Journal of Memory and Language 66 (2012) 568–587

Contents lists available at SciVerse ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Is young children's passive syntax semantically constrained? Evidence from syntactic priming

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ARTICLE INFO

Article history:
Received 14 September 2010
revision received 26 March 2012
Available online 20 April 2012

Keywords:
Passives
Syntactic priming
Children

ABSTRACT

Previous research suggests that English-speaking children comprehend agent–patient verb passives earlier than experiencer–theme verb passives (Maratsos, Fox, Becker, & Chalkley, 1985). We report three experiments examining whether such effects reflect delayed acquisition of the passive syntax or instead are an artifact of the experimental task, relating to children's poor picture recognition for such verbs. In two syntactic priming experiments, 3- and 4-year-olds produced more agent–patient passives after hearing passive primes involving agent–patient and theme–experiencer verbs (Experiment 1), and theme–experiencer and experiencer–theme verbs (Experiment 2), than after corresponding active primes; moreover, the magnitude of priming was unaffected by verb type. However, a picture-sentence matching task (Experiment 3) replicated previous findings: Children performed more poorly on experiencer–theme sentences than agent–patient sentences. Our results suggest that children's acquisition of passive syntax is not delayed, and that semantic effects found in previous studies may instead be task-related.

Background

The question of why children appear to limit their earliest structural representation for the passive to *actional* verbs (i.e., those typically involving agent–patient thematic roles) until relatively late in language development (beyond 5 or 6 years) has been widely investigated (e.g. Maratsos, Fox, Becker, & Chalkley, 1985). Such a limitation is perhaps surprising: If by five or six children have acquired a structural representation that is sufficiently abstract to correctly interpret passives involving a range of actional verbs, we might expect them to be able to process all passive structures. This apparent limitation has been explained variously in terms of delayed acquisition of passive syntax, with young children initially using alternative strategies for processing passives, or delayed generalization of passive syntax to different semantic classes of verbs. In this paper, we use a syntactic priming paradigm to investigate whether children are able to process the syntax of passives involving different classes of verbs at an early age, and whether their apparent difficulty with *non-actional* (i.e., mental or experiential) verb passives might actually lie in the tasks that have previously been used to test them.

A number of studies investigating English-speaking children's early processing of the passive showed that children are able to comprehend, and tend to produce, passives with certain types of verbs earlier than with other types (e.g. Maratsos et al., 1985; Pinker, Lebeaux, & Frost, 1987). By 4 or 5 years of age, children reliably comprehend passives containing actional verbs; that is, they reliably comprehend passives containing verbs that encode an action and that canonically assign an agent role to the verb's subject and a patient role to the verb's object in an active sentence (*agent–patient* verbs, as in (1a)). However, they

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http://dx.doi.org/10.1016/j.jml.2012.03.008

do not show reliable comprehension of passives containing non-actional verbs, until around 7–9 years (e.g. Maratsos et al., 1985). Studies that have investigated comprehension of non-actional verb passives have exclusively used verbs that canonically assign an experiencer role to the verb's subject and a theme role to its object in an active sentence (*experiencer–theme* verbs), as in (1b).

(1) a. Active: The boy$_{[\text{AGENT}]}$ *kissed/washed/pushed/kicked* the girl$_{[\text{PATIENT}]}$
Passive: *The girl was kissed/washed/pushed/kicked by the boy*
b. Active: The boy$_{[\text{EXPERIENCER}]}$ *saw/knew/loved/remembered* the girl$_{[\text{THEME}]}$
Passive: *The girl was seen/known/loved/remembered by the boy*

This disparity between comprehension of passive sentences involving agent–patient verbs vs. experiencer–theme verbs has been replicated in a number of studies using tasks in which the child is presented with a sentence and asked to identify a picture (picture-sentence matching tasks) or a particular referent (stimulus sentence-question tasks) that matches the sentence (Fox & Grodzinsky, 1998; Gordon & Chafetz, 1990; Hirsch & Wexler, 2006; Maratsos et al., 1985; Sudhalter & Braine, 1985). These studies have all shown that 5-year-olds' performance with agent–patient verb passives is reliably above chance but their performance with experiencer–theme verb passives is unreliable.

A number of theories have been proposed to account for children's poor performance with non-actional verb passives, with much research focusing on the possibility of a syntactic source for their difficulties. Two such accounts are particularly well established. Borer and Wexler (1987) suggested that the acquisition of passive syntax is delayed. In particular, they argued that grammatical principles are acquired at different rates, with object-to-subject argument-chain (A-chain) formation being maturationally constrained to a relatively late stage of development. Under this account, children younger than five cannot process sentences such as (2a) as verbal passives (in which *broken* is a verb) because they have not yet acquired the grammatical principles required to form object-to-subject A-chains, which allow movement of the direct object from underlying object position to surface subject position (indicated by the trace indexes in [2]). However, they are able to process such sentences by using an alternative strategy, in which *broken* is interpreted as an adjective (2b). In other words, they analyze them as adjectival passives, which have the same surface form as short verbal passives (i.e., passives that do not include a *by*-phrase). Such an analysis does not involve object-to-subject chains (because the subject of such clauses is generated in situ).

Using this strategy results in successful comprehension of agent–patient verb passives because these verbs have passive participles that are generally felicitous as adjectives (compare [2a] and [2b]); however, it results in poor performance on experiencer–theme verb passives (2c), because these verbs have passive participles that are not generally felicitous as adjectives (2d).

(2) a. *The vase$_i$ was* [$_V$ *broken*] t$_i$ (*by the boy*)
b. *The vase was* [$_{ADJ}$ *broken*] (*but still mendable*)
c. *The cat$_i$ was* [$_V$ *seen*] t$_i$ (*by the dog*)
d. **The cat was* [$_{ADJ}$ *seen*] (*but still uncatchable*)
(where *seen* is an adjective)

Under this account, then, 3- and 4-year-old children have not yet acquired the syntax of verbal passives, and instead process passives by analogy with adjectival passives, yielding successful interpretation for agent–patient verb passives but not experiencer–theme verb passives.

Fox and Grodzinsky (1998) proposed an alternative syntactic explanation for children's difficulty in understanding experiencer–theme verb passives. As in Borer and Wexler's (1987) account, they assumed that children's early passives are based on short passives; but in their account the locus of difficulty lies in transmission of the verb's thematic-role to the external noun phrase (i.e., the noun phrase that would appear as subject in an active sentence). They argued that due to either processing or maturational constraints, young children are unable to assign the thematic role from the verb to the noun that appears in the *by*-phrase.

Under this account, children are able to successfully interpret short passives, irrespective of verb type, because short passives do not include a *by*-phrase requiring thematic role transmission. Fox and Grodzinsky argued that they are also able to successfully interpret full passives (i.e., passives that include a *by*-phrase) when these involve agent–patient verbs: In these cases, they can use the preposition *by* to assign an agentive thematic role to the external noun. Because this assignment is compatible with the thematic role that the verb would assign, it leads to above-chance performance on full passives with agent–patient verbs. However, this strategy fails to yield the correct interpretation for full passives involving experiencer–theme verbs, because it wrongly assigns an agentive role, not the required experiencer role, to the external noun. Consistent with their account, Fox and Grodzinksy found that children showed above-chance comprehension of short and full agent–patient verb passives and short experiencer–theme verb passives, but at-chance performance with full experiencer–theme verb passives.

These proposals suggest that (some element of) passive syntax is acquired late and that the semantic restrictions on passive comprehension that have been observed occur because the alternative syntactic strategies that children use to process passive sentences are compatible with verbs that assign agent–patient thematic roles but not with verbs that assign experiencer–theme thematic roles.

Note that both of these proposals are based on evidence from children's comprehension of passives. However, it is generally assumed that the same representations would underlie children's production of passives, and thus that young children's production of passives should similarly involve an adjectival or short passive analysis (Baldie,

1976; Horgan, 1978). Such an assumption is in keeping with evidence that children produce short passives substantially more frequently and more accurately than full passives (Budwig, 1990; Marchman, Bates, Burkardt, & Good, 1991; Slobin, 1968).

Although considerable research has focused on such syntactic explanations for restrictions on children's early passives, other research has suggested that the restrictions may have a basis in semantic factors. One such account was proposed by Maratsos et al. (1985). They suggested that children's development of the passive construction may be semantically constrained, such that they generalize their knowledge of the passive structure along a 'semantic-transitivity' gradient, initially to prototypically transitive verbs (e.g. agent–patient verbs), and then later to less prototypically transitive verbs (such as experiencer–theme verbs). They suggested that this generalization may be guided by adult use of the passive, citing as additional evidence a brief analysis of adults' child-directed speech in which they found very few passive exemplars, most of which occurred with resultative actional (i.e., agent–patient) verbs (e.g. *bend*, *clean*, *break*, *dress*); they reported no adult passives with experiencer–theme (non-actional) verbs.

However, Maratsos et al. (1985) found that adults do produce passives involving psychological (i.e., non-actional) verbs that canonically assign a theme role to the verb's subject and an experiencer role to its object in an active sentence (*theme–experiencer* verbs, such as in (3)); such verbs tend to be resultative or involve a change in state, and thus are more prototypically transitive than experiencer–theme verbs.

(3) Active: The boy$_{[\text{THEME}]}$ *scared/surprised/irritated/confused* the girl$_{[\text{EXPERIENCER}]}$
Passive: *The girl was scared/surprised/irritated/confused by the boy*

Consistent with this, Ferreira (1994) found that when adult participants were asked to produce sentences using a specified verb, subject and object, they produced 31% passive sentences when given theme–experiencer verbs, compared with just 4% passive sentences when given agent–patient/experiencer–theme verbs (which she grouped into a single category).

We note that Maratsos et al.'s suggestion that children's acquisition of the passive is closely related to the input to which they have been exposed, is consistent with more recent usage-based accounts of language development (e.g., Tomasello, 2000). However, it assumes that the relevant input relates to the frequency of particular constructions with respect to a semantic class of verbs rather than with respect to individual verbs (as for example Tomasello's account would assume).

If children's generalization of the passive is guided by degree of verb transitivity, we might expect them to comprehend theme–experiencer verb passives earlier than experiencer–theme verb passives. Thus theme–experiencer verbs provide an interesting test case, which has not previously been explored: If experiencer–theme verb passives are more difficult for children to comprehend because such verbs are less proto-typically transitive than agent–patient verbs, then we might expect the same children to perform comparatively better with theme–experiencer verb passives because these verbs are more prototypically transitive, in that they involve a change in state or result. However, if young children have difficulty with non-actional verb passives as a general class (involving theme and experiencer roles in any configuration), we would expect them to perform as poorly with theme–experiencer verb passives as with experiencer–theme verb passives.

Note that it is not clear from Maratsos et al.'s (1985) account precisely which aspects of processing the proposed semantic constraints might impact. For example, they might affect the extent to which children are able to generalize passive constituent structure, so that experiencer–theme verb passives cannot initially be associated with the same syntactic structure as actional verb passives. In that case, the semantic constraints would affect syntactic processing. Alternatively, their impact might be limited to semantic aspects of processing. In that case, children might be able to retrieve an appropriate syntactic structure for experiencer–theme verb passives (and this would be the same as for actional verb passives), but they would not be able to carry out later stages of interpretation correctly.

So far, we have discussed two types of explanation for the semantic distinction in children's performance with passives, which focus on possible difficulties in processing the structure of the passive. Under the first account, the semantic distinction in children's performance with passives is explained in terms of delayed acquisition of passive syntax (either A-chain maturation or thematic role transmission), with young children initially using alternative strategies for processing passives that are only consistent with certain classes of verbs. Under the second account, these results are explained in terms of delayed generalization of passive syntax to different semantic classes of verbs, with generalization to proto-typically transitive verbs (e.g. agent–patient verbs) preceding generalization to less proto-typically transitive verbs (e.g. experiencer–theme verbs). But there is an alternative possible explanation, under which their poor performance on experiencer–theme verb passives is not caused by specific difficulties in processing passive structure, but rather by difficulties in carrying out the experimental task correctly.

There is increasing evidence that children's performance in linguistic tests may be contingent on the task that is used to test them (e.g., Bencini & Valian, 2008; Crain & Fodor, 1993; Crain, Thornton, & Murasugi, 2009; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007). For example, Maratsos et al. (1985) found that children's performance on agent–patient verb passives varied substantially according to the experimental task: 83–91% accuracy in a picture-sentence matching task compared to only 67% accuracy in a stimulus sentence-question task. Furthermore, Beilin (1975) noted that 4-year-old children achieved lower scores, even with active sentences, in a picture-sentence matching task (73.8% pictures correctly matched) than in an enactment task (84.5% sentences correctly enacted).

We suggest that tasks such as these may be particularly difficult for children to complete consistently, for reasons other than linguistic competence. For example, in a picture-sentence matching task, children are typically presented with two pictures showing the same characters and the same (transitive) event but with the characters' roles swapped across the pictures. They hear a sentence describing one of the events (for example *a penguin is hitting a pirate*) and must find the picture that depicts this event, ignoring the picture depicting the same event but with swapped roles (i.e. a pirate hitting a penguin). Thus, to demonstrate comprehension of the passive, they must process the sentence *and* identify the correct picture. Tasks such as these are known to be difficult (Chan, Meints, Lieven, & Tomasello, 2010). If children have difficulty in distinguishing the pairs of *pictures*, not necessarily in processing the *sentences*, then they will perform poorly; and such poor picture recognition could be misinterpreted as delayed acquisition of the passive syntax or of certain semantic classes of passive.

It is therefore possible that the relatively poor performance on experiencer–theme verb passives that is observed in young children in such tasks may reflect particular difficulties with performing the experimental task when it involves this class of verb. Specifically, they may perform poorly in picture-sentence matching tasks involving experiencer–theme verbs because it is harder to depict unambiguously events involving such verbs (e.g. seeing) and the roles played in them by the relevant protagonists (e.g., the see-er vs. the seen) than, for example, events involving agent–patient verbs (such as pushing or kissing) and the roles of the protagonists (e.g. the hitter vs. the hit-ee). In concrete terms, it is relatively easy to distinguish a picture in which a penguin is hitting from a picture in which it is being hit; however, it may be much more difficult to distinguish a picture in which a penguin is seeing (matching an experiencer–theme verb passive such as "*the pirate was seen by the penguin*") from a picture in which it is not seeing (but rather is being seen); in both cases, the penguin is in some sense, presumably, seeing.

Hence young children's difficulty in processing passive sentences in general in these tasks (reflected in below 100% accuracy even with agent–patient events) may be compounded with experiencer–theme verb sentences, for example, by their difficulty in perceiving the experiencer of such verbs or any difference in pairs of these pictures. Thus it may be the case that young children would show better performance on experiencer–theme passives if a different experimental task were used.

To investigate whether young children's observed poor performance with these passives reflects syntactic constraints, semantic constraints that affect syntactic processing, or task-related difficulties, we therefore turn to an alternative task that provides an implicit measure of children's syntactic representations, namely a syntactic priming paradigm. Syntactic priming is the tendency to repeat aspects of syntactic structure across otherwise unrelated sentences, such that prior processing of a particular syntactic structure facilitates subsequent processing of the same structure (see Branigan (2007) and Pickering and Ferreira (2008) for reviews). Such priming occurs from comprehension to production and vice versa, as well as within modalities, suggesting that it taps into representations that are modality-independent (e.g., Bock, 1986; Branigan, Pickering, & Cleland, 2000; Branigan, Pickering, & McLean, 2005). Syntactic priming depends on the language processor having an abstract representation of structure that it applies to both the *prime* and *target* sentences, and is therefore informative about the nature of syntactic representation (Branigan, Pickering, Liversedge, Stewart, & Urbach, 1995). As such, syntactic priming can be used as an implicit test of the extent to which children have acquired abstract, generalized syntactic representations. Specifically, for syntactic priming to occur for a particular structure, children must have acquired an abstract representation for that structure which they can retrieve during processing of the prime sentence and then re-use in subsequent processing.

Whilst a number of recent studies have demonstrated syntactic priming of passive sentences in children (Bencini & Valian, 2008; Huttenlocher, Vasilyeva, & Shimpi, 2004; Shimpi et al., 2007; though see Savage, Lieven, Theakston, and Tomasello (2003) for alternative results and interpretation), these effects have only been found between agent–patient verb primes and targets. For example, Huttenlocher et al. (2004) had 4-year-old children and an experimenter take turns describing pictures of agent–patient transitive events. Half of the children heard active prime descriptions (e.g., *The rain watered the flower*), and the other half heard passive prime descriptions (e.g., *The flower was watered by the rain*), before describing another transitive event. Children who heard passive descriptions were 14–23% more likely to produce passive descriptions than those who heard active primes.

In a similar between-participants blocked priming task that used the same materials as Huttenlocher et al. (2004), Shimpi et al. (2007) showed that both 3- and 4-year-olds who heard and repeated passive prime sentences produced more passive descriptions than those who heard and repeated active prime sentences. Bencini and Valian (2008) similarly found that 3-year-olds who heard and repeated agent–patient verb passive sentences were 9–14% more likely to produce passives than children who heard and repeated active sentences. Such findings have been taken as evidence that children already have an abstract (rather than lexically-specific) representation for the passive by 4 or 5 years (Huttenlocher et al., 2004) or even by 3 years (Bencini & Valian, 2008; Shimpi et al., 2007), which they used during comprehension and/or production of the prime and then re-used during subsequent production of the target.

However, such evidence is restricted to primes and targets involving agent–patient verb passives. It therefore does not elucidate whether any such passive representation is constrained to agent–patient verbs at this age, or whether it is generalized to other verb classes; and it cannot rule out accounts in which children do not have an abstract representation of the passive but rather use alternative processing strategies and representations that yield the correct interpretation for agent–patient (but not experiencer–theme) passives (e.g., Borer & Wexler, 1987; Fox & Grodzinsky, 1998) and that could themselves be

primed. Additionally, such results might reflect priming of particular orders of thematic roles (Chang, Bock, & Goldberg, 2003).

In the present study, we therefore examined whether syntactic priming effects could also be found in 3- and 4-year-old children following active and passive prime sentences that involved agent–patient, theme–experiencer and experiencer–theme verbs; the target sentences always involved agent–patient verbs. Our goals were to investigate whether children of this age had a syntactic representation for the passive before the age of five, and if so, whether this representation was semantically constrained. Recall that previous studies using tasks such as sentence-picture matching have found that children continue to show poor performance with experiencer–theme passives at 5–6 years of age. If children younger than five do not show effects of verb type in an alternative task, then this would provide strong evidence against accounts of delayed acquisition of the passive syntax. We explored these issues in two syntactic priming experiments in which 3- and 4-year-old children and adult controls described pictures of transitive events; and an additional picture-sentence matching experiment using similar materials, in which 3- and 4-year-old children and adult controls chose pictures to match sentences that they heard.

The picture description task in the syntactic priming experiments was presented as a variation of the popular British children's game 'Snap', with the experimenter and the child alternating in turning over and describing picture cards (Branigan, McLean, & Jones, 2005). We manipulated the structure (active vs. passive) and verb type (agent–patient, theme–experiencer and experiencer–theme) of the experimenter's descriptions, and examined how the structure of the experimenter's prime descriptions affected the syntactic structure of the child's immediately subsequent target description; the target sentences always involved agent–patient verbs. Note that our experiments used a within-participants design in which participants experienced both active and passive primes in a randomized order, allowing us to examine whether children were primed on a trial-by-trial basis. They therefore further extend previous studies with children, which examined priming for passives in a between-participants design (i.e., children heard only active or only passive primes; Bencini & Valian, 2008; Huttenlocher et al., 2004; Shimpi et al., 2007), in which priming may have been reliant on a cumulative effect (e.g., Kaschak, 2007). The picture-sentence matching experiment used the same task and design as previous experiments investigating these structures (e.g., Maratsos et al., 1985, Experiment 2).

Under a syntactic account of the restrictions on children's early passives, whereby children do not have an abstract representation of the passive by five or six (and instead use syntactic strategies that work successfully for agent–patient but not experiencer–theme passives), hearing an agent–patient verb passive might prime subsequent production of an agent–patient verb passive (if these syntactic strategies could themselves be primed), but hearing an experiencer–theme verb passive would not prime production of an agent–patient verb passive, because processing the prime and target would not involve repeated use of the same representations (or strategies). Because performance is argued to reflect underlying deficiencies in representation, children's performance on a given class of passive would not be affected by task; hence they should show comparable performance in the picture-sentence matching experiment as in the priming experiments.

Under an account in which semantic constraints affect syntactic processing such that children initially restrict their generalization of the syntax of the passive construction to a core class of highly transitive verbs until beyond the age of five or six, children should be able to retrieve an appropriate abstract representation when they are exposed to both agent–patient verb and theme–experiencer verb passive primes, which could be drawn upon during subsequent production. However, at this younger age, they should not retrieve such a representation when exposed to an experiencer–theme verb passive, because such verbs are not highly transitive. Hence the semantic account would predict priming of passive target responses following agent–patient verb and theme–experiencer verb passives, but not following experiencer–theme verb passives. This pattern of performance would also hold irrespective of task. Syntactic priming is therefore informative about whether children's syntactic representation of the passive is semantically constrained; however, we note that because it is assumed to reflect repeated access of constituent structure representations, it cannot test whether there are semantic constraints on other aspects of processing (e.g., during later post-syntactic stages of interpretation).

Finally, if by the age of four or five, children have acquired a syntactic representation of the passive that is not constrained to particular classes of verbs, but find certain experimental tasks harder with some classes of passive than with others, they should be able to retrieve an appropriate abstract syntactic representation when they are exposed to agent–patient verb, theme–experiencer verb, and experiencer–theme verb passive primes. This would manifest itself in a tendency to produce target descriptions with passive syntax to the same extent following all three types of passive prime.

Note that because such priming would be based upon facilitation of constituent structure representations, such a tendency might occur even if the target description were ill-formed with respect to other aspects of structure. Thus following all three types of passive primes, children might sometimes produce *reversed passive* descriptions, a characteristic error in young children involving passive constituent structure but reversed thematic role mappings (e.g., *The boy*$_{[\text{AGENT}]}$ *was kissed by the girl*$_{[\text{PATIENT}]}$ in place of *The girl*$_{[\text{PATIENT}]}$ *was kissed by the boy*$_{[\text{AGENT}]}$; Hayhurst, 1967; Horgan, 1978; Lempert, 1989; see Messenger, Branigan, and McLean (in press), for evidence of such reversed passive priming in older children). Such a tendency would of course provide strong evidence that the priming effect was genuinely syntactic.

However, if children's performance is related to task, we might find differences in children's performance between verb classes in a task that required them to choose between pictures. Specifically, we might expect them to show poorer performance for experiencer–theme verb passives than agent–patient/theme–experiencer verb passives in the picture-sentence matching experiment.

Experiment 1 therefore examined whether children have a common abstract representation for agent–patient verb and theme–experiencer verb passives before 5 years by comparing whether they were more likely to produce agent–patient verb passive descriptions after hearing these passives than after hearing corresponding actives. Experiment 2 compared production of agent–patient verb passives following experiencer–theme and theme–experiencer verb passive primes. Experiment 3 examined children's comprehension of all three types of passive (agent–patient, experiencer–theme and theme–experiencer) in a picture-sentence matching task.

Experiment 1: Agent–patient primes vs. theme–experiencer primes

Experiment 1 compared the priming effect of agent–patient verb and theme–experiencer verb active and passive sentences on a group of 3- and 4-year-old children's descriptions of agent–patient verb transitive events. Thus we examined whether children would be more likely to produce a (well-formed) passive description after hearing the experimenter produce a passive prime sentence than an active prime sentence. We compared their performance with that of adult controls; if priming depends upon an abstract representation of the passive, then adults should show a priming effect irrespective of verb type. In addition, given the wide age range of the group, we examined whether the child's age was predictive of priming effects. Although all of our child participants were younger than the age at which effects of verb type have previously been found using other tasks, it is nevertheless plausible that older children would be more likely to have developed a generalized (i.e., semantically unrestricted) syntactic representation for the passive and we might therefore find evidence of a developmental trajectory within the group.

In additional analyses, we examined two aspects of participants' 'other' responses (i.e., responses that did not meet the scoring criteria for a correct and complete active or passive sentence). We first examined whether there was any influence of prime type or verb type on participants' 'other' responses: If a particular type of passive is hard for children to process (either because they are not able to apply an appropriate syntactic analysis or because of semantic restrictions on the generalization of passive syntax), they might be more susceptible to producing errors or non-standard responses following such a prime. We then focused on a subset of the 'other' responses, specifically reversed passive responses, and examined whether such responses were more likely following a passive Prime than an active prime. Such an effect would provide further evidence that participants were primed with respect to passive constituent structure.

Method

Participants

The participants were 20 monolingual pre-school children (10 girls), ranging in age from 3;1 to 4;11 (mean age 4;2). They were recruited from and tested in local nurseries. No developmental or language delays were reported. A control group of 20 adult, monolingual native speakers of English, (15 female; mean age 21;6), were recruited from the University of Edinburgh student population and paid for their participation.

Design

We used a $2 \times 2 \times 2$ mixed design: the within-participants factors were: Prime (active vs. passive) and Verb Type (agent–patient vs. theme–experiencer); Group (children vs. adults) was a between-participants factor.

Materials

We created 24 experimental items, each comprising a prime picture, its associated active and passive description, and a target picture; all depicted a transitive event with animal characters as agents and human characters as patients (see Fig. 1). Active and passive prime descriptions were in the present progressive form (to avoid a possible adjectival interpretation of the passive sentences). Target pictures involved agent–patient events and depicted different characters to those in the associated prime picture. We used animal agents and human patients in order to raise the overall likelihood of passive production and hence to avoid floor effects (see Branigan, Pickering, & Tanaka, 2008). There were two versions of each prime picture; one version depicted an agent–patient event (*bite*, *carry*, *hit*, *pat*, *pull* or *squash*; all agent–patient Prime verbs were different to the agent–patient target verbs), the other version depicted a theme–experiencer event (*annoy*, *frighten*, *scare*, *shock*, *surprise* or *upset*). Both versions included the same characters (see Appendix for a complete list of the experimental items).

We also created eight 'Snap' items (four actives and four passives) depicting transitive actions corresponding to four further verbs, which served as filler (non-experimental) items; these 'Snap' items required the experimenter and the child to have identical cards. The 'Snap' and experimental items were depicted on cards and used as the playing cards for the game. We created an additional set of four practice items using different actions and entities to the experimental and 'Snap' items. We produced four lists of the items, such that across the four lists each target occurred once in each of the four priming conditions and within a list six targets occurred in each of the four priming conditions. Each participant received an individually randomized order.

Procedure

The experiment began with a warm-up session in which the child was asked to identify the characters (depicted on individual cards) that would appear on the target items. This was followed by a short game of Snap using the practice items. In both the practice and the main experiment, the experimenter placed a set of pre-arranged picture cards face-down in front of each player (the experimenter and the participating child). She told the participant that they would take it in turns to describe the pictures and look for 'Snap' items to win. The experimenter began each game by turning over the top card and describing it (following a script); this constituted the prime. The participant then took their top card and described it; this constituted the target response. The game continued with players

Fig. 1. Agent–patient (*hit*) and theme–experiencer (*shock*) verb prime items and target item (*scratch*).

alternating until all cards had been described. If the same picture appeared on both players up-turned card, the first player to shout "Snap" would win the cards in play. We tested adult participants using the same procedure and told them that the experiment was designed to test young children, hence the child-oriented nature of the task and materials. The experimental sessions were audio-recorded; participants' responses were transcribed and scored according to the criteria outlined below. A second coder who was blind to condition independently scored 10% of the data; coder agreement was 97% (111/114 responses; Cohen's $k = 0.96$, $p < .001$).

Scoring

We scored the first target description that a child produced on each trial as complete or incomplete: Complete descriptions were those with a subject, verb and object; incomplete utterances were those where the participant's first response included only a subject and main verb or subject and passive auxiliary and were therefore clearly the start of an (incomplete) active or passive. A target description was scored as an Active if it was a complete sentence that provided an appropriate description of the transitive event in the target picture and contained a subject bearing the agent role, a verb, and a direct object bearing the patient role, and could also be expressed in the alternative form (i.e., a passive). A target description was scored as a Passive if it was a complete sentence that appropriately described the picture's event and contained a subject bearing the patient role, an auxiliary verb (*get* or *be*), a main verb, a preposition *by* and an object bearing the patient role, and that could also be expressed in the alternative form (i.e., an active). All other descriptions, including short passives, incomplete utterances and non-transitive utterances, were scored as Other. We included Reversed Passive descriptions as a separate category within Other; a description was scored as a Reversed Passive if it was a complete passive sentence that described the picture's event and contained a subject bearing the *agent* role, an auxiliary verb (*get* or *be*), a main verb, a preposition *by* and an object bearing the *patient* role (i.e., the agent and patient role mappings were reversed), and could also be expressed in the alternative form (i.e., an active). Note that if a child initially produced an incomplete description but subsequently produced a complete description (e.g., "*a frog is getting kiss – a frog kissed the doctor*", only the first (incomplete) description was scored (as Other).

The scoring used in our analyses corresponds to the scoring criteria typically applied to adult priming experiments. Note that this scoring is stricter than that typically used in priming experiments with children (Huttenlocher et al., 2004; Shimpi et al., 2007; see Bencini and Valian (2008) for further discussion): Previous studies also scored utterances containing just a subject and verb as active (*the bunny was eating*) or passive (*the flower was eaten*; examples from Huttenlocher et al. (2004, p. 185)), whereas we only coded full utterances with a subject, verb and object, to avoid including any short, possibly adjectival, passive descriptions in the data. We also re-coded the data (and the data from Experiment 2) using more lenient scoring criteria corresponding to the criteria used in previous priming experiments with children (whereby short passive and short active descriptions were coded as Passive and Active descriptions respectively); our results did not change under this lenient coding, and hence we do not report them further.

Results

The frequency of Active, Passive, and Other target responses for each Group, Verb Type and Prime are shown in Table 1. The total for the Other target responses includes responses scored as Reversed Passive, the numbers of which are presented in parentheses. Twelve (3%) of the children's trials were eliminated because the experimenter produced the wrong prime (1), the participant did not provide a description (8) or the response was lost due to misplaced cards (3) and 7 (1.5%) of the adults' trials were eliminated because the experimenter produced the wrong prime. The number of passive responses shown in Table 1 provides evidence that passive target descriptions were disfavored by both the adults and children in the sample; however both groups produced more passive target descriptions after passive primes than active primes and this occurred for both agent–patient and theme–experiencer verbs. Table 2 breaks down in detail the types of passive responses produced in each condition.

Passive responses

As the dependent variable (Target Response) was binomial (Active or Passive), we modeled the responses using logit mixed effects models (Breslow & Clayton, 1993; Debroy & Bates, 2004). Mixed models allow the simultaneous inclusion of by-participant and by-item variation and thus remove the need for separate F1 and F2 analyses. These models can be thought of as predicting the probability of a specific response (a passive response) in the different conditions (see Agresti, 2002; Jaeger, 2008).

Table 1
Frequency of Active, Passive, and Other (Reversed Passive) target responses by Group, Verb Type and Prime Condition in Experiment 1.

Group	Verb type	Prime	Target responses		
			Active	Passive	Other (of which reversed passive)
Children	Agent–patient	Active	73	8	37 (4)
		Passive	41	31	42 (10)
	Theme–experiencer	Active	77	11	29 (3)
		Passive	47	29	43 (12)
Adults	Agent–patient	Active	103	10	4 (0)
		Passive	79	35	4 (0)
	Theme–experiencer	Active	99	11	10 (0)
		Passive	80	28	10 (1)

Table 2
Frequency of different passive forms by group, verb type and Prime Condition in Experiment 1.

Passive verb phrase form	Priming condition									
	Active				Passive					
	Agent–patient		Theme–experiencer		Agent–patient		Theme–experiencer		Total (%)	
	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults
NP is/NP's being verbed	2	8	2	6	14	33	11	26	29 (*36.7*)	73 (*86.9*)
NP being verbed	2	1	5	1	10	2	9	2	26 (*32.9*)	6 (*7.1*)
NP is/NP's getting verbed	2	0	2	2	3	0	4	0	11 (*13.9*)	2 (*2.4*)
NP has/NP's been verbed	0	0	0	1	2	0	2	0	4 (*5.0*)	1 (*1.2*)
NP is/NP's verbed	0	1	0	1	1	0	2	0	3 (*3.8*)	2 (*2.4*)
NP verbed	2	0	1	0	0	0	0	0	3 (*3.8*)	0
NP getting verbed	0	0	1	0	1	0	0	0	2 (*2.7*)	0
NP that's being verbed	0	0	0	0	0	0	1	0	1 (*1.3*)	0
Totals per condition	*8*	*10*	*11*	*11*	*31*	*35*	*29*	*28*		

Factor labels were transformed into numerical values, and centered prior to analysis, so as to have a mean of 0 and a range of 1. This procedure minimizes collinearity between variables (Baayen, 2008), and, in combination with sum coding of contrasts, allows coefficients to be interpreted in an analogous way to the main effects and interactions in an Analysis of Variance. For each result, we report the coefficient for each independent variable and its level of significance. Coefficients in mixed logit models are given in log-odds.

We ran mixed logit models with Group, Prime and Verb Type and all the two-way interactions between them as fixed factors, and participant and items as random effects. Random slope parameters were included in the models using forward selection (Baayen, 2008). Random slope parameters for main effects and interactions were added sequentially, first for participants, and then for items. The final model incorporated only those random slope parameters whose inclusion resulted in a better model fit than simpler models.

The best fit model is summarized in Table 3. None of the interactions nor the main effect of Verb Type reached significance and were removed from the model ($p > .4$). There was a main effect of Group; children produced more passive target responses (25%) than adults (19%) and a main effect of Prime; all participants produced more passive target responses following passive primes (16%) than following active primes (5%).

In order to examine whether there was any effect of age in the child group, we analyzed the children's production of Passive responses using mixed logit models with Prime and Verb Type and included Age (in months) as a fixed factor. All the two-way interactions and the three-way interaction were included; participant and items were random effects. As with the other factors, Age was centered prior to the analysis. The best fit model included only a main effect of Prime: Children produced more passive target responses after Passive primes (41%) than after Active primes (11%) (log-odds coefficient $B = 1.98$ [SE = 0.33], $p < .001$). The model was not improved by the addition of Age ($p > .4$).[1]

We also ran analyses to explore whether there was a cumulative priming effect (e.g., Kaschak, Loney, & Borreggine, 2006), such that children were affected by previously experienced sentences beyond the most recent prime. We therefore ran another mixed logit model which added four additional variables to the best fit model for the children. Following Jaeger and Snider (2008), we included two variables to measure effects of participants' prior production: the number of passives produced previously by the participant, and the number of actives produced previously by the participant; and two variables to measure effects of

[1] To minimize the impact of collinearity, all factors were centered before being entered into the analysis. However, to ensure that collinearity between Age and Prime was not affecting the model, we measured the variance inflation factor (vif) using code adapted for linear mixed models (Jaeger, 2011); vif above 5 indicates a potential problem with collinearity. The vif for a model that included the interaction of Prime and Age was 1.017, and for the three way interaction, it was 1.167. This suggests that collinearity was not a problem.

Table 3
Model coefficients and probabilities for best-fitting models for Experiment 1. The intercept represents the log-odds for the specified target response. The "Slope" column indicates whether the random slope parameter corresponding to the effect was included in the model for participants (p) or items (i).

Target response	Predictor	Coefficient	Std. error	Wald Z	p (Coefficient $\neq 0$)	Slope
Passives	Intercept	1.87	0.30	6.15	<.001	
	Group	−0.77	0.30	−2.62	<.01	(p)
	Prime	1.99	0.37	5.40	<.001	(p)
Others	Intercept	−2.89	0.25	−11.4	<.001	
	Group	1.82	0.31	5.97	<.001	
	Prime	0.13	0.24	0.55	n.s.	
	Verb Type	0.10	0.24	0.43	n.s.	

participants' prior comprehension: the number of passives and the number of actives comprehended previously by the participant. The model was not improved by the addition of any of these variables ($p > .14$).

Other responses

We conducted further analyses in order to examine whether there were any differences in the number of 'Other' responses between conditions, which might indicate particular processing difficulty in particular conditions. We ran mixed logit models for the Other target responses (see Table 1). These models were conducted in the same manner as before, with the dependent variable being whether the response was an Other or not. The best fit model is summarized in Table 3. None of the interactions reached significance, and all were removed from the model ($p > .3$). There was a main effect of Group: Children produced more Other target responses (32%) than adults (6%). The factors Prime and Verb Type as predictors were not significant.

We then conducted additional analyses on a subset of the Other responses, namely the children's Reversed Passive responses (note that whilst children produced several Reversed Passives (29/151 Other responses), adults produced such responses extremely rarely, (1/28 Other responses). We examined whether children produced more Reversed Passives, i.e., passive constituent structure but with reversed thematic mappings, following passive primes than following active primes. In these models the dependent variable was binomial: The response was either a Reversed Passive or not. The best fit model included only a main effect of Prime: Children produced more Reversed Passive target responses after Passive primes (15%) than after Active primes (5%) (log-odds coefficient $B = 1.300$ [SE = 0.47], $p < .01$). The model was not improved by the addition of Verb Type ($p > .8$). Thus children showed priming for passive constituent structure, even when they did not appropriately map thematic roles to grammatical functions.

Discussion

In a picture-description task, 3- and 4-year-old children produced more passive descriptions (both correct passives and reversed passives, where the agent and patient were reversed) after hearing passive prime sentences (involving different nouns and verbs) than after hearing active prime sentences; the magnitude of the priming effect was not affected by whether the prime contained an agent–patient or a theme–experiencer verb. Similarly, adults also produced more (correct) passive descriptions after hearing passive primes than after hearing active primes, irrespective of verb type. These results imply that when they heard the prime sentence, children were able to retrieve an abstract syntactic representation for it that could be re-used during production of the target sentence, irrespective of whether it involved an agent–patient or theme–experiencer verb. The fact that they did not always repeat the detailed constituent structure of the prime in their passive utterances (e.g., with respect to the internal structure of the auxiliary phrase; recall that passive primes were always of the form *NP is being VERB-ed by NP*) is consistent with previous findings in adults suggesting that the relevant abstract representation does not pertain to the whole sentence, but rather some part of it (e.g., Branigan, Pickering, McLean, & Stewart, 2006; Pickering & Branigan, 1998). Furthermore, we found that the priming effect was not modulated by age, neither in group-level comparisons nor at an individual level within the group of 3- and 4-year-olds. In addition, participants did not produce more Other responses following theme–experiencer verb primes than following agent–patient verb primes.

The finding of equal priming for agent–patient verb passive targets following agent–patient verb passive primes and theme–experiencer verb passive primes rules out any explanation of the effect based on repetition of particular orders of thematic roles (e.g., Chang et al., 2003). Additionally, the reliable priming of reversed passives (in which the animal agent appeared as the subject and the human patient appeared as the oblique object) following (human–patient/animal-agent) passive primes suggests that the priming effect had a basis in the repetition of constituent structure rather than the repeated binding of particular animacy features (e.g., humanness) to particular grammatical functions.

These findings also argue against a syntactic account in which children cannot process passive structures that involve thematic roles other than agent–patient (Fox & Grodzinsky, 1998). Furthermore, because our prime sentences were in the present progressive form (e.g., *A girl is being shocked by a sheep*), they appear incompatible with an account in which children use an adjectival passive strategy to interpret passives: Although both agent–patient and theme–experiencer verb participles can form felicitous adjectival passives in perfective sentences (e.g., *A girl is shocked*; Borer & Wexler, 1987), this analysis is not possible

in progressive sentences. However, the results are consistent with an account in which children acquire an abstract representation for prototypically transitive verbs (but not for proto-typically non-transitive verbs) at an early stage (Maratsos et al., 1985).

In Experiment 2, we therefore compared priming following theme–experiencer verb and experiencer–theme verb passive primes. This provided a further test of an account in which children use an adjectival passive strategy to process passives: Even if they did apply this strategy to passives in the progressive form (which should not be possible), they should not be able to retrieve an appropriate syntactic representation when they hear an experiencer–theme verb passive, and hence that hearing an experiencer–theme verb passive should not prime production of an agent–patient verb passive target. More critically, an account in which children's acquisition of passive syntax is semantically constrained makes the same prediction (we again note that syntactic priming is uninformative about semantic constraints on other, non-syntactic aspects of the passive). However, if children have acquired an abstract syntactic representation of the passive irrespective of verb class, both theme–experiencer verb and experiencer–theme verb passive primes should elicit passive descriptions.

Experiment 2: Theme–experiencer primes vs. experiencer–theme primes

Experiment 2 examined the priming effect of theme–experiencer verb and experiencer–theme verb active and passive sentences on a group of 3- and 4-year-old children's descriptions of agent–patient verb transitive events, and compared their performance with that of adult controls. In this experiment, we also examined whether the child's level of language development was predictive of priming effects. Though we found no effect of age in Experiment 1, children's rates of language development vary independently of age, and it is possible that we would find evidence of delayed syntax or semantic restrictions on the passive in children at less advanced stages of language development.

Method

Participants

The participants were 24 monolingual children (14 girls), ranging in age from 3;4 to 4;11 (mean age 4;2). They were recruited and tested in local nurseries. The children's receptive vocabularies (standardized score), measured using the British Picture Vocabulary Scale II test (BPVS; Dunn, Dunn, Whetton, & Burley, 1997), ranged from 87 to 119 (mean 104). No developmental or language delays were reported. We also tested a control group of 24 monolingual adults (23 females, mean age 18.8) from the University of Edinburgh who received course credit for their participation.

Design, materials and procedure

Experiment 2 used the same 2 (Prime) × 2 (Verb-Type) × 2 (Group) design as Experiment 1. We created an experiencer–theme verb version of the prime items using

Fig. 2. Theme–experiencer (*shock*) and experiencer–theme (*love*) verb prime items and target item (*scratch*).

Table 4
Frequency of Active, Passive, and Other (Reversed Passive) target responses by Group, Verb Type and Prime Condition in Experiment 2.

Group	Verb type	Prime	Target responses		
			Active	Passive	Other (of which reversed passive)
Children	Experiencer–theme	Active	79	10	46 (5)
		Passive	54	25	58 (15)
	Theme–experiencer	Active	87	8	42 (6)
		Passive	53	30	52 (9)
Adults	Experiencer–theme	Active	119	12	6 (0)
		Passive	106	22	9 (1)
	Theme–experiencer	Active	126	13	5 (1)
		Passive	95	34	8 (0)

Table 5
Frequency of different passive forms by group, verb type and Prime Condition in Experiment 2

Passive verb phrase form	Priming condition									
	Active				Passive					
	Experiencer–theme		Theme–experiencer		Experiencer–theme		Theme–experiencer		Total (%)	
	Children	Adults	Children	Adults	Children	Adults	Children	Adults	Children	Adults
NP is/NP's being verbed	6	12	5	11	18	21	17	31	46 (*63*)	75 (*92.5*)
NP being verbed	4	0	3	0	4	1	8	1	19 (*26*)	2 (*2.5*)
NP has been verbed	0	0	0	1	3	0	5	1	8 (*11*)	2 (*2.5*)
NP is verbed	0	0	0	1	0	0	0	1	0 (*00*)	2 (*2.5*)
Totals per condition	*10*	*12*	*8*	*13*	*25*	*22*	*30*	*34*		

Table 6
Model coefficients and probabilities for best-fitting models for Experiment 2. All intercepts represent the log-odds for the specified target response.

Target response	Predictor	Coefficient	Std. error	Wald *Z*	*p* (Coefficient ≠0)	Slopes
Passive	Intercept	1.76	0.18	9.46	<.001	
	Group	−0.24	0.10	2.49	<.05	(p)
	Prime	0.68	0.10	6.65	<.001	
Other	Intercept	−1.99	0.22	−8.96	<.001	
	Group	2.65	0.23	11.6	<.001	
	Prime	−0.44	0.17	−2.56	<.05	

experiencer–theme verbs that previous studies also tested (*hear*, *ignore*, *like*, *love*, *remember* and *see*) and we re-used the theme–experiencer verb prime items created for Experiment 1. Thus, in this experiment, there was a theme–experiencer verb and an experiencer–theme verb version of each prime depicted with the same two entities (see Fig. 2). We used the same 24 (agent–patient verb) target pictures,[2] and the same Snap and practice items used in Experiment 1.

We again created four sets of the experiment and Snap items from which individually randomized lists were produced. This experiment followed the same procedure as Experiment 1. Following the Snap game, we administered the BPVS test to measure children's language level; note that previous research has demonstrated a correlation between BPVS score and measures of expressive language (e.g., sentence length, and complexity; Cutting & Dunn, 1999). The target responses were coded using the scoring criteria outlined in Experiment 1 (recall that this scoring corresponds to the scoring criteria used in adult priming experiments). A second coder who was blind to condition independently scored 10% of the responses; coder agreement was 99% (113/114 responses; Cohen's $k = 0.99$, $p < .001$).

Results

The frequency of Active, Passive and Other target productions for each Group, Verb Type and Prime are shown in Table 4. Again, the Other target responses include those responses which could be scored as Reversed Passive, presented in parentheses. Thirty-two (6%) of the children's trials were eliminated because the experimenter produced the wrong prime (5), the participant did not provide a description (14), or the response was lost due to recording problems (5) or misplaced cards (8); and 21 (4%) of the adults' trials were eliminated because the experimenter produced the wrong prime. Similarly to Experiment 1, Table 4 suggests that although there were many fewer passive than active target descriptions in both adults and children, both groups produced more passive target descriptions after passive primes, and this occurred for both experiencer–theme and theme–experiencer verb primes. Table 5 breaks down in detail the types of passive responses produced in each condition.

Passive responses

The results from Experiment 2 were analyzed using mixed logit models with Prime, Verb Type and Group and all the two-way interactions between them as fixed factors, and participant and items as random effects. None of the interactions nor the main effect of Verb Type reached significance; all were therefore removed from the model ($p > .2$). The best fit model is summarized in Table 6. There was a main effect of Group: Children produced more passive target responses (21%) than adults (15%); and a main effect of Prime: Participants produced more passive target responses following passive primes (13%) than following active primes (5%).

In order to examine whether there was any effect of age or language level, we analyzed the children's production of Passive responses using mixed logit models including Prime, Verb Type, Age (in months), and BPVS (standardized score) as a fixed factors. All interactions were included;

[2] Owing to experimenter error, two target pictures depicted the agent-patient verb *squash* in the child group lists but the agent-patient verb *hug* in the adult group lists (with both versions of each picture involving the same entities).

participant and items were random effects. As with the other factors, Age and BPVS were centered prior to the analysis. The best fit model included main effects for Prime and BPVS. Children produced more passive target responses after Passive primes (34%) than after Active primes (10%) (log-odds coefficient $B = 1.95$ (SE = 0.35), $p < .001$). However, BPVS as a predictor was not significant (log-odds coefficient $B = -0.06$ (SE = 0.04), $p = .12$). The model was not improved by the addition of Age ($p > .6$).[3]

To examine whether there was any cumulative priming, we ran another mixed logit model adding in four additional variables, as in the cumulative priming analyses described in Experiment 1, to the best fit model for the children. The model was not improved by the addition of any of these variables ($p > .55$).

Other responses

We again examined whether the participants' Other responses were influenced by Prime or Verb Type by running mixed logit models for the Other responses (see Table 4). The dependent variable was whether the response was an Other or not.

The best fit model is summarized in Table 6. None of the interactions nor the main effect of Verb Type reached significance, and all were removed from the model ($p > .2$). There was a main effect of Group: Children produced more Other target responses (36%) than adults (5%). There was also a main effect of Prime: Participants produced more Other target responses following passive primes (23%) than following active primes (18%).

We also conducted analyses on children's production of Reversed Passives in the same way as Experiment 1. The best fit model included only a main effect of Prime: Children produced more Reversed Passive target responses after Passive primes (12%) than after Active primes (6%) (log-odds coefficient $B = 0.950$ [SE = 0.41], $p < .05$). The model was not improved by the addition of Verb Type ($p > .3$).

Discussion

As in Experiment 1, 3- and 4-year-old children produced more agent–patient verb passive targets (both correct and reversed passives) after hearing passive primes than after hearing active primes; the overall priming effect collapsed across conditions was very similar in magnitude to that found in Experiment 1 (Experiment 1: 14%; Experiment 2: 17%[4]). More importantly, this priming effect was not affected by verb type (and did not differ from the priming effect found in adults, who also produced more passives following passive primes than following active primes, irrespective of verb type). For this to occur, children must have been able to retrieve a common abstract syntactic representation when they heard both theme–experiencer and experiencer–theme verb passives, which they were able to re-use during subsequent production of agent–patient passives. As in Experiment 1, they did not always repeat the exact constituent structure of the prime sentence in its entirety in their passive utterances, suggesting that the relevant representation was not specified with respect to the sentence as a whole. Furthermore, the tendency to produce more passive descriptions following experiencer–theme primes was not affected by age (at a group or individual level) or language level, suggesting that this representation was already stable.

Hence these results extend those of Experiment 1 in suggesting that by 4 years, children have a syntactic representation for the passive that is not restricted to agent–patient and theme–experiencer verbs, but is also generalized to experiencer–theme verbs. These results contrast with previous findings that children aged five perform poorly with experiencer–theme passives (Fox & Grodzinsky, 1998; Hirsch & Wexler, 2006; Maratsos et al., 1985; Sudhalter & Braine, 1985). Further evidence that experiencer–theme primes were not difficult for children to process comes from the analysis of Other responses, which showed no tendency for more Other responses following experiencer–theme primes.

In Experiments 1 and 2 children showed indistinguishable performance following experiencer–theme and theme–experiencer verb passives as following agent–patient verb passives. Moreover, they showed the same pattern of passive production as adults. This begs the question of why children performed poorly with experiencer–theme verb passives in other studies. To examine whether their poor performance might reflect the task used to test children's processing of passives with different verbs, we tested the same children who completed Experiment 2's priming task in an alternative task: a forced-choice picture sentence matching task, as used in earlier studies that demonstrated poor performance on experiencer–theme verb passives. A participant's comprehension of the passive sentences was measured by how frequently they matched a sentence to the correct picture.

Experiment 3: Picture-sentence matching task

In Experiment 3, 3- and 4-year-old children saw two pictures depicting the same characters and the same event but with the characters' roles swapped across the two pictures. They heard active or passive sentences, which matched one of these pictures, and indicated which picture they thought it matched. We again compared their performance with adult controls; if such tests measure knowledge of abstract passive structure, as is generally assumed, then adults should show no effect of verb type or structure when choosing the matching pictures.

Method

Participants

The children and adult participants who completed Experiment 2 took part in this experiment. All children

[3] As in Experiment 1, the vif was calculated for the factors to ensure that the models were not affected by collinearity between the factors. For a model that included the two-way interaction between Prime and Age, the vif was 1.033; for a model with three-interactions between Prime, Age and BPVS, the vif was 1.972. This suggests that collinearity was not a problem.

[4] A 2 (Experiment) × 2 (Group) ANOVA comparing the individual priming effects within each experiment showed no significant effect of Group ($F < 3$, $p > .1$), Experiment ($F < 2$, $p > .2$), nor an interaction between the two ($F < 1$, $p > .9$).

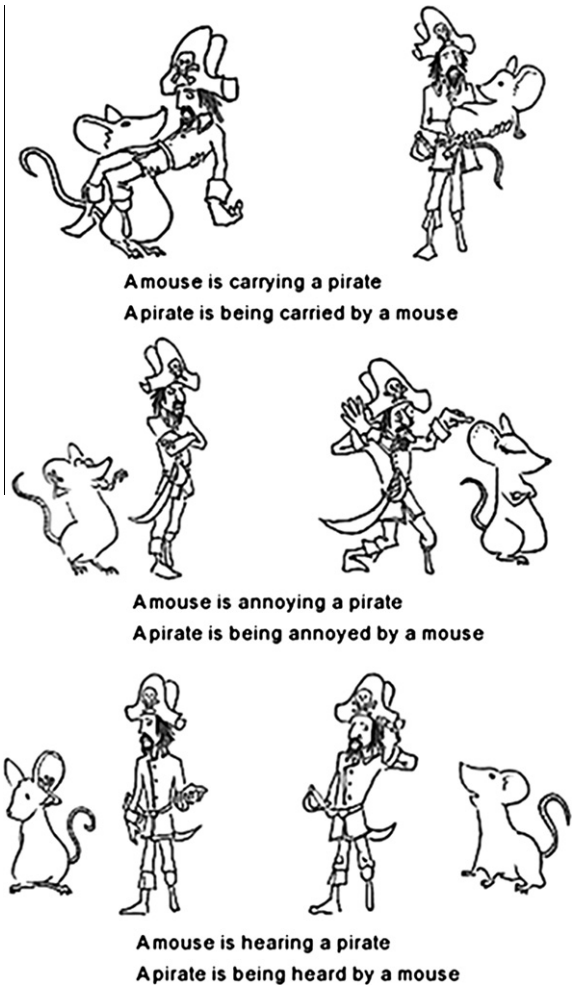

Fig. 3. Target and distractor versions of a picture-sentence matching item.

and adults participated in the picture-sentence matching task at least 1 week before Experiment 2.[5]

Design

We used a 2 × 3 × 2 design with Structure (active vs. passive) and Verb Type (agent–patient vs. experiencer–theme vs. theme–experiencer) as within-participants and within-items factors and Group (children vs. adults) as a between-participants and within-items factor. The items were counterbalanced for the side of the picture that the object appeared on and for the side of the participant that the target item was presented on.

Materials

There were 36 experimental items, each comprising a target picture paired with a distractor picture depicted on cards. The distractor picture depicted the same characters and transitive event as the target picture but with the characters' roles swapped (see Fig. 3 for examples of the target picture (left) and its distractor (right)).

There were three versions of each pairing: one version involved an agent–patient verb, the second involved an experiencer–theme verb and the third involved a theme–experiencer verb, each was depicted with the same animal-agent and human-patient pair (see Appendix A). We tested the same verbs as in the primes for Experiments 1 and 2 with the exception of *like* which was changed to *hate* in this task; it was deemed to be easier to depict the swap in roles across the target and distractor for *hate* than it was for *like*. Each version had an associated active and passive description.

Seven practice items preceded the 36 experimental items; four of these were actives, three were passives. These involved pairs of pictures that differed from each other more obviously to introduce the children to the picture-sentence matching task: The distractor picture of the practice items involved either one or two different characters but the same action to the target picture or the same characters carrying out different actions. We created six sets of the items such that across the six sets, each item appeared in each of the six conditions, and within each set six items appeared in each condition. We created six individually randomized experiment orders from each of these sets.

Procedure

The picture-sentence matching task was presented to the child as a sorting task – they were asked to find the picture cards that the experimenter wanted (described) and 'post' them into a letterbox. The picture cards were stacked in two piles in front of the child. The experimenter gave the description for the target picture and the child selected the picture it matched (picked it up and put it in a box) from the top of one of the two piles, the experimenter then removed the top picture from the other pile, such that two new pictures were visible on the top, and described the next target picture. We scored the pictures that the child had selected as correctly or incorrectly matched to the sentence and thus calculated the frequency of correctly- (and incorrectly-) matched sentences for each condition. Trials in which the participant picked up either both pictures or neither picture (i.e. failed to respond) were excluded from the analyses.

Results

The frequency of correct and incorrect match responses for each condition and group in the picture-sentence matching task are reported in Table 7. The children made many more errors with passive than active sentences, and made

[5] Note that we can exclude a possible concern that the child participants' performance in Experiment 2 was affected by their prior exposure to passives in Experiment 3. As Tables 1 and 4 show, the twenty children in Experiment 1 actually produced numerically more passive responses (79) than the twenty-four children in Experiment 2 (73 passive responses). We analyzed the children's production of Passive responses using mixed logit models and included Prime, Verb Type and Experiment as fixed factors. All the two-way interactions and the three-way interaction were included; participant and items were random effects. The best fit model included only a main effect of Prime (log-odds coefficient $B = -1.73$ [SE = 0.22], $p < .001$). The model was not improved by the addition of Experiment, ($p > 0.4$). Thus children who took part in Experiment 2 (after experiencing passives in Experiment 3) did not produce more passives than those who took part in Experiment 1. This pattern of results is consistent with Bencini and Valian (2008) who also found that exposure to passives in a comprehension test did not affect subsequent performance in a priming task.

Table 7
Frequency of correct and incorrect match response by group, verb type and structure in Experiment 3.

Group	Verb type	Structure	Match response	
			Correct	Incorrect
Children	Agent–patient	Active	120	23
		Passive	111	32
	Theme–experiencer	Active	111	33
		Passive	99	44
	Experiencer–theme	Active	90	54
		Passive	58	84
Adults	Agent–patient	Active	144	0
		Passive	144	0
	Theme–experiencer	Active	138	6
		Passive	143	1
	Experiencer–theme	Active	141	3
		Passive	138	6

Table 8
Model coefficients and probabilities for best-fitting models for Experiment 3. All intercepts represent the log-odds for a correct match response.

Predictor	Coefficient	Std. error	Wald Z	p (Coefficient $\neq 0$)
Intercept	−2.60	0.17	−15.6	<.001
Group	3.41	0.27	12.5	<.001
Structure	0.55	0.15	3.68	<.001
Verb "Experiencer–Theme vs. Other Verb Types"	−1.49	0.19	−7.82	<.001
Verb "Agent–Patient vs. Theme–Experiencer"	−0.15	0.13	−1.16	ns

more errors with the experiencer–theme verb sentences than the other two types of sentence. The adults, by comparison, correctly matched all the agent–patient verb sentences to their pictures but made some mistakes with the non-actional verb sentences (i.e. those involving some configuration of theme and experiencer roles) sentences.

The dependent variable in this experiment was binomial (correct or incorrect match), thus we modeled the responses using logit mixed effects models where we estimated the probability of a correct match response. The factors Group and Structure were numerical coded and centered. Contrast coding was used to explore the different Verb Types, firstly to explore whether the number of correct match responses differed after experiencer–theme verbs compared to agent–patient and theme–experiencer verbs, and secondly whether they differed for agent–patient and theme–experiencer verbs.

None of the interactions reached significance, and they were therefore removed from the model ($p > .1$); note that because there were no interactions with Group, we do not report separate analyses for the child and adult groups. The best fit model is summarized in Table 8; no random slope parameters were included. There was a main effect of Group: adults correctly matched more sentences (98%) than children (69%). There was also a main effect of Structure: Participants correctly matched more sentences for Active sentences (86%) than Passive sentences (80%). There was a main effect of Verb Type for the first contrast (experiencer–theme vs. the two other verb types): Participants produced fewer correct matches for experiencer–theme verbs (74%) than for the other verbs (88%). There was no significant difference between agent–patient and theme–experiencer verbs.

We also examined whether children's matching scores were significantly above chance (set at 3 correctly-matched sentences out of the total of 6 sentences per condition) for each verb-type condition. Their scores were above chance for agent–patient verb passives ($t(23) = 5.42$, $p < .001$) and theme–experiencer verb passives ($t(23) = 3.96$, $p = .001$); for experiencer–theme verb passives, however, they were marginally below chance ($t(23) = -1.83$, $p = .08$). If this latter effect were reliable, it might suggest a possible tendency to reverse the meaning of these passives. For active sentences, children's matching scores were above chance for all verb types: agent–patient ($t(23) = 8.58$, $p < .001$), theme–experiencer ($t(23) = 6.58$, $p < .001$) and experiencer–theme ($t(23) = 2.92$, $p = .008$).

Discussion

Experiment 3 tested children's and adults' comprehension of actives and passives with agent–patient, experiencer–theme and theme–experiencer verbs in a picture-sentence matching task. As in previous studies with slightly older children, 3- and 4-year-olds matched active sentences more accurately than passives, and matched agent–patient verb sentences more accurately than experiencer–theme verb sentences. Note that we did not find an interaction with structure: That is, unlike previous studies children were less accurate matching experiencer–theme verb *actives* as well as experiencer–theme verb passives. Additionally, they matched theme–experiencer verb sentences (both active and passive) more accurately than experiencer–theme verb sentences.

Strikingly, although a control group of adults showed a higher overall level of performance than children (i.e. matched more sentences to pictures accurately), they showed exactly the same pattern of effects as children, with more accurate performance on agent–patient and theme–experiencer verb sentences than on experiencer–theme verb sentences, for both active and passive sentences.

General discussion

Previous findings that children comprehend passives involving agent–patient verbs (e.g., *kiss*) earlier than passives involving experiencer–theme verbs (e.g., *see*) have been interpreted as evidence that children's acquisition of passive syntax is delayed. In three experiments, we found striking evidence that 3- and 4-year-old children showed similarly pervasive priming and similarly (in)accurate picture-matching as adults on passive sentences involving three different types of verb. Furthermore, our results show that in both groups, performance was critically affected by task.

In Experiments 1 and 2, participants played a game in which they described pictures of events involving agent–patient verbs after hearing the experimenter produce an active or passive description of an unrelated event involving an agent–patient, experiencer–theme, or theme–experiencer (e.g., *scare*) verb. In both experiments, children were more likely to produce a passive description after hearing a passive description than after hearing an active description, irrespective of verb type. Moreover, they did so to the same extent as adults.

In Experiment 3, participants heard a description of an event involving an agent–patient, theme–experiencer, or experiencer–theme verb, and then had to choose which of two pictures best matched the description. In this task, there were effects of verb type: Children were more accurate at choosing the correct picture after agent–patient and theme–experiencer verb sentences than after experiencer–theme verb sentences. But surprisingly, exactly the same pattern of poorer performance with experiencer–theme sentences was also displayed by the adult controls. Moreover, difficulty with experiencer–theme sentences extended to active as well as passive sentences.

We first discuss the interpretation and implications of the priming results (Experiments 1 and 2) as well as alternative possible explanations; we then turn to the interpretation and implications of the results from Experiment 3 (the picture-sentence matching task), and in particular the possible role of task effects.

Syntactic priming following agent–patient, experiencer–theme, and theme–experiencer verb passives

The finding that children were more likely to produce an agent–patient passive after hearing a theme–experiencer or an experiencer–theme passive than after an active has important implications regarding children's early representation of the passive. For priming to have occurred in these cases children must have treated the prime and target sentences as being related; if they did not do so, then processing the prime sentence would not facilitate processing the target sentence. Hence the tendency for children to produce agent–patient verb passives after hearing theme–experiencer or experiencer–theme verb passive primes (and to do so to the same extent as after agent–patient verb primes) provides evidence that they had an abstract (lexically non-specific) structural representation of these non-actional verb passives, and moreover that this representation was the same as that used when processing agent–patient verb passives.

The results of Experiments 1 and 2 therefore cast doubt on earlier claims that children of this age do not have an abstract syntactic representation of the passive and instead use alternative strategies for interpretation that allow successful comprehension of passives involving agent–patient verbs but not other verbs (e.g., Borer & Wexler, 1987; Fox & Grodzinsky, 1998). Experiment 1 showed that children were able to retrieve an abstract syntactic representation for passive sentences involving theme–experiencer verbs. It therefore rules out an account in which children process passives using a strategy in which they assign an agent thematic role to the subject noun from the preposition *by* (Fox & Grodzinsky, 1998), as such an account wrongly predicts that any priming effect would be restricted to passive sentences involving agent–patient roles. It also provides some evidence against an account in which children of this age process passives by analogy with adjectival passives (Borer & Wexler, 1987), because the passive primes were in the present progressive form, which is incompatible with such an analysis.

Experiment 2 showed that children were able to retrieve an abstract syntactic representation for passive sentences involving experiencer–theme verbs. It therefore provides further evidence against an adjectival passive account (Borer & Wexler, 1987), as such a strategy would fail for passives involving experiencer–theme verbs, and hence could not yield priming. The results of Experiment 2 also argue against an account in which children's passive syntax is initially semantically constrained to highly transitive verbs, consistent with Maratsos et al.'s (1985) proposals, since this too would predict that children should not be able to retrieve an abstract syntactic representation for passives involving experiencer–theme verbs, and hence should not demonstrate priming for passive structure.

These findings also rule out an alternative explanation of priming effects found in earlier studies (e.g., Huttenlocher et al., 2004), namely that children were primed to produce particular orders of thematic roles. Such an account could explain why children were more likely to produce an agent–patient passive after hearing an agent–patient passive (because both involve patient-agent order), but could not explain why they were more likely to produce both an agent–patient verb passive following a theme–experiencer verb passive or an experiencer–theme verb passive. Furthermore, the finding of comparable priming when the order of thematic roles was repeated (i.e., following agent–patient verb primes) and when it was not (following theme–experiencer or experiencer–theme verb primes) suggests that any priming effect based on order of thematic roles was overridden by priming based on repetition of syntactic structure. This is consistent with results found in adults, where priming effects based on repetition of syntactic structure (e.g., Pickering & Branigan, 1998) are typically substantially larger than those based on repetition of thematic role order (e.g., Chang et al., 2003). Indeed, our results also argue against any account based on the repetition of particular orders of proto-roles (under which agents and experiencers on the one hand, and patients and themes on the other, might pattern together; Dowty, 1991)

rather than specific thematic roles: Any such account could explain priming for agent–patient verb passives following experiencer–theme verb passives, but not following theme–experiencer verb passives.

Might the priming effects observed here and in previous experiments reflect repetition of closed-class content rather than abstract syntactic representations? This seems unlikely, for two reasons. First, evidence from adult studies shows no evidence for priming based on, or indeed boosted by, the repetition of closed-class content. For example, Bock and Loebell (1990) found that priming of the dative alternation (*to*- and *for*-datives) occurred to the same extent whether or not the preposition was repeated; moreover, priming did not occur between *to*-dative and *to*-infinitive sentences that shared closed class content but not underlying structural similarity in sentences (see also Pickering & Branigan, 1998). Whilst it is conceivable that priming effects in children may be subserved by different mechanisms, other experiments that used the same paradigm as the present study found no evidence that syntactic priming in children is dependent on the repetition of closed-class content: Children were primed to produce full passives (including a prepositional *by*-phrase) following short passives (which did not include the preposition; Messenger, Branigan, & McLean, 2011), and also to produce passives with a *get*-auxiliary form after hearing a passive with a *be*-auxiliary form (Messenger, Branigan, McLean, & Sorace, 2010). Thus it seems unlikely that our effects were based on the repetition of closed-class content.

We can also rule out an explanation based on repeatedly binding particular animacy features to particular grammatical roles (e.g., repeatedly binding a human character to the subject role). Although one study has found a tendency to repeat such bindings across sentences (Bock, Loebell, & Morey, 1992), other studies in a number of languages have failed to replicate these effects whilst nevertheless replicating a tendency to repeat constituent structure across sentences (i.e., syntactic priming; Bernolet, Hartsuiker, & Pickering, 2009; Tanaka, 2008). Moreover, our experiments showed a significant priming effect for reversed passive targets following (correct) passive primes. That is, in addition to producing more well-formed passives following passive primes than following active primes, children also produced more responses with passive constituent structure but incorrect thematic role mappings following passive primes than following active primes. Crucially, such priming unambiguously demonstrates repetition of constituent structure rather than animacy bindings, since the binding that children produced in the target (animal to subject and human to oblique object) is a reversal of the binding that they encountered in the prime (human to subject and animal to oblique object). Instead, the results of Experiments 1 and 2 provide further evidence that 3- and 4-year-old children have an abstract and primeable syntactic representation of passives, in keeping with previous findings (Bencini & Valian, 2008; Huttenlocher et al., 2004; Shimpi et al., 2007). The prime and target sentences always involved different nouns and verbs; thus the priming effect cannot have been based upon the repetition of representations that were specified for lexical content. Instead, it appears that when children heard a passive prime sentence, they retrieved an abstract representation of it that was specified for syntactic category but not for lexical content, and this representation was re-used with different lexical content when they subsequently produced a description of an agent–patient verb event. Furthermore, the fact that children's passive responses did not always involve repetition of the exact constituent structure of the prime sentence (e.g., with respect to the auxiliary phrase) suggests that this representation was specified for some part of the sentence rather than for the sentence as a whole, in keeping with previous findings for adults (Branigan et al., 2006; Pickering & Branigan, 1998).

Taken together, the results of Experiments 1 and 2 suggest that 3- and 4-year-old children have an abstract syntactic representation for passive structures, irrespective of verb type, and moreover that this representation is implicated in both comprehension and production of passive sentences. In addition, the fact that children were primed to produce passives on a trial-by-trial basis, and in particular the absence of any cumulative effect of either prior production or prior comprehension of passives, suggests that this representation was relatively accessible, and that its use was not contingent upon repeated exposure. The absence of any developmental trend in our groups, when either age or language level were considered, further suggests that this representation is already stable by this age. Moreover, the striking absence of any difference between children and adults' behavior in priming following passive sentences involving all three kinds of verb suggests that this representation is already adult-like in crucial respects.

This conclusion has an important restriction, which we noted above, in that it relates strictly to the issue of children's syntactic (constituent structure) representations: We argue that syntactic priming effects are informative about the nature of the syntactic representations that children retrieve when they are exposed to agent–patient and other passive sentences, but we do not claim that they are informative about children's ultimate interpretation of those sentences. That is, children may have greater difficulty in interpreting certain types of passive than others, for reasons that may plausibly be associated with the specific thematic roles involved or the type of event encoded. Our measure in the priming experiments was whether children were more likely to produce a particular syntactic structure after hearing a prime with the same structure (thus yielding an implicit measure of their syntactic processing of the prime); we did not test their interpretation of the prime sentence that they heard. Hence we cannot draw any conclusions from the priming data about their overall comprehension of the different types of passive sentence. It is therefore possible that children's passives are initially semantically constrained with respect to non-syntactic aspects of processing, in particular post-syntactic interpretational processing, and this would be in keeping with one interpretation of Maratsos et al.'s (1985) proposals. However, we can conclude that the syntactic component of the comprehension process shows no evidence for semantic restrictions on processing of the passive syntax, and thus that disparities in interpretation be-

tween different types of passive sentence cannot be attributed to underlying differences in syntactic representation (i.e., Borer & Wexler, 1987; Fox & Grodzinsky, 1998).

In our experiments, children's target descriptions nearly always involved descriptions of agent–patient events (because the target pictures depicted agent–patient events). However, just as we found comparable priming for agent–patient passive descriptions following experiencer–theme and theme–experiencer verb passive primes as following agent–patient verb passive primes, we would also expect that children would produce experiencer–theme and theme–experiencer verb passive descriptions following agent–patient, experiencer–theme and theme–experiencer verb passive primes.

This prediction is supported by data from the responses produced in the experiments. Although the target pictures depicted agent–patient events, in both priming experiments children and adults sometimes used non-actional verbs (theme–experiencer *and* experiencer–theme) to describe them: In Experiment 1, the children produced 14 non-actional verb passives (*frighten* (4), *annoy* (3), *scare* (3), *surprise* (2), *love* (1), *upset* (1)); they also produced 24 non-actional verb actives. Of the 14 passives, three occurred following active primes and 11 occurred following passive primes; importantly, only five of the passives occurred immediately after a passive prime containing the same verb. In Experiment 2, children produced 21 non-actional verb passives (*scare* (8), *annoy* (6), *frighten* (2), *upset* (1), *love* (3), and *see* (1)) and 31 non-actional verb actives. Of the 21 passives, 6 occurred following active primes and 15 occurred following passive primes; only seven of these passives occurred immediately after a passive prime containing the same verb. Thus, these responses provide further evidence that before five, children have acquired a syntactic representation for the passive that underlies different syntactic classes of verbs, and that they are able to use this representation both in production and in comprehension.

Picture-sentence matching with agent–patient, experiencer–theme, and theme–experiencer verb sentences

In contrast to the results of Experiments 1 and 2, Experiment 3 found differences in children's (and adults') performance between agent–patient verb passives and experiencer–theme verb passives in a picture-sentence matching task. Thus the same children who showed reliable priming from experiencer–theme verb passives in Experiment 2 showed consistently poor performance when they were asked to choose a picture that matched an experiencer–theme verb passive, mirroring the pattern of results found in previous studies. How can this disparity be explained? One possibility, in keeping with our discussion above, is that young children may have an abstract syntactic representation of the passive that they are able to apply to different types of passive, but that they have difficulties in interpreting passives involving particular thematic roles and/or events. In that case, initial syntactic processing would not be semantically restricted, but subsequent interpretational processes would be. Children would therefore show syntactic priming effects after hearing a non-actional verb passive sentence, but may perform badly in a task that depended on correct interpretation of an experiencer–theme passive sentence.

This possibility is plausible, and would not undermine our earlier conclusions concerning the early existence of a generalized syntactic representation of the passive. However, it cannot explain why children also performed poorly on experiencer–theme verb actives, nor – more crucially – why adults also, strikingly, showed poor performance in the same task with experiencer–theme verb sentences. Presumably adults (and in particular the university students who served as participants in our experiments) have developed appropriate representations and processes for interpreting experiencer–theme active and passive sentences. Thus the surprising finding that the adult group's performance did not differ from the children's, and that they too performed significantly less well on experiencer–theme verb sentences in this task, suggests that the main cause of children's poor performance may lie in the experimental task itself.

Certainly most previous studies that found poor performance on experiencer–theme verbs generally used one of two tasks (a stimulus sentence-question task or, as here, a picture-sentence matching task) that have been argued to suppress levels of performance compared to other tasks (e.g., Maratsos et al., 1985). Most relevantly for Experiment 3, Beilin (1975) noted that children achieved lower scores in a picture-sentence matching task than in other tasks. This is supported by our finding that children's accuracy was below 100% accuracy in this task even with active sentences, for all three verb types. Furthermore, this task may induce higher levels of performance for agent–patient verbs and lower levels of performance for experiencer–theme verbs for two reasons: Not only is it easier to depict action verbs such as *hit* or *kiss* than to depict experiential verbs such as *love* or *hate* or even perception verbs such as *see*, but it is also easier to distinguish the verb's underlying subject – the causer of the event – for pictures involving verbs like *hit* than for verbs like *see* (and therefore easier to distinguish correctly the target picture from the distractor picture containing the same entities but with the roles swapped).

Children's particular difficulty in processing experiencer–theme verb passives in a picture-sentence matching task may therefore lie in interpreting (and distinguishing) the *pictures*, rather than in interpreting the sentence they have heard. The fact that even the adults sometimes chose the wrong picture in such cases, and that they (and the children) did so even for active sentences, lends weight to our suggestion that children's observed difficulties with experiencer–theme verb passives may be primarily rooted in the experimental task. Note that both groups showed greater accuracy in matching theme–experiencer verb sentences in this task; like agent–patient verbs, but unlike experiencer–theme verbs, theme–experiencer verbs (e.g. *scare*, *upset*) tend to be easier to depict in a way that distinguishes clearly the verb's underlying subject (i.e., which character is the cause of the experience) from its underlying object (i.e., which character is undergoing the experience). We cannot of course conclude on the basis of this experiment that children are able to interpret experienc-

er–theme verb passives as well as agent–patient verb passives; but we have shown that it is not safe to draw the opposite conclusion on the basis of earlier results using the same task.

Our results therefore add to the growing evidence that the nature of the task can crucially affect the extent to which participants manifest linguistic ability. For example, our finding of poor performance on experience-theme passive sentences in picture-sentence matching, yet significant priming following such sentences is consistent with evidence of a disparity between aphasics' performance in picture-sentence matching and grammaticality judgment tasks (Linebarger, Schwartz, & Saffran, 1983; Schwartz, Saffran, & Marin, 1980; see also Kolk & Weijts, 1996; Schwartz, Linebarger, Saffran, & Pate, 1987). We note that structural priming paradigms are not immune from such task effects, with younger children in particular appearing to be sensitive to the precise details of the experimental task (Bencini & Valian, 2008; Shimpi et al., 2007). However, our results suggest that priming paradigms may be less prone to such effects than at least some other tasks.

Conclusion

In conclusion, we find evidence that 3- and 4-year-old children draw upon an abstract syntactic representation of the passive when they hear or produce a passive sentence, and furthermore that this representation is not semantically constrained to certain classes of verb. These results argue against claims that passive syntax is late-acquired, and suggest that earlier findings of poor performance on experiencer–theme passives may reflect an artifact of the task rather than inherent limitations in young children's linguistic competence. These results underline the importance of ensuring that research taps into children's linguistic ability and not their ability to carry out a task (see Crain and Fodor (1993) for further discussion). We propose that research into language acquisition research can benefit from using a variety of methods, including the implicit measure of syntactic representation offered by syntactic priming paradigms.

Acknowledgments

The authors thank the children and staff from Uni-Tots, Forbes, Florence House and South Morningside Primary School Nurseries, Edinburgh, who took part in the experiments and Chris Thatcher who drew the stimuli. This research was funded by Economic and Social Research Council award PTA-031-2004-00280 to the first author.

A. Appendix

A.1. Experiments 1 and 2 primes and targets

(*agent–patient/theme–experiencer/experiencer–theme verbs; A = Active prime, P = Passive prime, T = target*)

1A. a bear is patting/frightening/ignoring a girl
1P. a girl is being patted/frightened/ignored by a bear
1T. tiger shaking doctor
2A. a rabbit is biting/surprising/remembering a doctor
2P. a doctor is being bitten/surprised/remembered by a rabbit
2T. elephant washing robber
3A. a horse is pulling/scaring/seeing a fairy
3P. a fairy is being pulled/scared/seen by a horse
3T. lion scratching nurse
4A. a lion is hitting/shocking/loving a fireman
4P. a fireman is being hit/shocked/loved by a lion
4T. cow licking king
5A. a cow is carrying/annoying/hearing a queen
5P. a queen is being carried/annoyed/heard by a cow
5T. pig pushing witch
6A. a pig is squashing/upsetting/liking a boy
6P. a boy is being squashed/upset/liked by a pig
6T. bear pinching soldier
7A. a cat is patting/frightening/ignoring a witch
7P. a witch is being patted/frightened/ignored by a cat
7T. rabbit hugging girl
8A. a dog is biting/surprising/remembering a robber
8P. a robber is being bitten/surprised/remembered by a dog
8T. frog tickling fairy
9A. a tiger is pulling/scaring/seeing a soldier
9P. a soldier is being pulled/scared/seen by a tiger
9T. horse kicking clown
10A. a frog is hitting/shocking/loving a king
10P. a king is being hit/shocked/loved by a frog
10T. cat chasing boy
11A. an elephant is carrying/annoying/hearing a clown
11P. a clown is being carried/annoyed/heard by an elephant
11T. sheep kissing queen
12A. a sheep is squashing/upsetting/liking a nurse
12P. a nurse is being squashed/upset/liked by a sheep
12T. dog punching fireman
13A. a dog is patting/frightening/ignoring a king
13P. a king is being patted/frightened/ignored by a dog
13T. elephant shaking witch
14A. a horse is biting/surprising/remembering a fireman
14P. a fireman is being bitten/surprised/remembered by a horse
14T. bear washing clown
15A. a bear is pulling/scaring/seeing a witch
15P. a witch is being pulled/scared/seen by a bear
15T. tiger scratching king
16A. a cat is hitting/shocking/loving a clown
16P. a clown is being/shocked/loved hit by a cat
16T. pig licking fairy
17A. a frog is carrying/annoying/hearing a boy
17P. a boy is being carried/annoyed/heard by a frog
17T. dog pushing girl
18A. an elephant is squashing/upsetting/liking a queen
18P. a queen is being squashed/upset/liked by an elephant
18T. cat pinching nurse
19A. a rabbit is patting/frightening/ignoring a soldier
19P. a soldier is being patted/frightened/ignored by a rabbit
19T. sheep hugging boy
20A. a tiger is biting/surprising/remembering a nurse
20P. a nurse is being bitten/surprised/remembered by a tiger

20T. rabbit tickling queen
21A. a lion is pulling/scaring/seeing a doctor
21P. a doctor is being pulled/scared/seen by a lion
21T. cow kicking fireman
22A. a sheep is hitting/shocking/loving a girl
22P. a girl is being hit/shocked/loved by a sheep
22T. horse chasing soldier
23A. a pig is carrying/annoying/hearing a robber
23P. a robber is being carried/annoyed/heard by a pig
23T. frog kissing doctor
24A. a cow is squashing/upsetting/liking a fairy
24P. a fairy is being squashed/upset/liked by a cow
24T. lion punching robber

A.2. Snap items

1. a bear is picking-up a king
2. a rabbit is feeding a witch
3. a cat is poking a queen
4. a dog is dropping a fairy
5. a girl is being picked-up by an elephant
6. a boy is being fed by a lion
7. a clown is being poked by a frog
8. a robber is being dropped by a tiger

A.3. Experiment 3: Picture-sentence matching task sentences

(*agent–patient/theme–experiencer/experiencer–theme verbs; active/passive sentences*)
For each target sentence/picture there is a corresponding distractor picture showing the same action and characters but with the characters' roles reversed, for example: for *a bear patting a soldier* there is also a picture of *a soldier patting a bear*.

1. a bear is ignoring/frightening/patting a soldier/a soldier is being ignored/frightened/patted by a bear
2. a cat is ignoring/frightening/patting a girl/a girl is being ignored/frightened/patted by a cat
3. a dog is ignoring/frightening/patting a witch/a witch is being ignored/frightened/patted by a dog
4. a rabbit is ignoring/frightening/patting a king/a king is being ignored/frightened/patted by a rabbit
5. a giraffe is ignoring/frightening/patting a postman/a postman is being ignored/frightened/patted by a giraffe
6. a goat is ignoring/frightening/patting a policeman/a policeman is being ignored/frightened/patted by a goat
7. a penguin is remembering/surprising/biting a postman/a postman is being remembered/surprised/bitten by a penguin
8. a monkey is remembering/surprising/biting a gnome/a gnome is being remembered/surprised/bitten by a monkey
9. a rabbit is remembering/surprising/biting a fireman/a fireman is being remembered/surprised/bitten by a rabbit
10. a dog is remembering/surprising/biting a nurse/a nurse is being remembered/surprised/bitten by a dog
11. a horse is remembering/surprising/biting a doctor/a doctor is being remembered/surprised/bitten by a horse
12. a tiger is remembering/surprising/biting a robber/a robber is being remembered/surprised/bitten by a tiger
13. a horse is seeing/scaring/pulling a soldier/a soldier is being seen/scared/pulled by a horse
14. a tiger is seeing/scaring/pulling a fairy/a fairy is being seen/scared/pulled by a tiger
15. a bear is seeing/scaring/pulling a doctor/a doctor is being seen/scared/pulled by a bear
16. a lion is seeing/scaring/pulling a witch/a witch is being seen/scared/pulled by a lion
17. a mouse is seeing/scaring/pulling a policeman/a policeman is being seen/scared/pulled by a mouse
18. a giraffe is seeing/scaring/pulling a ballerina/a ballerina is being seen/scared/pulled by a giraffe
19. a lion is loving/shocking/hitting a girl/a girl is being loved/shocked/hit by a lion
20. a penguin is loving/shocking/hitting a pirate/a pirate is being loved/shocked/hit by a penguin
21. a monkey is loving/shocking/hitting a builder/a builder is being loved/shocked/hit by a monkey
22. a frog is loving/shocking/hitting a fireman/a fireman is being loved/shocked/hit by a frog
23. a cat is loving/shocking/hitting a king/a king is being loved/shocked/hit by a cat
24. a sheep is loving/shocking/hitting a clown/a clown is being loved/shocked/hit by a sheep
25. a cow is hearing/annoying/carrying a robber/a robber is being heard/annoyed/carried by a cow
26. an elephant is hearing/annoying/carrying a boy/a boy is being heard/annoyed/carried by an elephant
27. a frog is hearing/annoying/carrying a clown/a clown is being heard/annoyed/carried by a frog
28. a pig is hearing/annoying/carrying a queen/a queen is being heard/annoyed/carried by a pig
29. a fox is hearing/annoying/carrying a builder/a builder is being heard/annoyed/carried by a fox
30. a mouse is hearing/annoying/carrying a pirate/a pirate is being heard/annoyed/carried by a mouse
31. a pig is hating/upsetting/squashing a nurse/a nurse is being hated/upset/squashed by a pig
32. a goat is hating/upsetting/squashing a ballerina/a ballerina is being hated/upset/squashed by a goat
33. a fox is hating/upsetting/squashing a gnome/a gnome is being hated/upset/squashed by a fox
34. a sheep is hating/upsetting/squashing a boy/a boy is being hated/upset/squashed by a sheep
35. an elephant is hating/upsetting/squashing a fairy/a fairy is being hated/upset/squashed by an elephant
36. a cow is hating/upsetting/squashing a queen/a queen is being hated/upset/squashed by a cow

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