Der Hund wieft den Löwen.
(The$_{\text{masculine·nomiative}}$ dog is weefing the$_{\text{masculine.accusative}}$ lion.)
Der Bär tammt den Elefanten.
(The$_{\text{masculine·nominative}}$ bear is tamming the$_{\text{masculine.accusative}}$ elephant.)

b. Word-order-only condition
Die Katze wieft die Ziege.
(The$_{\text{feminine}}$ cat is weefing the$_{\text{feminine}}$ goat.)
Das Schwein tammt das Zebra.
(The$_{\text{neuter}}$ pig is tamming the$_{\text{neuter}}$ zebra.)

c. Conflict condition
Den Tiger wieft der Bär.
(The$_{\text{masculine.accusative}}$ tiger is weefing the$_{\text{masculine.nominative}}$ bear.)
Den Hasen tammt der Frosch.
(The$_{\text{masculine.accusative}}$ bunny is tamming the$_{\text{masculine.nominative}}$ frog.)

d. Familiar verb condition
Der Tiger schubst den Hund.
(The$_{\text{masculine·nomiative}}$ tiger is pushing the$_{\text{masculine.accusative}}$ dog.)

Appendix B: Test Sentences Pointing Experiment (Study 3)

(Half of the children heard the sentences with reversed agent and patient)

e. Prototype condition
Der Hund wieft den Löwen.
(The$_{\text{masculine·nomiative}}$ dog is weefing the$_{\text{masculine.accusative}}$ lion.)
Der Bär tammt den Elefanten.
(The$_{\text{masculine·nominative}}$ bear is tamming the$_{\text{masculine.accusative}}$ elephant.)
Der Frosch bafft den Affen.
(The$_{\text{masculine·nominative}}$ frog is baffing the$_{\text{masculine.accusative}}$ monkey.)

f. Word-order-only condition
Die Katze wieft die Ziege.
(The$_{\text{feminine}}$ cat is weefing the$_{\text{feminine}}$ goat.)
Das Schwein tammt das Zebra.
(The$_{\text{neuter}}$ pig is tamming the$_{\text{neuter}}$ zebra.)
Das Schaf bafft das Pferd.
(The$_{\text{neuter}}$ sheep is baffing the$_{\text{neuter}}$ horse.)

g. Conflict condition
Den Tiger wieft der Bär.
(The$_{\text{masculine.accusative}}$ tiger is weefing the$_{\text{masculine.nominative}}$ bear.)
Den Hasen tammt der Frosch.
(The$_{\text{masculine.accusative}}$ bunny is tamming the$_{\text{masculine.nominative}}$ frog.)
Den Hund bafft der Elefant.
(The$_{\text{masculine.accusative}}$ dog is baffing the$_{\text{masculine.nominative}}$ elephant.)