CAMBRIDGE
UNIVERSITY PRESS

ARTICLE

The influence of the temporal characteristics of events on adults' and children's pronoun resolution

Gillian FRANCEY* [ID] and Kate CAIN [ID]

Department of Psychology, Lancaster University, UK
*Corresponding author. Gillian E. Francey, Dept. of Psychology, Lancaster University, Bailrigg, Lancaster, LA1 4YF. Email: g.francey@lancaster.ac.uk

Abstract

We examined the influence of the lexical and grammatical aspect of events on pronoun resolution in adults (18 to 23 years, N = 46), adolescents (13 to 14 years, N=66) and children (7 to 11 years, N=192). Participants were presented with 64 two-sentence stimuli: the first sentence described events with two same gender protagonists; the second began with a personal pronoun and described a status that could be attributed to either protagonist. Participants recorded to whom the pronoun referred, in a booklet. For all groups, Subject resolutions were more likely for events (a) without endpoints relative to those with endpoints, and (b) described as ongoing rather than completed, but this latter influence was restricted to events with endpoints for adults and adolescents. The findings provide support for the Event Structure Hypothesis of pronoun resolution (Rohde, Kehler & Elman, 2006) and provide new insights into the development of pronoun resolution.

Keywords: Lexical aspect; grammatical aspect; pronoun resolution; sentence comprehension

Introduction

There is widespread agreement that successful text comprehension involves constructing a mental representation of the situations described in the text (Johnson-Laird, 1983; Kintsch, 1988; Zwaan & Radvansky, 1998). This representation includes concepts which appeared in the text plus elements of prior knowledge that were activated by these concepts. As such it represents more than just a verbatim record of the text. A core feature of written and spoken text is the use of pronouns – for example, "he" or "she" – which provide reduced forms of expression to refer to protagonists in a text. Successful adult comprehenders rapidly resolve these co-references to achieve a cohesive and coherent mental model of the situation (Fukumura & van Gompel, 2015). An influential account of adults' pronoun resolution, The Event Structure Hypothesis (Rohde et al., 2006; see also Kehler, Kertz, Rohde & Elman, 2008) suggests that the temporal characteristics of events influence adults' resolution of a subsequent pronoun. This paper

CrossMark

examines a previously untested but interesting prediction of this account in a sample of adults – specifically, whether the presence/absence of an inherent endpoint influences adults' resolution of a subsequent pronoun. It also examines whether the temporal characteristics of events influence adolescents' and children's pronoun resolution.

In this paper, our focus is on events, which we define as verbs and their predicates. Events can differ in their temporal characteristics in two ways. The first is the inherent temporal properties of the events themselves: this determines their lexical aspect. Specifically, events can differ according to whether or not they have: (a) a specific endpoint (telic events) or no inherent endpoint (atelic events) (Comrie, 1976; Dowty, 1979); (b) duration (durative events) or not (punctual events) (Vendler, 1967); and (c) require a continual effort to be maintained or not (Vendler, 1967). Vendler (1967) classified events on the basis of these properties resulting in four categories of lexical aspect: states, achievements, accomplishments and activities. The study reported here focuses on anaphoric pronoun resolution (hereafter referred to as pronoun resolution) following events from the latter two lexical aspect categories. Accomplishments (e.g., pass a biscuit) are durative, require input of energy for them to take place, and they are telic: they have an inherent endpoint (when the biscuit is passed) involving a change of state, after which the particular action cannot continue. Activities (e.g., run) also have duration and require energy but, in contrast to accomplishments, they are atelic: they do not have an inherent endpoint (i.e., they can be terminated and begun again at any time).

The second way in which events can be temporally differentiated is by morphological inflection of the event verb itself. This is the grammatical aspect of an event and it primarily distinguishes between describing the event as an ongoing process (with imperfective grammatical aspect) or as a completed event (with perfective grammatical aspect) (Madden & Ferretti, 2009; Moens & Steedman, 1988). Grammatical aspect differs from tense: tense describes how events are sequenced with reference to some narrative timeline, whereas grammatical aspect describes the temporal characteristics of individual events within this time frame. Thus grammatical aspect distinctions can be achieved within different tenses. For example, in English, imperfective aspect is expressed using the auxiliary "is" and the verb infection "–ing" (e.g., is passing, is running) in the Present Progressive tense and using the auxiliary "was" and the verb inflection "–ing" (e.g., was passing, was running) in the Past Progressive tense. Similarly, perfective aspect is expressed using verb inflections "–es" or "–s" (e.g., passes, runs) in the Present tense and the verb inflection "–ed" or an irregular past participle (e.g., passed, ran) in the Simple Past tense. In this study we expressed imperfective aspect using the Past Progressive tense (e.g., was passing, was running) and perfective aspect using the Simple Past tense (e.g., passed, ran) to align with the majority of adult research investigating the effect of grammatical verb aspect on adults' mental representation of events (Becker, Ferretti & Madden-Lombardi, 2013; Ferretti, Rohde, Kehler & Crutchley, 2009; Madden & Zwaan, 2003; Magliano & Schleich, 2000; Morrow, 1985).

The Event Structure Hypothesis (Rohde et al., 2006) proposes that adults combine two probabilities when determining the referent of a pronoun. The first is the likelihood that a pronoun would be used to refer to a particular protagonist given their grammatical status in the preceding context. The second is the likelihood that a particular protagonist will be re-mentioned. It is argued that this re-mention probability is influenced by the temporal characteristics of an event (critically because this influences the type of coherence relation adults expect to follow and different coherence relations have different protagonists as their Subject; Kehler et al., 2008; Rohde et al., 2006).

Support for the proposal that adults' pronoun resolution is influenced by the grammatical status of protagonists comes from studies where adults have been asked to provide continuations without and with pronoun prompts. For example, adults are more likely to begin a continuation following the stimulus "John ₛₒᵤᵣᶜₑ hand**ed** a book to Bob ₉ₒₐₗ." with a reference to the previous Object protagonist (Bob) rather than the Subject protagonist (John). However, providing a pronoun at the start of the continuation increases the frequency with which adults provide continuations with John as the Subject (Stevenson, Crawley & Kleinman, 1994). This finding shows that, for adults, pronouns themselves confer a Subject bias interpretation. It is important to note that this bias does not in itself imply that adults will demonstrate an absolute Subject interpretation of the pronoun; only that the presence of a pronoun inclines adults more towards providing continuations starting with Subjects than if a pronoun was not present.

In the Event Structure account, adults' Subject bias interpretation of pronouns is explained as a consequence of their tendency to more frequently pronominalize re-mentions of Subject protagonists than Object protagonists in bare prompt conditions (Fukumura & van Gompel, 2010, 2015; Rohde, 2008; Stevenson et al., 1994). Importantly, this bias towards pronominalizing Subject re-mentions occurs regardless of which of the protagonists (John or Bob) is more frequently re-mentioned (Arnold, 2001; Ferretti et al., 2009; Fukumura & van Gompel, 2010; Kehler & Rohde, 2013a; Rohde & Kehler, 2014; Stevenson et al., 1994). Thus it is argued that, when adults encounter a pronoun, their production bias to more frequently pronominalize Subject re-mentions leads them to infer that the previous Object is less likely to be the referent of the pronoun than the previous clause Subject (Kehler & Rohde, 2013a; Rohde & Kehler, 2014).

The idea that adults have a re-mention bias for particular protagonists involved in an event has been suggested and evidenced several times (Arnold, 2001; Stevenson et al., 1994). The evidence supporting the Event structure claim that adults' re-mention bias is influenced by the temporal characteristics of events comes from studies in which adults are asked to produce a continuation for sentence stimuli. In these studies, the grammatical status of protagonists is maintained across stimuli but the grammatical aspect of the event is manipulated, as in examples 1a and 1b (Ferretti et al., 2009; Rohde et al., 2006).

1a. John ₛₒᵤᵣᶜₑ **handed** a book to Bob ₉ₒₐₗ. He…
1b. John ₛₒᵤᵣᶜₑ **was handing a** book to Bob ₉ₒₐₗ. He…

As noted above, when adults are asked to provide continuations following Source-Goal transfer events without pronoun prompts, they are more likely to refer to the Object protagonist (Bob) than the Subject protagonist (John) at the start of their continuations. Providing a pronoun at the start of the continuation (1a) increases the frequency with which adults begin the continuation with reference to the Subject protagonist to 51%. Expressing the event with imperfective aspect (1b) further increases the frequency with which adults begin the continuation with reference to the Subject protagonist (John) to 70% (Rohde et al., 2006). In the Event Structure account, the grammatical aspect with which transfer events are expressed influences pronoun resolution because it influences the re-mention bias for the Goal protagonist. It does this because transfer events are telic, they have duration and a natural endpoint and the Goal protagonist is central to this endpoint. The 51% resolution to the Source in the perfective condition (1a) found by Rohde et al. (2006) indicates that, despite a strong next mention bias towards the Goal, as found in bare prompt conditions, adults' Subject interpretation bias for ambiguous pronouns is strong enough to rival this Goal re-mention bias (Ferretti et al., 2009;

Rohde et al., 2006; Stevenson et al., 1994). In addition, the 70% resolution to the Source in the imperfective condition (1b) found by Rohde et al. (2006) indicates that, for adults, expressing telic events with imperfective aspect invokes a substantial reduction in their re-mention bias for the Goal protagonist. An eye-tracking study supports the claim that adults demonstrate a higher expectation for a re-mention of the Goal protagonist following perfectively rather than imperfectively expressed transfer events, before a pronoun is encountered (Grüter, Takeda, Rohde & Schafer, 2018)

Previous research has not examined whether the temporal characteristics of events influence children's pronoun resolution. This may explain why a contradictory pattern of performance has been observed: whilst some research has shown that participants from 3-year-olds through to adults demonstrate a Subject interpretation of an ambiguous pronoun (Hartshorne, Nappa & Snedeker, 2015; Song & Fisher, 2005), other work reports that 3- to 5-year-olds do not demonstrate this tendency (Arnold, Brown-Schmidt & Trueswell, 2007, experiment 2). All of these experiments tracked participants' eye movements as they viewed a picture while listening to sentences. It is important to note that in these experiments the presence of a Subject interpretation of the pronoun is assumed only if the Subject protagonist is selected on greater than 50% of the critical trials. Hartshorne et al. (2015) presented 5-year-olds and adults with stimuli such as 2a and 2b.

2a. Emily ate dinner with Hannah. She skipped her salad and only ate dessert.
2b. Emily and Hannah are going to Disneyland. Emily has never been to Disneyland. She is really excited about going to Disneyland.

In 2a and 2b, the protagonists are described performing a joint action and in 2b the Subject protagonist is repeated in the sentence prior to the pronoun. Children and adults demonstrated a Subject interpretation of the pronoun "She" for both 2a and 2b but the effect occurred sooner for adults. Other work shows that 3-year-olds resolve an ambiguous pronoun to the Subject protagonist when the Subject's name has been repeated in prior context sentences as in 2b above (Song & Fisher, 2005).

In contrast, Arnold et al. (2007) did not find a greater than 50% Subject interpretation of an ambiguous pronoun for the 3- to 5-year-old children in their study (experiment 2). Their stimuli differ from those used by Hartshorne et al. (2015). An example is provided in 3 below.

3. Donald is bringing some mail to Mickey while a big rain storm is beginning. He's carrying an umbrella and it looks like they're both going to need it.

This type of event has an inherent endpoint and the second mentioned protagonist is central to this. It has been argued that children's failure to demonstrate a greater than 50% Subject interpretation of the pronoun ("He" in the example) in Arnold et al. (2007) arose because the proximity of the pronoun and the disambiguating information limited the time available for children to demonstrate a Subject interpretation in the looking task used to measure performance (Hartshorne et al., 2015). This argument is supported by the findings of Hartshorne et al. (2015) where, when no disambiguating information was provided, children demonstrated a Subject interpretation of the pronoun.

However, there are other explanations for the Arnold et al. (2007) finding. As noted previously, when adults are asked to provide continuations for events with endpoints such as Source-Goal transfer events (Donald $_{source}$ brought some mail to Mickey $_{goal}$) they show a bias towards re-mentioning the second (Goal) protagonist (Stevenson et al., 1994). This re-

mention of the Goal protagonist is reduced when adults are asked to provide continuations beginning with pronouns (Stevenson et al., 1994). Indeed, adults only demonstrate a Subject (Source) interpretation of a subsequent pronoun when Source-Goal transfer events are expressed with imperfective aspect. Thus, the failure of young children to demonstrate a Subject interpretation of the pronoun in Arnold et al. (2007) may indicate that the presence of an endpoint is an important influence on children's resolution of a subsequent pronoun. Specifically, Arnold et al.'s (2007) finding may indicate that a re-mention bias for particular protagonists in events with endpoints develops prior to a Subject interpretation of pronouns. Another explanation for the Arnold et al. (2007) result is that expressing a telic event with imperfective aspect does not lead children to revise their expectation for a re-mention of the protagonist focused by the endpoint to the same extent as it does for adults.

Young children are sensitive to the lexical and grammatical aspect of events. For example, pre-schoolers are more likely to use imperfective markers with atelic events and perfective markers for telic events (Shirai & Andersen, 1995). According to Tomasello's (2003) usage-based theory of language acquisition (Distributional Bias hypothesis), this pattern of development is the result of the frequent association between particular verbs and particular inflections in the input (language environment). An alternative explanation for the development of verb tense marking is the Aspect First Hypothesis (Shirai & Andersen, 1995; Wagner, 2001, 2009), which claims that children's sensitivity to aspect is the result of their mental representation of events. There are various forms of this hypothesis: some assume a primary role for lexical aspect distinctions (in particular event telicity) in children's event construal (Shirai & Andersen, 1995), whilst others assume a primary role for grammatical aspect distinctions (the ongoing or completedness of events) in children's conceptualisation of events (Wagner, 2001).

From either the Distributional Bias (Tomasello, 2003) or the Aspect First (Shirai & Andersen, 1995; Wagner, 2001, 2009) accounts of language acquisition, it is clear that children have to learn to generalise their use of aspectual morphemes to express the ongoing nature of a telic event – for example, "closing a window" – and the perfective expression of an atelic event – for example, "played with blocks" (Wagner, 2009). A number of studies have examined the development of children's understanding of aspect in cross-sectional designs with young children between 2 to 6 years. In general, these studies have used a picture matching task to examine whether children associate events expressed with perfective aspect to depictions of completed events and events expressed with imperfective aspect to ongoing events.

In this regard, there are mixed findings in the research concerning the age at which children can reliably distinguish between the perfective/imperfective expression of events: some research shows this is achieved by 3 years of age (Weist, Atanassova, Wysocka & Pawlak, 1999; Weist, Lyytinen, Wysocka & Atanassova, 1997; Zhou, Crain & Zhan, 2014), whilst other research shows this is not achieved until 5 years of age and is not as reliable as adults' performance (Wagner, 2009). In addition, whilst 3-year-olds can distinguish between the perfective/imperfective expressions of telic events, they are less sensitive to a difference between the perfective/imperfective expressions of atelic events (Weist et al., 1999). Young children's difficulty with perfective atelic items may simply reflect a difficulty in representing such a situation pictorially – for example, the distinction between played/playing with blocks is arguably more difficult to portray than the telic version painted/painting a flower. Alternatively, children's difficulty may reflect that distinctions between the ongoing/completed expressions of atelic events are just less significant than distinctions between the ongoing/completed expressions of telic events.

There is some support for the latter argument from studies with adults. Using the N400 ERP as a measure of semantic difficulty, Becker et al. (2013) contrasted events from the

lexical category of accomplishment with activity events. For accomplishments, adults had less difficulty reading concepts which had been previously expressed in imperfective sentences than perfective sentences. In contrast, for activity events there was no difference in mean N400 ERP between the two grammatical aspect conditions. The authors suggest that grammatical aspect influences adults' concept integration for accomplishment events because their mental representations of the two aspect manipulations differ. In contrast, they suggest that expressing activity events – for example, talk as "was talking" or "talked" – results in similar representations of the event.

Another reason for determining whether the temporal characteristics of events influence children's pronoun resolution is that it may provide insight into children's reading comprehension difficulties, in general. Seven- to 11-year-old children with poor reading comprehension have difficulties with pronoun resolution (Ehrlich & Remond, 1997; Elbro, Oakhill, Megherbi & Seigneuric, 2017; Engelen, Bouwmeester, de Bruin & Zwaan, 2013; Francey & Cain, 2014; Megherbi & Ehrlich, 2005; Oakhill & Yuill, 1986; Yuill & Oakhill, 1991), which contributes unique variance in reading comprehension (Elbro et al., 2017). Of note, some research finds that poor comprehenders have particular difficulty identifying the referents of personal pronouns when these are co-referential with the Subject protagonist (Megherbi & Ehrlich, 2005): whereas 7- to 8-year-old good comprehenders demonstrate an advantage for Subject antecedents, same age poor comprehenders demonstrate an Object advantage.

These, and other, findings have been interpreted to reflect a difficulty in a backwards search for appropriate referents when the pronoun is encountered (Ehrlich & Remond, 1997). However, Engelen et al. (2013) found that 6- to 11-year-old good and poor comprehenders differed in their EXPECTANCY for a re-mention of particular protagonists when listening to a narrative. In their study, children listened to a narrative while viewing a display containing line drawings of the four characters. Throughout the story, the characters were re-mentioned either by name (e.g., "squirrel") or using a personal pronoun ("he"). Differences in the pattern of eye movements between the good and poor comprehenders were evident at the onset of a pronoun rather than after hearing a referring expression. Specifically, good comprehenders were more likely to fixate a pronoun's referent than were the poor comprehenders, indicating that the good comprehenders anticipated the re-mention of the referent. The Engelen et al. (2013) study is the first to show that good and poor comprehenders may differ in their processing of sentences prior to the pronoun.

In summary, the Event Structure account of pronoun processing claims that the temporal characteristics of events influence pronoun processing but to date this has only been tested in adults through the manipulation of the grammatical aspect of events with inherent endpoints (accomplishments). To examine this claim in more detail, this study examines adults' pronoun resolution following events without inherent endpoints (activities) as well as those with inherent endpoints (accomplishments). Specifically, we test the prediction of the Event Structure hypothesis, that adults will be more likely to resolve a pronoun towards the previous Subject protagonist for events without inherent endpoints (activities) than for events with inherent endpoints (accomplishments). We also examine the influence of grammatical aspect on adults' pronoun resolution within these two types of event. We test the reproducibility of the finding that the grammatical aspect of events with endpoints (accomplishments) influences adults' pronoun resolution and test the Event Structure claim that the grammatical aspect of events without endpoints (activities) will not influence adults' resolution of a subsequent pronoun (Kehler & Rohde, 2013b). There is indirect evidence supporting this claim in the findings of the effect of grammatical

aspect on adults' concept integration, but it has not previously been directly investigated (Becker et al., 2013).

There are contradictory findings in the literature regarding the age at which children demonstrate a Subject interpretation of an ambiguous pronoun and it is possible that this may be explained as a result of differences in the lexical and grammatical aspect of stimuli used in these studies. To examine this hypothesis, this study examines the influence of lexical and grammatical aspect on younger (7- to 11-year-old) and adolescent children's (13- to 14-year-old) pronoun resolution and compares the performance of these two groups to adults' performance using the same materials. Previous research has established that young children are sensitive to the thematic roles of protagonists in their pronoun resolution (Pyykkönen, Matthews & Järvikivi, 2010) and can discriminate between events expressed with alternative grammatical aspects (Weist et al., 1997, 1999; Wagner, 2009; Zhou et al., 2014). However, to date, there have been no investigations of whether the lexical or grammatical aspect of events influences children's pronoun resolution. The younger age range was included to establish whether or not there is an influence of lexical and/or grammatical aspect on the pronoun resolution in an unselected sample of children in this age range, which may identify a potential source of difficulty for children of this age with poor reading comprehension (Ehrlich & Remond, 1997; Elbro et al., 2017; Engelen et al., 2013; Francey & Cain, 2014; Megherbi & Ehrlich, 2005; Oakhill & Yuill, 1986; Yuill & Oakhill, 1991). The older age range was included to establish developmental trends in the influence of lexical and grammatical aspect on pronoun resolution. It was predicted that both groups of children would demonstrate the same pattern of influence as adults, but that adolescents' performance would be more similar to adults' than younger children's.

Method

Participants

Forty-six students from Lancaster University participated (37 female, $M = 20; 8$, $SD = 1; 6$, minimum = 18; 2, maximum = 23; 11). All were native English speakers and participated for a small fee.

Two hundred and fifty-eight children from two urban (East-Midlands and North-East regions of England) and two rural (North-West region of England) primary schools, and one rural (North-West region of England) secondary school participated in this study. All schools served mixed socioeconomic catchment areas. All participants spoke English as their first language and were from five year groups.

In the younger (7- to 11-year-old) age group there were 53 children from Year Three, aged 7 to 8 years (24 girls, $M = 8; 1$, $SD = 3$ months); 53 children from Year Four, aged 8 to 9 years (25 girls, $M = 9; 1$, $SD = 4$ months); 49 children from Year Five, aged 9 to 10 years (19 girls, $M = 10; 1$, $SD = 4$ months); and 37 children from Year Six, aged 10 to 11 years (19 girls, $M = 11; 5$, $SD = 3$ months). In the adolescent (13- to 14-year-old) age group there were 66 children from Year 9 (40 girls, $M = 13; 8$, $SD = 4$ months). Consent was obtained from parents and head teachers, and all participating children gave their assent prior to testing. The study was approved by the Faculty of Science and Technology Research Ethics Committee Lancaster University.

Materials

The influence of grammatical aspect on adults' pronoun resolution has previously been examined by presenting stimulus sentences and asking adults to provide written

Table 1. Stimuli Used in the Two Lexical and Two Grammatical Aspect Conditions (List A)

Lexical Aspect	Grammatical Aspect	
	Perfective	Imperfective
Activity	Joanne talked on the phone with Tracey. She sighed.	Martha was talking in the playgroup with Mary. She sighed.
Accomplishment	Kay handed a skipping rope to Liz. She chuckled.	Nina was handing a racquet to Gemma. She chuckled.

continuation sentences starting with a pronoun. This method is not suitable for a developmental study including 7- to 14-year-olds because significant advances in literacy, as well as language comprehension and production, are evident across this age range (Nagy, Berninger & Abbott, 2006). For that reason a simpler task, where participants were asked to identify the referent of a given continuation, was used.

The stimuli consisted of 64 experimental items each comprising a stimulus sentence followed by a continuation sentence. Thirty-two of the stimulus sentences described activity events, and 32 described accomplishment events. Examples of each are provided in Table 1 (full list of materials is provided in Appendix A).

Activity items were constructed using eight verbs (four regular and four irregular) selected from the Becker et al. (2013) activity stimulus sentences. The regular verbs were: "to play", "to watch", "to study", and "to talk". The irregular verbs were "to stand", "to drink", "to speak", and "to run". Each of these verbs was used four times, twice in the imperfective form and twice in the imperfective form. Each stimulus sentence had the same form and described two same gender protagonists engaged in the activity at a single location. Names in each item were matched for the number of syllables. There were equal numbers of male and female pairs across the four repetitions of each verb.

The accomplishment items were constructed using eight Source-Goal verbs of transfer (four regular and four irregular) selected from the Ferretti et al. (2009) stimulus sentences. For these verbs the Source protagonist is the grammatical Subject and the Goal is the grammatical Object. The regular verbs were: "to hand", "to toss", "to chuck", and "to carry". The irregular verbs were: "to take", "to give", "to bring", and "to throw". As with the activity stimulus sentences, each verb was used four times, twice in the imperfective form and twice in the perfective form. Thirty-two concrete nouns were selected to act as the item of transfer within these sentences. In each item Source and Goal referents were same gender proper names, matched for the number of syllables. There were equal numbers of male and female pairs across the four repetitions of each verb.

Eight continuation sentences were added to the stimulus sentences. The continuations comprised a personal pronoun followed by an action that could be attributed to either of the two protagonists. The actions were taken from the Ferretti et al. (2009) continuation sentences ("smiled", "chuckled", "sighed", "giggled", "laughed", "grinned", "groaned", and "frowned"). In each lexical aspect condition each continuation was repeated four times, twice in the imperfective condition and twice in the perfective condition. The continuations were balanced across stimulus sentences with female or male protagonists and across stimulus sentences with regular or irregular verbs.

Two lists of 64 experimental items were prepared with the order of items kept the same across the lists but with the aspect of the verb in each item counterbalanced across the lists. In the adult sample, twenty-three participants received list A (17 female), twenty-three

participants received list B (20 female). In the children sample, one hundred and thirty-four participants received list A, one hundred and twenty-four participants received list B with approximately equal numbers of children in each year group receiving each list.

Procedure

Adults were tested individually in a quiet room. Each pair of sentences was numbered and displayed for 9 seconds on a computer monitor using a timed PowerPoint presentation – for example, "1. Kay handed a skipping rope to Liz. She chuckled." After each experimental item, a question with the continuation and the names of the two protagonists was shown for 5 seconds – for example, "1. Who chuckled? Kay/Liz". For children, the task was administered as a group assessment in the children's classrooms using the classroom whiteboard to display the same timed PowerPoint presentation. The experimental items and questions were read out loud by the assessor who was experienced in classroom management, and the regular classroom teacher and teaching assistants were also present. A formal testing environment was adopted to encourage independence of responding. For both adults and children, the questions were also printed in a booklet, together with the two possible referents of the pronoun. Participants read/listened to the stimulus sentences and questions and circled their responses in the booklet. Eight comprehension questions were included; one after every eight items. Four questions asked whether a particular object had been mentioned in the previous eight items for example, "Was a bag of sweets mentioned?" and four asked whether a particular location had been mentioned – for example, "Was a library mentioned?" There were equal numbers of Yes/No answers across the two question types. These comprehension questions were read out to the children by the assessor. The same explanation of the task and instructions were read to each participant and three practice items and a practice comprehension question were administered prior to the experimental items. Participants were told there were no right or wrong answers to further encourage independence of responding. Any questions about the procedure were addressed before the presentation of the experimental items began.

Results

The mean correct scores to the eight comprehension questions obtained in each year group and for adults are reported in Table 2. Year 3 scores differed from Year 9 and adult scores at the Bonferroni adjusted level of significance $F (5,298) = 3.75$, $p = .01$, $\eta^2 = .06$. However, the Year 3 group achieved >80% correct indicating that these children engaged with the task.

The mean proportion of Subject selections by lexical aspect and grammatical aspect are shown in Figure 1 (see Appendix B for the table of means and standard deviations). Inspection of the mean proportions indicated the following: (a) all age groups selected the previous Subject as the referent of the pronoun more frequently following activity events than accomplishment events; (b) for accomplishment events, adults, 13- to 14-year-olds, and one of the older child age groups (9- to 10-year-olds) resolved the ambiguous pronoun more frequently towards the Subject protagonist than the Object protagonist in the imperfective condition compared to the perfective condition, and (c) for activity events, imperfective rather than perfective aspect did not increase adults', 13- to 14-year-olds', or children's resolution of the pronoun to the previous Subject. An examination of the patterns of responding revealed the same age group and condition patterns by

Table 2. Mean Correct Comprehension Question Scores (and Standard Deviation) by Year Group

Year Group	Age range	Mean	SD	Minimum	Maximum
Year 3 ($n = 53$)	7 to 8 years	6.55	0.98	4	8
Year 4 ($n = 53$)	8 to 9 years	6.92	1.08	4	8
Year 5 ($n = 49$)	9 to 10 years	7.00	1.03	4	8
Year 6 ($n = 37$)	10 to 11 years	6.81	1.21	4	8
Year 9 ($n = 66$)	13 to 14 years	7.23	0.88	5	8
Adult ($n = 46$)	18 to 23 years	7.26	0.79	5	8
($N = 304$)		6.97	1.02	4	8
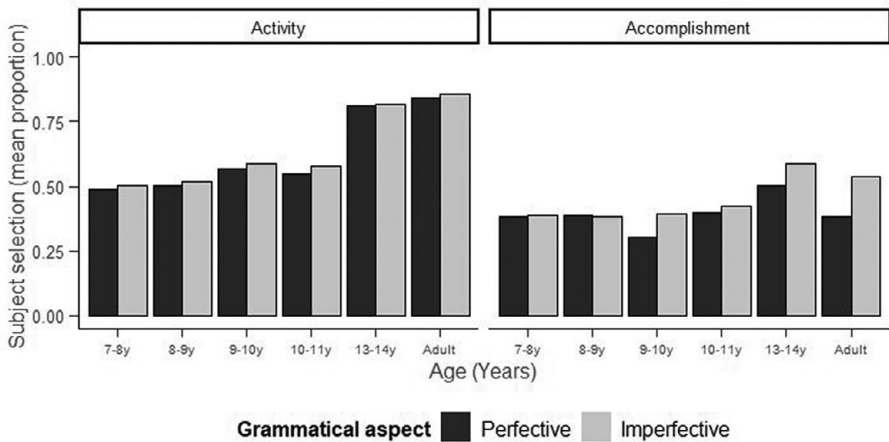
Figure 1. Mean Proportion of Subject Selections in the Two Lexical and Two Grammatical Aspect Conditions

quartiles, indicating that participants did not develop different strategies during the course of the experiment.

To examine these comparisons statistically, the data were analysed by modelling the probability (log odds) of selecting the Subject in a series of mixed effects binomial models in the R statistics environment (R Development Core Team, 2014) using the lme4 package (Bates, Mächler, Bolker & Walker, 2015). This method is essentially an extension of logistic regression, such that a mixed effects analysis provides estimates for the effects of experimentally manipulated variables while taking into account random error variance due to differences between participants or between stimulus items sampled for the study. Age was treated as a categorical variable with participants grouped into three age ranges: adult, adolescent (13 to 14 years) and younger children (7 to 11 years) with adult as the reference category. The grammatical aspect and lexical aspect variables were contrast coded (imperfective 1, perfective -1: activity 1, accomplishment -1). This coding was adopted so that the intercept could be interpreted as the overall log odds probability of an adult selecting the Subject as the referent of the pronoun and main effects for adults of lexical aspect, grammatical aspect and any interaction between these could be interpreted

Table 3. Summary GLMM for (log odds) Subject Selection: Effects for Lexical Aspect (LA), Grammatical Aspect (GA), Age Group and Interactions

Fixed effects	Estimated coefficient (*b*)	SE	z	Pr(>|z|)
(Intercept)	**1.14**	**0.23**	**4.89**	**< .01**
LA (adult)	**1.28**	**0.13**	**9.85**	**< .01**
GA (adult)	**0.27**	**0.05**	**5.96**	**< .01**
LA x GA (adult)	**−0.19**	**0.05**	**−3.56**	**< .01**
Age Group (adolescent)	0.29	0.29	1.01	0.31
Age Group (younger)	**−1.35**	**0.25**	**−5.44**	**< .01**
LA x Age Group (adolescent)	**−0.42**	**0.13**	**−3.29**	**< .01**
LA x Age Group (younger)	**−0.89**	**0.11**	**−7.46**	**< .01**
GA x Age Group (adolescent)	-0.12	0.07	−1.84	.07
GA x Age Group (younger)	**−0.21**	**0.06**	**−3.73**	**< .01**
LA x GA x Age Group (adolescent)	0.07	0.07	1.00	0.32
LA x GA x Age Group (younger)	**0.18**	**0.06**	**3.21**	**< .01**

Random effects			Variance	SD
Participant:		(intercept)	1.98	1.41
		LA (slope)	0.25	0.50
Item:		(intercept)	0.49	0.70
		GA (slope)	0.01	0.11
		Age Group (adolescent)	0.06	0.24
		Age Group (younger)	0.22	0.47
R^2 marginal[a] = 0.16, R^2 conditional[b] = 0.52				

Note. 19456 observations; 304 participants, 64 items. R^2 calculated using the MuMIn package in R, [a] represents the variance explained by the fixed effects, [b] represents the variance explained by the entire model including both fixed and random effects.

from the coefficients. Effects of age group on lexical or grammatical main effects and the interaction between these could also be interpreted from the coefficients using this coding.

The model specified with maximal random effects structure (Barr, Levy, Scheepers & Tily, 2013) did not converge so we report the model which did converge and which includes all fixed effects plus those random effects that were supported by the data (Matuschek, Kliegl, Vasishth, Baayen & Bates, 2017). These included random effects terms corresponding to: (a) random differences in overall selection of the Subject protagonist between participants and between items (random intercepts); (b) random differences in the slopes of the effect of lexical aspect between participants; and (c) random differences in the effect of grammatical aspect and age group between items. A summary of the final model is reported in Table 3.

The first column provides the coefficient estimates for the effects. The significant positive value of the intercept shows that adults were more likely to select the Subject as the referent of the ambiguous pronoun than the Object, overall. The significant positive
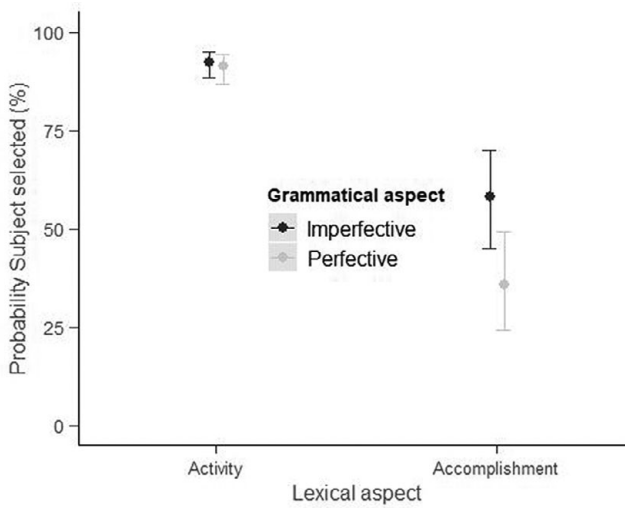
Figure 2. Interaction Between Lexical Aspect and Grammatical Aspect (Adult)

value of the lexical aspect co-efficient shows that adults were more likely to select the Subject for activity compared to accomplishment events. The significant positive value of the grammatical aspect co-efficient shows that adults were more likely to select the Subject in the imperfective compared to the perfective condition. These main effects were qualified by a significant interaction. The nature of the significant lexical aspect x grammatical aspect (adult) interaction is shown in Figure 2.

Traditionally, interaction effects have been explored by sub-setting data and running the same model as previously to examine the effect of one factor (e.g., grammatical aspect) separately at each level of another factor (e.g., lexical aspect). There are important concerns about this approach (see Von der Malsburg & Angele, 2017, for a relevant discussion) that render significance tests problematic. However, the coefficients estimates from such subset analyses are helpful as descriptions of the average differences between conditions in outcomes. Thus, in the following, we report estimates but not p-values. If we estimate the effect of grammatical aspect separately for each lexical aspect condition, we see that for adults it is larger for accomplishment events (coefficient $B = 0.45$ ($SE=0.07$), $z = 6.79$) than for activity events ($B = 0.07$ ($SE=0.09$), $z = 0.86$) (see Appendix C for the full models). Figure 2 and the subset analysis show that grammatical aspect had an influence on adults' pronoun resolution for accomplishment events but not activity events.

The coefficients in Table 3 show that adolescents were similar to adults in their Subject selections in general: there was no main effect of Age Group (adolescent), no significant difference between adults and adolescents in the influence of grammatical aspect, and interaction between grammatical aspect and lexical aspect. Adolescents did however demonstrate a reduced influence of lexical aspect compared to adults. This interaction is shown in Figure 3; the effects for adults and younger children are shown for comparison.

Figure 3 indicates that although adolescents' Subject selections for activity items were similar to adults', the reduction in Subject selections for accomplishment items was less pronounced than were adults'.

The coefficients in Table 3 show that effects for younger children diverged from adult effects to a greater extent than for adolescents. This is illustrated in Figure 4 which shows
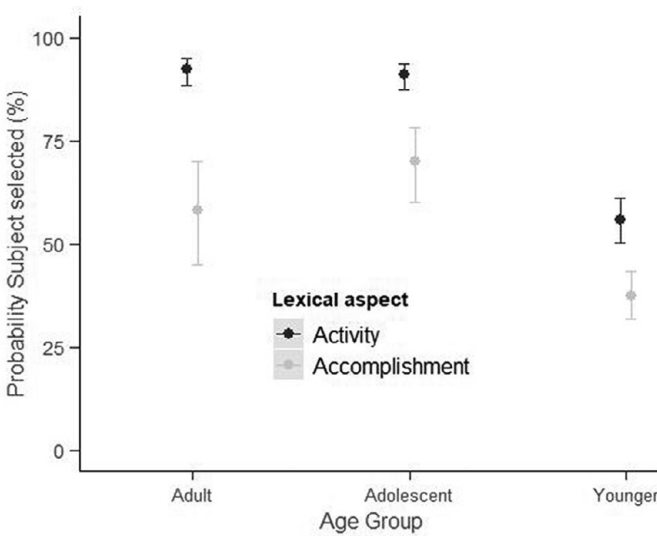
Figure 3. Interaction Between Lexical Aspect and Age Groups Adolescent and Younger
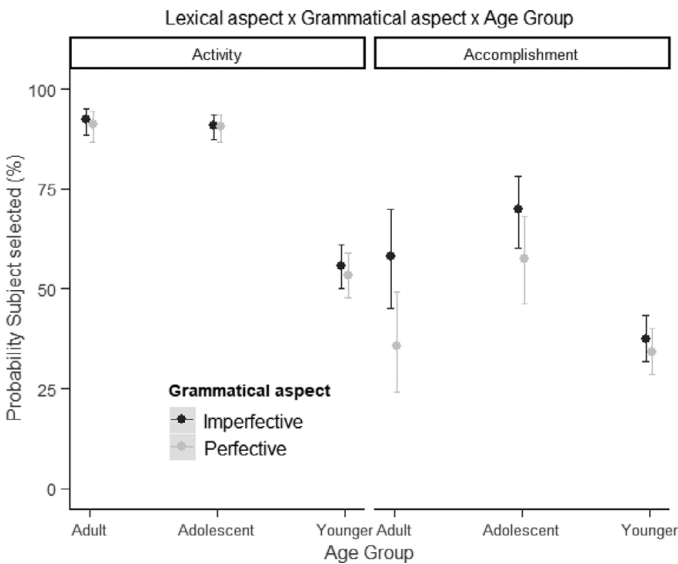

Figure 4. Interactions Between Lexical Aspect, Grammatical Aspect and Age Group

the interactions between lexical x grammatical x age group for adults, adolescents and younger children. Figure 4 clearly shows that, for adults and adolescents, grammatical aspect had an effect on pronoun resolution for accomplishment events but not activity events. It also shows that this distinction was less evident in younger children.

The previous analysis modelled the influence of grammatical and lexical aspect on adults' pronoun resolution and the extent to which these effects differed for adolescents and children. For example, it provides estimates for the effect of lexical aspect for adults to

Table 4. Summary GLMM for (log odds) Subject Selection: Effects for Lexical Aspect (LA), Grammatical Aspect (GA), Centered Age (cAge) and Interactions for Children (7 to 11 years)

Fixed effects	Estimated coefficient (b)	SE	z	Pr(>|z|)
(Intercept)[1]	−0.20	0.10	−2.06	.04
LA	0.38	0.06	6.85	< .01
GA	0.06	0.03	2.23	.03
cAge	0.08	0.07	1.16	0.25
LA x GA	−0.01	0.03	−0.55	0.58
LA x cAge	0.07	0.03	2.13	0.03
GA x cAge	0.02	0.02	1.37	.17
LA x GA x cAge	−0.02	0.02	−0.92	.36
Random effects			Variance	SD
Participant:	(intercept)		1.34	1.16
	LA (slope)		0.14	0.38
	GA (slope)		0.003	0.05
Item:	(intercept)		0.12	0.35
	GA (slope)		0.02	0.14
	cAge		0.01	0.11
R^2 marginal[a] = 0.03, R^2 conditional[b] = 0.36				

Note. 12288 observations; 192 participants, 64 items. R^2 calculated using the MuMIn package in R, [a] represents the variance explained by the fixed effects, [b] represents the variance explained by the entire model including both fixed and random effects.

be $b = 1.28$ and for children to be $b = 1.28 – 0.89 = 0.39$, and for the effect of grammatical aspect for adults to be $b = 0.27$ and for children to be $b = 0.27 -0.21= 0.06$. However, it only tells us if the estimates for adults and children are significantly different from each other. To explore the significance of these effects for younger children (7 to 11 years) alone a second analysis was performed, with only the data from the younger age groups. The same model as previous was used, with the addition of a slope for individual differences in the influence of grammatical aspect in the subject random intercept. A summary of this model is reported in Table 4 (in this model age was treated as a continuous variable and centered on the mean age of the younger children group – 9 years, 6 months).

---

[1]The intercept coefficient is the log odds of selecting the Subject at the mean age of the sample (9y6m). The odds of selecting the Subject is exp(-.20) = .82 which represents an overall probability of selecting the Subject as .82/ 1+.82 = .45. The log odds of selecting the Subject for activity items is -.20 + .38 = .18. The odds of selecting the Subject for activity items is exp(.18) = 1.20. The probability of selecting the Subject for activity items is 1.20/ 1 + 1.20 = .55. This estimate takes into account individual variation in both participants and item responses and is reflected in the combined 7- to 11-year-old Subject selection group means for activity items shown in Table 6, Appendix B. The log odds of selecting the Subject for accomplishment items is -.20 - .38 = -.58. The odds of selecting the Subject for accomplishment items is exp(-.58) = .56. The probability of selecting the Subject for accomplishment items is .56/1 + .56 = .36. As above, this estimate takes into account individual variation in both participants and items responses and is reflected in the combined 7- to 11-year-old Subject selection group means for accomplishment items of .39 shown in Table 6, Appendix B.

Figure 5. Interaction Between Lexical Aspect and Age (7 to 11 years)

The lexical aspect and grammatical aspect coefficients in Table 4 show respectively that children (7 to 11 years) were more likely to select the Subject for activity compared to accomplishment items and for imperfectively compared to perfectively expressed items. However, as indicated in the first analysis, children in this age range did not demonstrate an interaction between grammatical and lexical aspect. The lexical aspect x age interaction is shown in Figure 5. Figure 5 shows that 7- to 11-year-old children's selection of the Subject increased with age for activity items but not for accomplishment items.

Discussion

There was evidence that the lexical aspect of events influences adults' processing of pronouns; adults were more likely to select the Subject as the pronoun referent for activity events (which do not have endpoint) than for accomplishment events (which do). This finding supports Kehler and Rohde's (2013a) proposal that the inherent temporal characteristic of events influences pronoun resolution. There was also evidence that the grammatical aspect with which accomplishment events are described influences adults' processing of pronouns; adults were more likely to select the Subject as the pronoun referent when these events were described with imperfective aspect rather than perfective aspect, consistent with previous research (Rohde et al., 2006). Grammatical aspect did not influence adults' pronoun resolution for activity events, consistent with previous research examining adults' concept integration (Becker et al., 2013). The contrasting influence of grammatical aspect on adults' pronoun resolution for events with and without endpoints supports the Event Structure account of pronoun processing (Kehler & Rohde, 2013b). As predicted, the influences of lexical and grammatical aspect on adolescents' (13 to 14 years) pronoun resolution were more similar to the adult pattern of performance than those for younger (7 to 11 years) children.

Taking the development of lexical aspect as an influence first, adolescents were as likely as adults to select the Subject as the referent of the pronoun for activity events (events without endpoints). However, adolescents were more likely than adults to select the Subject as the referent for accomplishment events. In contrast, whilst younger children

showed the same tendency to resolve the pronoun more frequently to the Subject for activity compared to accomplishment items, they were less likely than adults to select the Subject as the referent for both type of event. Importantly, the younger children demonstrated an increase in selection of the Subject protagonist with age for activity events but not for accomplishment events. This suggests that the influence of lexical aspect on children's pronoun resolution is developing within the age range 7 to 11 years.

Turning now to the development of grammatical aspect as an influence on children's pronoun resolution, adolescents performed like adults for accomplishment events and resolved the pronoun more often to the Subject when events were expressed with imperfective compared to perfective aspect. Also, like adults, adolescents demonstrated no influence of grammatical aspect on their resolution of pronouns following activity events. In contrast, whilst younger children resolved the pronoun more often to the Subject following imperfectively expressed events than perfectively expressed events, this influence applied to both activity and accomplishment events. Rather than this finding reflecting a broader influence of grammatical aspect on younger children's pronoun resolution compared to that of adolescents' or adults', the more likely explanation is that the significantly smaller effect of grammatical aspect on pronoun resolution for the younger children limited the opportunity to observe an interaction between grammatical and lexical aspect in this age range. In contrast to the influence of lexical aspect, younger children did not demonstrate an increase in sensitivity to grammatical aspect with age. Previous research has shown that very young children (3- to 6-year-olds) are sensitive to the grammatical morphemes that mark the imperfective/perfective expression of events in picture recognition tasks (Wagner, 2009; Zhou et al., 2014). The current study is the first to examine whether this sensitivity results in alternative processing of a subsequent ambiguous pronoun at the start of a continuation. The results suggest that children's use of grammatical aspect to identify pronoun referents undergoes development between 11 to 13 years.

Finding an influence of lexical and grammatical aspect on younger children's pronoun resolution is important for a number of reasons. First, the findings suggest that children do not develop a Subject interpretation of pronouns at a particular age and apply this across all types of event. The results from this study show that the pronoun was more often resolved to the Subject in 4a than 4b (see Table 6, Appendix B).

Activity (no inherent endpoint):

4a. Julia stood/was standing in a queue with Alison. She smiled.

Accomplishment (inherent endpoint):

4b. Nina handed/was handing a racquet to Gemma. She chuckled.

This informs the debate in the literature regarding the age at which children demonstrate a Subject interpretation of a pronoun (see Hartshorne et al., 2015). Previous research has found that 5-year-old children do not demonstrate a Subject interpretation of an ambiguous pronoun for events with endpoints (Arnold et al., 2007). The results of the current study are consistent with Arnold et al. (2007) and extend this finding to children in the age range 7 to 11 years. Previous research has also found that, given stimuli without inherent endpoints or with repeat mention of the Subject character, 5-year-old children behave like adults and demonstrate a Subject interpretation of a subsequent pronoun (see

Hartshorne et al., 2015; see also Arnold, Castro-Schilo, Zerkle & Rao, 2019). Adults' and children's more frequent resolution of a pronoun to the Subject for events without endpoints than with endpoints in the current study is also consistent with this finding.

A second reason why finding a developing influence of lexical and grammatical aspect on children's pronoun resolution in the age range 7 to 11 years is important is because this provides some insight into potential sources of difficulty some children have with pronoun resolution. A number of studies have found that children with poor reading comprehension find resolving pronouns easier when these refer back to a recently mentioned (Object) protagonist than a more distant (Subject) protagonist (Francey & Cain, 2014; Megherbi & Ehrlich, 2005). This pattern has been explained as a consequence of weak working memory in children with poor reading comprehension. In the two examples above (4a, 4b), the distance (in terms of the number of intervening words between the pronoun and the two protagonists) is the same. Thus the results of this study suggest that, in some cases, pronoun resolution difficulties may stem from a difficulty in recognising or taking into account the temporal characteristics of events. Pertinent to this point, Francey and Cain (2014) used Source-Goal transfer verbs expressed with perfective aspect in their pronoun resolution task. They found that 7- to11-year-old children with good listening comprehension were more likely to resolve an ambiguous pronoun at the start of a following explanation clause (because he/she…..) to the Goal protagonist than the Source. In contrast, those with poor listening comprehension showed this tendency only after an imagery training intervention, designed to improve comprehension. This suggests that instruction in the use of imagery to represent sentence meanings may aid children's estimation of the likelihood of the re-mention of particular protagonists.

Potential explanations for the developmental trends observed in this study and suggestions for future research to explore these are discussed next. Adults have a greater tendency to resolve a pronoun to the Subject protagonist following an imperfectively expressed Source-Goal transfer event compared to a perfectively expressed transfer event. According to the Event Structure Hypothesis this is because these expressions differently influence adults' expectancies for particular coherence relations to follow. The evidence for this comes from an examination of the coherence relations that adults provide following imperfectively or perfectively expressed transfer events beginning with ambiguous pronouns (Kehler et al., 2008; Rohde et al., 2006). Five types of coherence relation were included in that study: Occasion, Elaboration, Explanation, Result and Parallel (definitions and examples are provided in Appendix D). Adults were more likely to provide continuations with Elaboration and Explanation relations when transfers were expressed with imperfective aspect. These continuations more often began with a reference to the Subject (Source) than an Object (Goal). In contrast, adults were more likely to provide continuations with Occasion and Result coherence relations when transfers were expressed with perfective aspect. These continuations more often began with a reference to the Object (Goal) than and Subject (Source). On this account, the findings of the current study suggest that adolescent children are as likely as adults to infer Elaboration or Explanation coherence relations following imperfectively expressed transfer events, whilst younger children, given the same stimuli, are less likely to infer these types of relation.

Exposure to print is a key driver of language development for children in age range 7 to 11 years influencing vocabulary development (Cain & Oakhill, 2011) and syntactic processing (Montag & MacDonald, 2015). In addition, print exposure predicts 5- to 14-year-olds (Arnold et al., 2019) and adults' (Arnold, Strangmann, Hwang, Zerkle & Nappa, 2018) tendency to select the Subject as the referent of an ambiguous pronoun. An examination of the frequency with which events from different lexical categories are

expressed with imperfective and perfective aspect in an appropriate corpus of children's literature would provide much needed information about whether or not print exposure might be driving the pattern of children's pronoun resolution preferences reported here. Furthermore, this examination could determine the frequency with which the above events are followed by particular coherence relations. This would examine the hypothesis that Elaboration and/or Explanation relations are more frequent in literature read by older compared to younger children, following activity rather than accomplishment events, and following imperfectively compared to perfectively expressed accomplishment events. Specifically, it would be informative to explore whether the increase in resolution to the Subject following activity events, with age, seen in this study, is reflected in an increase in Elaboration/Explanation relations following these types of events in literature read by this age group. Greater exposure to these types of coherence relations in one particular lexical aspect (activity) rather than another (accomplishment) may be the driving force for generalising the possibility of these types of relations to the imperfective expression of accomplishment events.

Related to the exposure explanation outlined above, another potential explanation for younger children's sensitivity to the imperfective expression of transfer events in this study may lie in the UK National curriculum being taught to 7- to 11-year-old children during the period of data collection. Shortly after the data collection period the Year 6 sample would have sat the Spelling, Punctuation and Grammar (SPAG) test. In contrast, younger children would have been being prepared to sit a revised SPAG test, which requires children to use and identify the progressive form of verbs in the present and past tense to mark actions in progress (e.g., she is drumming, he was shouting). There was previously no requirement to teach the progressive form of verbs to this age group. This may explain why, in Figure 1, the Year 5 sample appear to show greater sensitivity to grammatical aspect in the accomplishment condition compared to the Year 6 sample and why there was no increasing effect of grammatical aspect with age within this sample. Interestingly, the apparent greater sensitivity for grammatical aspect seen in the Year 5 sample compared to the Year 6 sample was only observed in the accomplishment and not the activity condition means.

One of the limitations of the current study is that the influence of the temporal characteristics of events on children's pronoun resolution was only examined for aspectual events presented as isolated sentences. Future research should examine the extent of these influences in more naturalistic reading contexts – for example, when stimuli are embedded in narratives. This would provide a fuller picture of how these influences might contribute to children's narrative comprehension. In addition, the extent to which children perceive imperfectively and perfectively expressed events to be ongoing or completed within narratives should be assessed directly. This could be achieved by direct questioning as in adult studies (Magliano & Schleich, 2000). Whether children's tendency to resolve a pronoun to the Subject protagonist is related to the consistency with which they pronominalize re-mentions of Subject protagonists is also an important area for future research.

In conclusion, this study found that when events are presented as isolated sentences, adults' and children's subsequent pronoun resolution is influenced by the lexical aspect of those events and the grammatical aspect with which they are expressed. These findings explain previous inconsistent findings in the literature regarding the age at which children demonstrate a Subject interpretation of a pronoun. The findings provide support for Rohde et al.'s (2006) Event Structure Hypothesis and new insights into understanding children's pronoun resolution development. They also suggest new areas to investigate to determine why some children experience difficulty with pronoun resolution.

Competing interests. The authors declare none.

References

Arnold, J. E. (2001). The effect of thematic roles on pronoun use and frequency of reference continuation. *Discourse Processes*, **31**(2), 137–162. https://doi.org/10.1207/S15326950DP3102_02

Arnold, J. E., Brown-Schmidt, S., & Trueswell, J. (2007). Children's use of gender and order-of-mention during pronoun comprehension. *Language and Cognitive Processes*, **22**(4), 527–565. https://doi.org/10.1080/01690960600845950

Arnold, J. E., Castro-Schilo, L., Zerkle, S., & Rao, L. (2019). Print exposure predicts pronoun comprehension strategies in children. *Journal of Child Language* 1–31. https://doi.org/10.1017/S0305000919000102

Arnold, J. E., Strangmann, I., Hwang, H., Zerkle, S., & Nappa, R. (2018). Linguistic experience affects pronoun interpretation. *Journal of Memory and Language*, **102**, 41–54. https://doi.org/10.1016/j.jml.2018.05.002

Barr, D., Levy, R., Scheepers, C., & Tily, H. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, **68**(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, **67**(1). https://doi.org/10.18637/jss.v067.i01

Becker, R. B., Ferretti, T. R., & Madden-Lombardi, C. J. (2013). Grammatical aspect, lexical aspect, and event duration constrain the availability of events in narratives. *Cognition*, **129**(2), 212–220. https://doi.org/10.1016/j.cognition.2013.06.014

Cain, K., & Oakhill, J. (2011). Matthew Effects in Young Readers: Reading comprehension and reading experience aid vocabulary development. *Journal of Learning Disabilities*, **44**(5), 431–443. https://doi.org/10.1177/0022219411410042

Comrie, B. (1976). *Aspect : an introduction to the study of verbal aspect and related problems*: Cambridge ; New York : Cambridge University Press.

Dowty, D. R. (1979). *Word meaning and Montague grammar: The semantics of verbs and times in generative semantics and in Montague's PTQ* (Vol. **7**): Reidel, Boston: Springer.

Ehrlich, M., & Remond, M. (1997). Skilled and less skilled comprehenders: French children's processing of anaphoric devices in written texts. *British Journal of Development Psychology*, **15**, 291–308. https://doi.org/10.1111/j.2044-835X.1997.tb00522.x

Elbro, C., Oakhill, J., Megherbi, H., & Seigneuric, A. (2017). Aspects of pronominal resolution as markers of reading comprehension: The role of antecedent variability. *Reading and Writing: An Interdisciplinary Journal*, **30**(4), 813–827. https://doi.org/10.1007/s11145-016-9702-4

Engelen, J. A. A., Bouwmeester, S., de Bruin, A. B. H., & Zwaan, R. A. (2013). Eye movements reveal differences in children's referential processing during narrative comprehension. *Journal of Experimental Child Psychology*. **118**, 57–77. https://doi.org/10.1016/j.jecp.2013.09.005

Ferretti, T. R., Rohde, H., Kehler, A., & Crutchley, M. (2009). Verb aspect, event structure, and coreferential processing. *Journal of Memory and Language*, **61**(2). 191–205. https://doi.org/10.1016/j.jml.2009.04.001

Francey, G., & Cain, K. (2014). Effect of imagery training on children's comprehension of pronouns. *The Journal of Educational Research*, **108**(1), 1–9. https://doi.org/10.1080/00220671.2013.824869

Fukumura, K., & van Gompel, R. P. G. (2010). Choosing anaphoric expressions: Do people take into account likelihood of reference? *Journal of Memory and Language*, **62**(2), 52–66. https://doi.org/10.1016/j.jml.2009.09.001

Fukumura, K., & van Gompel, R. P. G. (2015). Effects of order of mention and grammatical role on anaphor resolution. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **41**(2), 501–525. https://doi.org/10.1037/xlm0000041

Grüter, T., Takeda, A., Rohde, H., & Schafer, A. (2018). Intersentential coreference expectations reflect mental models of events. *Cognition*, **177**, 172–176. https://doi.org/10.1016/j.cognition.2018.04.015

Hartshorne, J., Nappa, R., & Snedeker, J. (2015). Development of the first-mention bias. *Journal of Child Language*, **42**(2), 423–446. https://doi.org/10.1017/S0305000914000075

Johnson-Laird, P. (1983). *Mental models : Towards a cognitive science of language, inference and consciousness*. Cambridge [Cambridgeshire] ; New York: Cambridge University Press.

Kehler, A., Kertz, L., Rohde, H., & Elman, J. L. (2008). Coherence and Coreference Revisited. *Journal of semantics*, **25**(1), 1–44. https://doi.org/10.1093/jos/ffm018

Kehler, A., & Rohde, H. (2013a). A probabilistic reconciliation of coherence-driven and centering-driven theories of pronoun interpretation. *Theoretical Linguistics*, **39**(1), 1–37. https://doi.org/10.1515/tl-2013-0001

Kehler, A., & Rohde, H. (2013b). Aspects of a theory of pronoun interpretation. *Theoretical Linguistics*, **39**(3-4), 295–309. https://doi.org/10.1515/tl-2013-0019

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, **95**(2), 163–182. https://doi.org/10.1037/0033-295X.95.2.163

Madden, C. J., & Ferretti, T. R. (2009). Verb aspect and the mental representation of situations. In *The Expression of Time* (Vol. 3, pp. 217–231). Berlin, Germany: Mouton de Gruyter. https://doi.org/10.1515/9783110199031.217

Madden, C. J., & Zwaan, R. (2003). How does verb aspect constrain event representations? *Memory and Cognition*, **31**(5), 663–672. https://doi.org/10.3758/BF03196106

Magliano, J. P., & Schleich, M. C. (2000). Verb aspect and situation models. *Discourse Processes*, **29**(2), 83–112. https://doi.org/10.1207/S15326950dp2902_1

Matuschek, H., Kliegl, R., Vasishth, S., Baayen, H., & Bates, D. M. (2017). Balancing Type 1 error and power in linear mixed models. *Journal of Memory and Language*, **94**, 305–315. https://doi.org/10.1016/j.jml.2017.01.001

Megherbi, H., & Ehrlich, M.-F. (2005). Language impairment in less skilled comprehenders: The on-line processing of anaphoric pronouns in a listening situation. *Reading and Writing: An Interdisciplinary Journal*, **18**(7-9), 715–753. https://doi.org/10.1007/s11145-005-8131-6

Moens, M., & Steedman, M. (1988). Temporal ontology and temporal reference. *Computational Linguistics*, **14**(2), 15–28. https://dl.acm.org/doi/10.5555/55056.55058

Montag, J. L., & MacDonald, M. C. (2015). Text exposure predicts spoken production of complex sentences in 8- and 12-year-old children and adults. *Journal of Experimental Psychology: General*, **144**(2), 447–468. https://doi.org/10.1037/xge0000054

Morrow, D. G. (1985). Prepositions and verb aspect in narrative understanding. *Journal of Memory and Language*, **24**(4), 390–404. https://doi.org/10.1016/0749-596X(85)90036-1

Nagy, W., Berninger, V. W., & Abbott, R. D. (2006). Contributions of morphology beyond phonology to literacy outcomes of upper elementary and middle-school students. *Journal of Educational Psychology*, **98**(1), 134–147. https://doi.org/10.1037/0022-0663.98.1.134

Oakhill, J., & Yuill, N. (1986). Pronoun resolution in skilled and less-skilled comprehenders: Effects of memory load and inferential complexity. *Language and Speech*, **29**(1), 25–37. https://doi.org/10.1177/002383098602900104

Pyykkönen, P., Matthews, D., & Järvikivi, J. (2010). Three-year-olds are sensitive to semantic prominence during online spoken language comprehension: A visual world study of pronoun resolution. *Language and Cognitive Processes*, **25**, 115–129. https://doi.org/10.1080/01690960902944014

R Development Core Team. (2014). R: A language and environment for statistical computing. Vienna, Austria; 2014. ISBN 3-900051-07-0

Rohde, H. (2008). *Coherence driven effects in sentence and discourse processing.* [Doctoral thesis, UC San Diego]. https://escholarship.org/uc/item/0v09m5zt

Rohde, H., & Kehler, A. (2014). Grammatical and information-structural influences on pronoun production. *Language, Cognition and Neuroscience*, **29**(8), 912–927. https://doi.org/10.1080/01690965.2013.854918

Rohde, H., Kehler, A., & Elman, J. (2006). Event structure and discourse coherence biases in pronoun interpretation. *Proceedings of the Annual Meeting of the Cognitive Science Society*, 28. https://escholarship.org/uc/item/9js9w79w

Shirai, Y., & Andersen, R. W. (1995). The acquisition of tense- aspect morphology: A prototype account. *Language*, **71**(4), 743–762. https://doi.org/10.2307/415743

Song, H. J., & Fisher, C. (2005). Who's "she"? Discourse prominence influences preschoolers' comprehension of pronouns. *Journal of Memory and Language*, **52**2), 29–57. https://doi.org/10.1016/j.jml.2004.06.012

Stevenson, R. J., Crawley, R. A., & Kleinman, D. (1994). Thematic roles, focus and the representation of events. *Language and Cognitive Processes*, **9**(4), 519–548. https://doi.org/10.1080/01690969408402130

Tomasello, M. (2003). *Constructing a language : A usage-based theory of language acquisition*. Cambridge, MA: Harvard University Press.

Vendler, Z. (1967). *Linguistics in philosophy*. Ithasa, NY: Cornell University Press.

Von der Malsburg, T., & Angele, B. (2017). False positives and other statistical errors in standard analyses of eye movements in reading. *Journal of Memory and Language*, **94**, 119–133. https://doi.org/10.1016/j.jml.2016.10.003

Wagner, L. (2001). Aspectual influences on early tense comprehension. *Journal of Child Language*, **28**(3), 661–681. https://doi.org/10.1017/S0305000901004792

Wagner, L. (2009). I'll never grow up: Continuity in aspect representations. *Linguistics*, **47**(5), 1051–1074. https://doi.org/10.1515/LING.2009.037

Weist, R., Atanassova, M., Wysocka, H., & Pawlak, A. (1999). Spatial and temporal systems in child language and thought: A cross-linguistic study. *First Language*, **19**(3) (57), 267–312. https://doi.org/10.1177/014272379901905701

Weist, R., Lyytinen, P., Wysocka, J., & Atanassova, M. (1997). The interaction of language and thought in children's language acquisition: A cross-linguistic study. *Journal of Child Language*, **24**(1), 81–121. https://doi.org/10.1017/S0305000996003017

Yuill, N., & Oakhill, J. (1991). *Children's problems in text comprehension: An experimental investigation*: Cambridge University Press.

Zhou, P., Crain, S., & Zhan, L. (2014). Grammatical aspect and event recognition in children's online sentence comprehension. *Cognition*, **133**(1), 262–276. https://doi.org/10.1016/j.cognition.2014.06.018

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, **123**(2), 162–185. https://doi.org/10.1037/0033-2909.123.2.162

Appendix A

Table 5. Stimuli Used Showing the Grammatical Aspect of the Verb in the Alternative Presentations (list A or/list B) and the Lexical Aspect of the Items (Acc. = Accomplishment, Act. = Activity)

Practice items		
1	Sarah passed a lolly to Helen. She grinned.	Acc.
2	Graeme played in the park with Farrell. He laughed.	Act.
3	Paul was throwing a ball to Burt. He chuckled.	Acc.
Was a lolly mentioned?		
Test items are numbered		
1	Julia was standing/stood in a queue with Alison. She smiled.	Act.
2	Alan handed/was handing a bag of sweets to Nick. He grinned.	Acc.
3	Barry played/was playing on the wii with Stephan. He giggled.	Act.
4	Liam was taking/took a report to Gavin. He sighed.	Acc.
5	Emma watched/was watching at the match with Jenny. She frowned.	Act.
6	Alfie was running/ran in a race with Darren. He grinned.	Act.
7	Kath was tossing/tossed a biscuit to Ruth. She frowned.	Acc.
8	Carl was chucking/chucked a football shirt to Wayne. He giggled.	Acc.
Was a bag of sweets mentioned?		
9	Helen was drinking/drank at the café with Linda. She giggled.	Act.
10	Simon studied/was studying at the college with Richard. He smiled.	Act.
11	Anne carried/was carrying a basket to Lynn. She laughed.	Acc.
12	Stephanie was giving/gave an ice-cream to Alison. She grinned.	Acc.
13	Joanne talked/was talking on the phone with Tracey. She sighed.	Act.
14	Josh brought/was bringing a coat to Kyle. He frowned.	Acc.
15	Nina was handing/handed a racquet to Gemma. She chuckled.	Acc.
16	Lewis was speaking/spoke at the bus stop with Jimmy. He frowned.	Act.
Was a farm mentioned?		
17	Jack stood/was standing on the touch line with Dan. He sighed.	Act.
18	Dennis tossed/was tossing a football to Aaron. He groaned.	Acc.
19	Wendy chucked/was chucking a ball to Sheila. She sighed.	Acc.
20	Harriet was playing/played in the bedroom with Stephanie. She grinned.	Act.
21	Polly spoke/was speaking in the office with Amy. She laughed.	Act.
22	Bob gave/was giving a reading book to Dan. He chuckled.	Acc.
23	Bethany was throwing/threw a frisbee to Sabrina. She groaned.	Acc.
24	Michael was talking/talked in the meeting with Gary. He laughed.	Act.

Table 5. *(Continued)*

	Was a baby's rattle mentioned?	
25	Sally took/was taking a sunhat to Brenda. She smiled.	Acc.
26	Maxine was studying/studied in the library with Rachael. She chuckled.	Act.
27	David drank/was drinking at the bar with Tony. He chuckled.	Act.
28	Harry was carrying/carried a bowl of cereal to Kevin. He smiled.	Acc.
29	Carol ran/was running along the road with Charlotte. She groaned.	Act.
30	Stuart threw/was throwing a dish cloth to Roger. He laughed.	Acc.
31	Luke was watching/watched at the match with John. He groaned.	Act.
32	Alice was bringing/brought a cup of coffee to Polly. She giggled.	Acc.
	Was a library mentioned?	
33	Gail stood/was standing at the bus stop with Beth. She smiled.	Act.
34	Philip was tossing/tossed a bunch of keys to Joseph. He groaned.	Acc.
35	Anne gave/was giving a sandwich to Liz. She grinned.	Acc.
36	Josh was standing/stood by the swings with Ben. He sighed.	Act.
37	Louise was taking/took a glass of juice to Tracey. She smiled.	Acc.
38	Mike talked/was talking in the garage with Bob. He laughed.	Act.
39	Sharon threw/was throwing a ball to Nancy. She groaned.	Acc.
40	Stephen was handing/handed a jumper to Jimmy. He grinned.	Acc.
	Was a supermarket mentioned?	
41	Alice was running/ran on the track with Joanne. She groaned.	Act.
42	Kyle was playing/played on the x-box with John. He giggled.	Act.
43	Jasmine tossed/was tossing a bag of crisps to Becky. She frowned.	Acc.
44	Edward carried/was carrying a bag to Patrick. He smiled.	Acc.
45	Grace drank/was drinking at the water tap with Claire. She giggled.	Act.
46	Ross was throwing/threw a rubber to Matt. He laughed.	Acc.
47	Harriet was watching/watched at the cinema with Julia. She frowned.	Act.
48	Kevin took/was taking a screwdriver to Robert. He sighed.	Acc.
	Was a piano mentioned?	
49	Mike spoke/was speaking at the concert with Jack. He frowned.	Act.
50	Martha was talking/talked at the playgroup with Mary. She sighed.	Act.
51	Rachael brought/was bringing a cold drink to Charlotte. She giggled.	Acc.
52	Kay handed/was handing a skipping rope to Liz. She chuckled.	Acc.
53	Josh ran/was running down the lane with Luke. He grinned.	Act.
54	Eve was carrying/carried a tray to Kate. She laughed.	Acc.
55	Barry watched/was watching at the races with Lewis. He groaned.	Act.
56	Benjamin was giving/gave a pencil to Cameron. He chuckled.	Acc.

Table 5. *(Continued)*

Was a skipping rope mentioned?		
57	Peter was drinking/drank at the bar with Ian. He chuckled.	Act.
58	Mary played/was playing in the park with Jenny. She grinned.	Act.
59	Richard was bringing/brought a cup of tea to Darren. He frowned.	Acc.
60	Mavis was speaking/spoke in the corridor with Emma. She laughed.	Act.
61	Helen studied/was studying in the classroom with Sheila. She chuckled.	Act.
62	Maxine was chucking/chucked a cloth to Carol. She sighed.	Acc.
63	Tom was studying/studied in the lesson with Wayne. He smiled.	Act.
64	Simon chucked/was chucking a torch to Alfie. He giggled.	Acc.
Was a classroom mentioned?		

Appendix B

Table 6. Mean Proportion of Subject Selections (and Standard Deviations) in the Two Lexical Aspect and Two Grammatical Aspect Conditions

Lexical aspect Activity	Age Group	Grammatical Aspect		Total
		Perfective	Imperfective	
	7 to 8 years	0.49 (0.50)	0.50 (0.50)	0.50 (0.50)
	8 to 9 years	0.50 (0.50)	0.52 (0.50)	0.51 (0.50)
	9 to 10 years	0.57 (0.50)	0.59 (0.49)	0.58 (0.49)
	10 to 11 years	0.55 (0.49)	0.58 (0.50)	0.56 (0.50)
	13 to 14 years	0.81 (0.39)	0.82 (0.39)	0.81 (0.39)
	Adult	0.84 (0.36)	0.85 (0.35)	0.85 (0.36)
Accomplishment				
	7 to 8 years	0.38 (0.49)	0.39 (0.49)	0.39 (0.49)
	8 to 9 years	0.39 (0.49)	0.38 (0.49)	0.39 (0.49)
	9 to 10 years	0.30 (0.46)	0.39 (0.49)	0.35 (0.48)
	10 to 11 years	0.40 (0.49)	0.42 (0.49)	0.41 (0.49)
	13 to 14 years	0.50 (0.50)	0.59 (0.49)	0.55 (0.50)
	Adult	0.38 (0.49)	0.54 (0.50)	0.46 (0.50)

Table 7. Summary GLMM for (log odds) Subject Selection: Effects for Grammatical Aspect (GA) in the Two Lexical Aspect Conditions Separately

	Lexical Aspect							
	Accomplishment				Activity			
Fixed effects	Estimated coefficient (*b*)	SE	z	Pr(>|z|)	Estimated coefficient (*b*)	SE	z	Pr(>|z|)
(Intercept)	−0.16	0.26	−0.63	.53	**2.44**	**0.26**	**9.46**	**< .01**
GA (Adult)	**0.45**	**0.07**	**6.79**	**< .01**	0.07	0.09	0.86	.39
Age Group (Adolescent)	**0.65**	**0.30**	**2.17**	**0.03**	−0.33	0.29	−1.12	0.24
Age Group (Younger)	−0.42	0.26	−1.61	0.12	**−2.27**	**0.26**	**−8.77**	**< .01**
GA x Age Group (Adolescent)	**−0.19**	**0.08**	**−2.21**	**0.03**	−0.06	0.10	−0.55	0.58
GA x Age Group (Younger)	**−0.38**	**0.07**	**−5.46**	**< .01**	−0.03	0.09	−0.30	0.76
Random effects			Variance	SD			Variance	SD
Participant:	(intercept)		2.16	1.50			1.66	1.29
Item:	(intercept)		0.44	0.66			0.60	0.78
	GA (slope)		0.01	0.11			0.01	0.11
	Age Group (Adolescent)		0.07	0.26			0.10	0.32
	Age Group (Younger)		0.19	0.43			0.31	0.56

Note. For each analysis: 9728 observations; 304 participants, 32 items

Appendix D

Table 8. Coherence Relation Definitions and Examples of Continuations Collected in the Perfective Condition for the Stimulus **Matt passed a sandwich to David. He…**

Coherence relation	Definition	Example continuation	% frequency
Occasion	Infer a change of state from the second sentence, taking its initial state to be the final state of the eventuality described in the first sentence.	…ate it up.	43.2
Elaboration	Infer that both sentences provide descriptions of the same eventuality.	…gave a ham one to him.	31.5
Explanation	Infer that the second sentence describes a cause or reason for the eventuality described in the first sentence.	…didn't want David to starve.	18.2
Result	Infer that the first sentence describes a cause or reason for the eventuality described in the second sentence.	…thanked Matt.	0.5
Parallel	Infer that the first and second sentences express similar eventualities, as if each provides a partial answer to a common question.	…gave a drink to Maria.	0.2

Note. Definitions and examples taken from Kehler and Rohde (2013a).