Online processing of English Which-questions by children and adults: a visual world paradigm study

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Online processing of English Which-questions by children and adults: a visual world paradigm study

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1. Introduction

One of the central goals in the study of human language comprehension is to understand how we recover the syntactic structure of a sentence from a string of words.

While adult psycholinguistic studies in the past decades have extensively investigated incremental properties of the sentence comprehension mechanism, the developmental research on incremental sentence processing capacity in children is still relatively unexplored (e.g., Trueswell et al., 1999; Felser, Marinis & Clahsen, 2003). In the process of development, we know that children need to perceive and encode the input with their own parsers, as the input must be converted to mental representations that can feed the learning processes. However, we do not have extensive knowledge on how children parse strings of words and assign interpretation to them.

Growing evidence on the development of sentence processing mechanisms indicates that, despite the achievements in grammatical knowledge, children can show non-adult-like behaviours in on-line sentence processing (e.g., Gagliardi et al, submitted; Omaki et al., 2013; Stromsword et al., 2002; Trueswell et al., 1999; a.o.).

In an eye-tracking study, Trueswell et al. (1999) examined the way children resolved temporary PP-attachment ambiguities (e.g., *Put the frog on the napkin in the box*). Children's eye movements were recorded as they responded to spoken instructions asking them to move objects around on a table. Trueswell et al. found that five year-old children preferentially interpreted the postverbal PP *on the napkin* as the Destination (or Goal) argument of the verb *put* rather than as a modifier of the NP *the frog*, even in the presence of disambiguating contextual information.

Trueswell et al.'s results could be taken to indicate that when resolving temporary PP-attachment ambiguities during on-line comprehension, children relied primarily on lexical/structural information, and largely failed to take into account the information provided by the visual context.

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Also, as observed from the eye-movement results, Trueswell et al. (1999) offered a developmental reason for why five-year-old children failed to revise their goal interpretation upon hearing the PP *into the box*. It was suggested that the children's difficulty to revise was the result of executive function processes, specifically the ability to select competing representations, an ability that develops with age. That is, maturational differences explained why the first interpretation that children arrived at tended to be the only interpretation they could entertain.

The lack of flexibility and revision ability observed by Trueswell et al. has been confirmed by several other studies on filler-gap sentences (Gagliardi et al, submitted; Omaki et al., 2013) and binding (see Leddon & Lidz, 2006; Musolino & Lidz, 2006; cf. Gualmini, 2004). These results open an important question on weather the lack of flexibility observed in child parsing can potentially interfere with the children's acquisition of new grammatical rules. In order to acquire the target grammar, children must be able to assign a target-like syntactic representation to the input; however if children's sentence processing mechanisms operate differently than the target grammar, a correct linguistic representation may not be assigned to the input (Valian, 1990). This suggests that it is important for children to be able to revise their initial structural analyses in order to correct their parse and acquire the target-like grammar. However, if children's parsers have non-adult biases in incremental syntactic analyses and fail to retract such incremental commitments, then this raises the possibility that the input distribution might be skewed and may not be *correctly* represented in the child's mind.

In this paper, we investigate the children's processing flexibility by testing the on-line comprehension of Subject and Object Which-questions.

Wh-questions are classified according to the position from which the Wh-phrase has moved. Subject questions are derived by movement from the subject position, as in example (1), whereas object questions involve movement from an object position, as in example (2). In both cases, the moved element leaves a trace (marked by t_1) in its original position (copy theory of traces assumes that a trace is a silent copy of the moved constituent, Chomsky, 1995).

The domain of Wh-questions has been widely investigated in first language acquisition, mainly using production and off-line comprehension measures (e.g., elicitation, picture matching tasks). Although several cross-linguistic studies have shown that Wh-movement is already operative at age 1;7-3;0 (Guasti 1996 a.o.), object *who*-questions (2) pose a greater challenge than subject *who*-questions (1), both in comprehension and production.

(1) Who t_1 is kissing the boy?

(2) Who does the boy kiss t_1?

Moreover, cross-linguistic research showed that within the types of object extracted wh-questions, *which-object* are the hardest types of Wh-questions to comprehend for children (for French: Jakubowicz & Gutierrez, 2007; for Greek: Stravakaki 2006; for Italian: De Vincenzi, Arduino, Ciccarelli & Job 1999; Guasti et al. 2012, for Hebrew: Friedmann et al 2009, a.o.), and it has been shown that English-speaking children do not reach full mastery of *which-object* questions until the age of 7 (Yoshinaga 1996; Avrutin, 2000; Deevy and Leonard, 2004; Hirsch and Hartman, 2006; Stromswold, 1995).

In the present study we focus on the on-line processing of *which-subject* questions (S-WH), such as (3), compared to *which-object* questions (O-WH), such as (4), by English-speaking children and adults.

(3) Which girl t_1 is kissing the boy?

(4) Which girl is the boy kissing t_1?

S-WH and O-WH questions are an excellent testing ground for the analysis of the flexibility in processing routines in children compared to adults. In adult sentence processing, a dislocated constituent (or 'filler'), such as the fronted *wh*-phrase *which girl* in (4), is thought to trigger the anticipation of a lexical head to license it, or of a corresponding syntactic *gap* (Frazier and Clifton, 1989; Frazier and Flores d'Arcais, 1989; Gibson, 1998). Keeping a filler active in working memory incurs processing cost that has been found to increase with distance (see, a.o., Gibson, 1998). Once a potential gap has been identified, the filler will be retrieved from working memory and integrated into the emerging sentence representation.

In the present study, we use the eye-tracking technique that provides a continuous record of the listeners' eye movements and expectations as the utterance unfolds; this yields a detailed picture of processing over time, as well as an indication of the time course of initial expectations versus readjustment of expectations and recovery from misanalyses (Sussman & Sedivy 2003, a.o.). In particular, we will look at how and when children assign the correct interpretation to the filler in real time compared to adults, and how and when disambiguating information is correctly used in order to give a correct interpretation to the sentence.

To this aim, we also focus on the role of Number agreement in *which*-questions in which the subject and object NPs differ in terms of number properties. Recent findings on Hebrew (Friedman et al. 2009), English (Adani 2008, Contemori & Marinis, 2013a, 2013b) and Italian (Adani et al. 2010), showed that in *object* relative clauses (ORs), such as (6), the degree of complexity of the object extraction is related to the similarity between the NP intervening in the long distance dependency and the extracted object and its trace. Italian and English-speaking children were tested on the comprehension of a set of ORs, where the subject and the object NPs were either similar (e.g., (6) and (8)) or different in terms of Number features (e.g., (7) and (9)). The results showed that children were more accurate in comprehending the conditions of Mismatch (7) and (9), than those of Match (6) and (8), demonstrating that the intervention effect in ORs is sensitive to the NP feature internal structure (for English: Adani 2008, Contemori & Marinis, 2013a, 2013b; for Italian: Adani et al. 2010).

(6) Match: The lion-SG that the cat-SG is touching is sitting on the ground
(7) Mismatch: The lion-SG that the crocs-PL are touching is sitting on the ground
(8) Match: The lions-PL that the cats-PL are touching are sitting on the ground
(9) Mismatch: The lions-PL that the croc-SG is touching are sitting on the ground

Furthermore, by measuring reaction times in a self-paced listening task, Contemori & Marinis (2013a, 2013b) showed no qualitative differences in the on-line processing of ORs with match or mismatch of Number features in 6-8;11 year-old children compared to adults. Based on their results, the authors speculated that the advantage in ORs with a mismatch between the head of the OR and the subject within the relative clause for children is not due to an on-line facilitation, but rather represents a late off-line effect.

Although Contemori & Marinis' study contributed to the understanding of on-line processing of ORs with number match and mismatch of features by using a self-paced listening task, it also left several open questions. First of all, the authors only analysed reaction times for correctly comprehended sentences; it is unclear how processing of long-distance dependencies unfolds in real time when children do not comprehend the target sentence accurately. Furthermore, Contemori & Marinis (2013a, 2013b) tested children at an age (7-8;11), in which their comprehension of ORs is becoming more adult-like, and did not provide any information on the processing and comprehension of younger children who experience more difficulty with long-distance dependencies. Therefore, there are several open questions regarding the feature specification and its role in the comprehension of long distance dependencies in younger children who are less successful in processing long-distance filer-gap dependencies. The present study addresses these questions, by investigating the comprehension of O-WH questions, such as (10) and (11), and S-WH questions, such as (12) and (13), in which we manipulate the number features of the subject and object DP within the two question types.

(10) O-WH PS: Which cow are the goats pushing t_1?

(11) O-WH-SS: Which cow is the goat pushing t_1?

(12) S-WH PS: Which cows t_1 are pushing the goat?

(13) S-WH-SS: Which cow t_1 is pushing the goat**?**

S-WH and O-WH questions represent interesting cases of filler-gap dependencies for the manipulation of the Number feature. First of all, Which-questions differ from relative clauses in that the number information disambiguating for an object interpretation is available on the auxiliary verb. When presented with a sentence, such as (10), the number mismatch between the first NP (*the cow*) and the auxiliary verb (*are*) is a strong syntactic cue that the filler cannot be posited yet, and thus, this is not a Subject question. However, in the case of Number feature match between the subject NP and the auxiliary, such as in (11), the interpretation of the sentence is consistent with that of both a Subject and an Object question until the parser encounters the subject NP (*the goat*), at which point it becomes clear that this is an Object question. Therefore, the parser has to keep two potential interpretations open for a longer time (the one in which *the cow* is the agent and the one in which it is the patient, as shown in the pictures presented to the participants). Alternatively, the parser has to commit to one of the possible interpretations (e.g., *the cow* in (11) is the agent of the action) and then revise the initial subject preference in favour of an object interpretation. In both cases, irrespective of whether the parser keeps two possible interpretations open, or it commits to one and revises, the task is more costly for children compared to adults because their working memory and executive functions are not fully developed. In the first case scenario, if children and adults keep the two potential interpretations open in an O-WH-SS, such as (11), occasionally children may not be able to keep the filler in memory until they get to the disambiguating information, and could therefore sometimes fail in interpreting the sentence correctly, despite showing a similar qualitative processing as adults. If this hypothesis is correct, we expect to observe a similar on-line processing for O-WH-SS in adults and children when the sentence is interpreted correctly. In contrast, when the O-WH-SS is interpreted incorrectly and children are not able to comprehend “who did what to whom”, we expect their eye-movements to be randomly distributed.

In the second case scenario, if the strategy adopted by children and adults when interpreting the O-WH-SS is to commit to a subject interpretation at the upcoming verb (*is*), children may take longer to make a revision when they encounter the subject (*the goat*) in an O-WH-SS compared to a O-WH-SP because the Number feature of the auxiliary in the O-WH-SP provides an early disambiguation cue, which is not available in the O-WH-SS. This effect may be present in children, but not in adults, if the children's parser is indeed less flexible and more likely to fail to retract incremental commitments than adults (e.g., Trueswell et al, 1999, Trueswell & Gleitmann, 2004). If this last hypothesis is correct, children should be less accurate in correctly interpreting (11) compared to (10). Furthermore, when a O-WH-SS is not interpreted correctly, we expect children's eye-movements not to behave at random, but to keep interpreting the first NP (*the cow* in 11) as the agent of the action. To conclude, while we do not expect particular problems in the interpretation of S-WHs, that are known to be relatively easy for children to comprehend, we expect children to show difficulties with O-WH, specifically when the Number features of the subject and object NPs match.

The present study has three aims. First, the study aims at providing detailed insights into the processing similarities/differences between *which*-subject and object questions in adults and children. Secondly, by testing the comprehension of *which*-object questions with manipulation of the Number features, we will address whether or not English-speaking children make use of the number cues in their on-line and off-line interpretation. The third aim is to use the eye-tracking while listening method to demonstrate in a younger group of children (5-7;10) and in more detail than self-paced listening (Contemori & Marinis, 2013a, 2013b) how children and adults derive meaning when they parse *which*-questions in real-time.

2. Method

Thirty one English-speaking children and 21 adults participated in a visual-word-paradigm task. The adults were 19;0–43;0 years old (M=31; SD=12) students at the University of Reading and were granted credits for their participation. The children were 5–7;10 years old (mean age: 6;04; SD: 0.10) and were randomly selected from the child development database at the University of Reading (UK). All children and adults were monolingual speakers of English and did not have a history of language delay or impairment. The project received ethical approval from the University of Reading research ethics committee.

Eye-movements were recorded while participants looked at two pictures (Target, Competitor), as illustrated in Figures 1-3, and listened to a S-WH or O-WH question, as in (14)-(17). After listening to the sentence, participants had to press a button to match the correct picture to the sentence.

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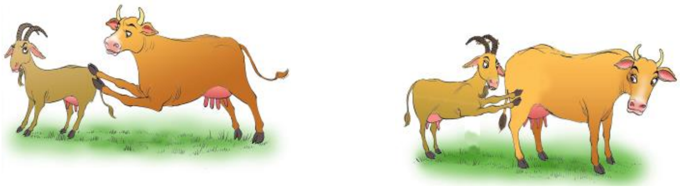
Figure 1.



(14) S-WH-SS: Which cow is pushing the goat ?

(15) O-WH-SS: Which cow is the goat pushing?

Figure 2.

(16) O-WH SP: Which cow are the goats pushing?

Figure 3.

(17) S-WH PS: Which cows are pushing the goat?

3. Results

Two analyses were conducted: one for the accuracy in the off-line comprehension questions and one for the eye-movement data. We first present the accuracy data and then the eye-movement data.

3.1. Accuracy results

Table 1 shows the off-line accuracy of the two groups in the four conditions.

Table 1. Off-line accuracy data in percentage, number correct, mean correct out of 10, and standard deviation.

Conditions	Adults		Children	
S-WH SS	99%	208/210 (M= 9.9, SD= 0.3)	95%	296/ 310 (M=9.5 , SD=0.72)
S-WH SP	99%	208/ 210 (M= 9.9, SD= 0.3)	96%	299/ 310 (M= 9.6, SD= 0.6)
O-WH SS	95%	201/ 210 (M= 9.8, SD= 0.35)	62%	195/ 310 (M=6.3, SD= 3.07)
O-WH SP	98%	207/ 210 (M= 9.6, SD= 1.21)	88%	275/ 310 (M= 8.9, SD= 1.5)

For the off-line accuracy data we used a repeated measures ANOVA with Group (children, adults) as a between subjects factor, and Sentence type (Which subject vs. Which object) and Matching (Match vs. Mismatch) as within subjects factors per subjects (F1) and per items (F2). Interactions were followed up using pairwise comparisons with Bonferroni correction.

The ANOVA showed main effects of Group ($F1$ (1, 50) = 31.889; $p < 0.0001$; ηp2= 0.389; $F2$ (1, 18) = 101.073; $p < 0.0001$, ηp2= 0.849), Matching ($F1$ (1, 50) = 41.507; $p < 0.0001$, ηp2= 0.454; $F2$ (1, 18) = 17.676; $p < 0.001$, ηp2= 0.495), and Sentence type ($F1$ (1, 50) = 24.714; $p < 0.0001$, ηp2= 0.331; $F2$ (1, 18) = 74.375, $p < 0.0001$; ηp2= 0.805).

We also found an interaction between Group, Matching and Sentence type only per subject ($F1$ (1, 50) = 8.507; $p < 0.0001$; ηp2= 0.45; $F2$ (1, 18) = 3.271; $p < 0.087$, ηp2= 0.154), Group and Matching ($F1$ (1, 50) = 25.077; $p < 0.0001$, ηp2= 0.334; $F2$ (1, 18) = 0.002; $p < 0.001$, ηp2= 0.143), Matching and Sentence type ($F1$ (1, 50) = 15.061; $p < 0.0001$, ηp2= 0.231; $F2$ (1, 18) = 13.551; $p <$

0.002, ηp2= 0.429), and Sentence type and Group (*F1* (1, 50) = 14.645; $p < 0.0001$, ηp2= 0.227; *F2* (1, 18) = 74.375; $p < 0.0001$, ηp2= 0.648). Pairwise comparisons were used to compare the different conditions and disentangle the interactions. The pairwise comparisons showed no significant differences between the conditions for the adults, but for the children's group there was a significant difference between S-WH-SS and O-WH-SS: (*F1* (1, 30) = 36.348; $p < 0.0001$; ηp2= 0.548; *F2* (1, 9) = 10.873; $p < 0.009$; ηp2=0.547), S-WH-SP and O-WH-SP : (*F1* (1, 30) = 6.289; $p < 0.018$; ηp2= 0.173; *F2* (1, 9) = 56.911; $p < 0.0001$; ηp2=0.863), and O-WH-SS and O-WH-SP (*F1* (1, 30) = 62.514; $p < 0.0001$; ηp2= 0.676; *F2* (1, 9) = 59.000; $p < 0.0001$; ηp2=0.868).

The pairwise comparisons between children and adults showed that adults were significantly more accurate than children in the S-WH-SS (t (50) = 2.231; $p < 0.03$), O-WH-SS (t (50) = 5.822; $p < 0.0001$), and O-WH-SP condition (t (50) = 3.027; $p < 0.004$). No difference emerged between the two groups for the S-WH-SP condition.

In the next two sections we present the eye-moment results for correctly and incorrectly comprehended questions.

3.2 Eye-tracking results for correctly comprehended questions

Figures 4 and 5 show the proportions of looks to the Target and Competitor picture for correctly comprehended S-WH-SS and S-WH-SP respectively in children and adults. Figures 6 and 7 show the proportions of looks to the Target and Competitor picture for correctly comprehended O-WH-SS and O-WH-SP in children and adults.

Figure 4. Proportions of looks to Target and Competitor in S-WH-SS for correctly comprehended sentences in adults and children

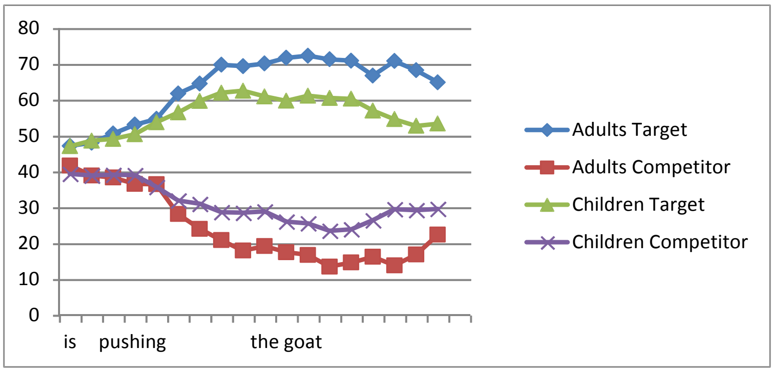


Figure 5. Proportions of looks to Target and Competitor in S-WH-SP for correctly comprehended sentences in adults and children

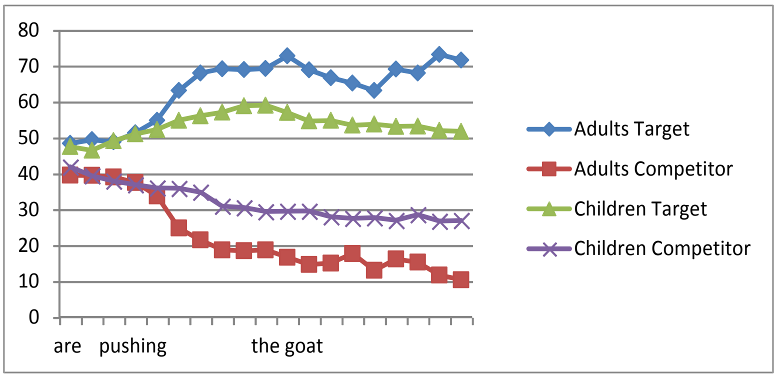


Figure 6. Proportions of looks to Target and Competitor in O-WH-SS for correctly comprehended sentences in adults and children

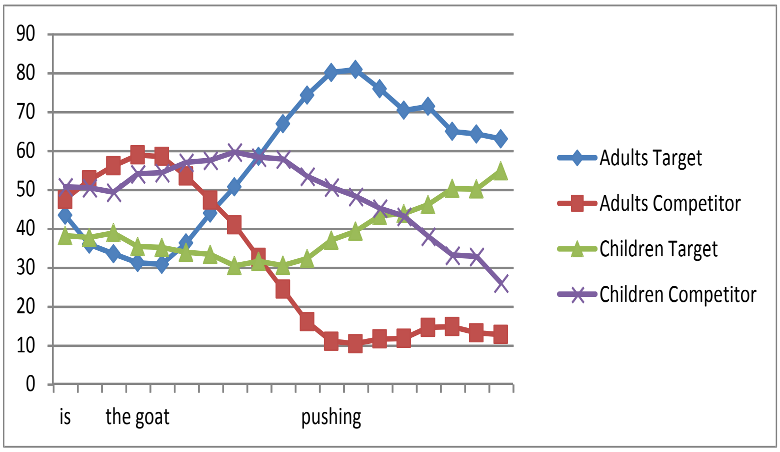
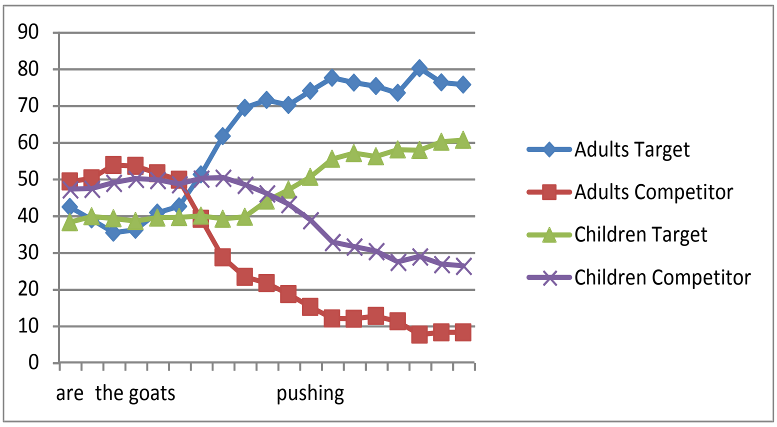


Figure 7. Proportions of looks to Target and Competitor in O-WH PS for correctly comprehended sentences in adults and children



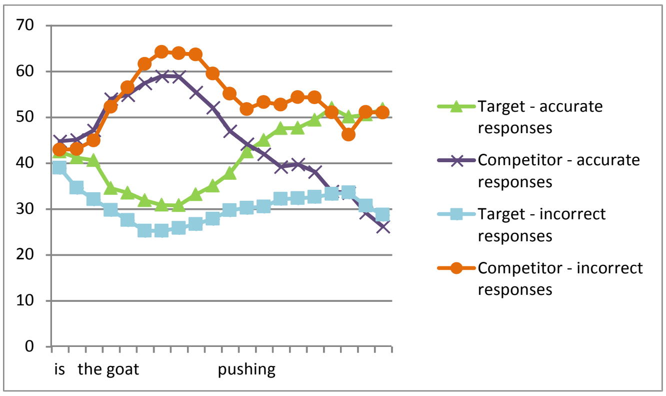
Eye-movements were time-locked to the onset of the auxiliary verb (*is/are*) and divided into five time-windows of 400 ms each. Differences in the proportion of eye-movements were analysed with Multi-level mixed logit modeling (Barr, 2008). The within subject factor were Sentence type (S-WH vs. O-WH) and Matching (singular vs. plural); Item and Participant were selected as random factors (Barr et al. 2013). The results for each time-window (TW1, TW2, TW3, TW4, TW5) are presented separately.

We found a main effect of Sentence type for TW1 (β=0.6, SE=.0.12, t=5.51, p<.001), TW2 (β=0.5, SE=.0.09, t=5.516, p<0.001), and TW3 (β=0.3, SE=0.08, t=4.414, p<0.0003) showing that until 1200 ms after the onset of the auxiliary, participants looked significantly more at the Competitor when presented with a O-WH question than a S-WH question. There was also a main effect of Group for TW3 (β=0.5, SE=0.06, t=8.312, p<0.001), TW4 (β=0.6, SE=0.06, t=10,503 p<0.001) and TW5 (β=1.1, SE=0.1, t=7.108, p<0.001), showing that overall children looked more at the Competitor than adults from 800 ms until 1600 ms after the onset of the auxiliary. We also found an interaction between Sentence type and Group in the absence of a three-way interaction in TW3 (β=0.17, SE=.0.05, t=2.958, p<0.004) and TW4 (β=0.2, SE=0.05, t=3.878, p<0.0006), with children looking significantly more at the Competitor than adults in O-WH questions compared to S-WH questions. Finally, in TW4 we found an interaction between Group, Sentence type, and Matching (β=0.13, SE=0.05, t=2.414, p<0.01). By comparing Sentence type and Matching only in the children's group, we found a main effect of Sentence type (ß=0.2, SE=0.2, t=3.638, p<0.005) and an interaction between Sentence type and Matching (ß=0.7, SE=0.34, t=2.269, p<0.04), indicating that from 1200 ms to 1600 ms children looked significantly more at the Competitor in O-WH-SS compared to O-WH-SP. By comparing Sentence type and Matching only in the adults' group, no main effect or interaction emerged.

3.3 Eye-tracking results (incorrect sentences)

This section presents the eye-moment results for the incorrectly compared to correctly comprehended questions in the O-WH-SS condition in children. The very small amount of inaccurate trials for the other three conditions and for the adult data (see Table 1) did not allow any analyses to be conducted for these conditions and for the adults. Figure 9 shows the proportions of looks to the Target and Competitor for correctly and incorrectly comprehended O-WH-SS. Only data for the children's group are presented here.

Figure 9. Proportions of looks to Target and Competitor in O-WH-SS for correctly and incorrectly comprehended sentences in children



As Figure 9 clearly shows, the children's looking pattern for incorrectly answered O-WH-SS was very similar to their looking pattern for correct S-WHs (see Figures 4 and 5). We compared the amount of looks to the Target and Competitor for O-WH-SS for accurate and inaccurate responses, by using a Multi-level mixed logit modelling, with Accuracy (accurate vs. inaccurate) as within subject factor and Item and Participant as random factors (Barr et al. 2013). The analysis showed a significant higher amount of looks to the Competitor for inaccurate O-WH-SS compared to accurate O-WH-SS from 1200 ms until 2000 after the onset of the auxiliary verb (TW4: β= 0.5, SE= 0.1, t= 4.843, $p<.0001$; TW5: β= 0.8, SE= 0.1, t= 5.336, $p<.0001$). The same comparison was not significant in the other time windows (from 0 to 1200 ms after the onset of the auxiliary verb).

4. Discussion & Conclusion

This study aimed at: 1) providing detailed insights into processing similarities and differences between *which*-subject and object questions in adults and children, 2) testing whether or not children make use of Number features in the interpretation of *which*-object questions off-line and on-line, and 3) providing a moment-by-moment record of how children and adults derive meaning when they parse *which*-questions in real-time using the visual word paradigm task. Accuracy analyses tested the children's off-line comprehension of subject and object *which*-questions and eye-movement analyses measured how children and adults process subject and object *which*-questions on-line. The results of the two analyses will be discussed separately.

The off-line data showed two main results: 1) children were less accurate than adults on S-WH-SS, O-WH-SS and O-WH-SP, and 2) children performed more accurately in S-WHs compared to O-WHs. These results are in line with previous studies showing a Subject-Object asymmetry in English-speaking children (e.g., Avrutin 2000 for English) and confirm previous cross-linguistic results on the comprehension of these structures (e.g., Friedmann et al. 2009 for Hebrew).

In our study, we also explored a novel morphological aspect of processing of Wh-questions, i.e. the role of number features in long-distance dependencies by manipulating the number properties of the subject/object NPs and auxiliary in S-WH and O-WH questions. The off-line results showed a facilitation for the mismatch condition in O-WH over the match condition and are consistent with previous results by Adani (2008) and Contemori & Marinis (2013a, 2013b) for Object relative clauses; by manipulating Number features in filler-gap dependencies, children experience a facilitation when the subject and object NPs differ in terms of number.

The eye-tracking data for the accurate sentences revealed that in the early time-windows (TW1, TW2 and TW3) both groups looked significantly more at the Competitor when an O-WH was presented compared to a S-WH. This indicates that both adults and children have a preference for a subject interpretation of the first NP (*the cow*) for all sentence types. In the time-windows TW3, TW4, adults looked more at the target than the competitor, whereas children continued to look more at the competitor than the target in O-WH questions. This indicates that after 1200 ms, adults successfully overrode the subject preference in O-WH questions, but children kept looking significantly longer than adults at the Competitor picture when an O-WH question was presented. The effect emerged between 800 and 1600 ms after the onset of the auxiliary, showing that children were significantly slower than adults in revising the subject preference in their interpretation of O-WH. Moreover, a triple interaction in TW4 indicates that among the two types of Object questions, children revised the initial subject interpretation earlier in O-WH-SP than in O-WH-SS. As mentioned in the introduction section, the disambiguation occurs earlier in O-WH-SP than in O-WH-SS. While in O-WH-SP the number information is available on the auxiliary verb (e.g., Which goat *are* the cows pushing?), in O-WH-SS, the disambiguation appears in the object NP. Thus, participants do not revise their interpretation until they encounter the object NP (e.g., Which goat is *the cow* pushing?). Adults revised their subject preference in both structures equally fast, and no such effect emerged in the adults' group in earlier time-windows. On the other hand, children seemed to commit to a subject interpretation more strongly than adults when they processed a O-WH-SS. This was shown both by the longer time they took to re-analyse a O-WH-SS, and by the more inaccurate off-line responses. Finally, for all sentence types children looked more at the Competitor than adults, showing that their preference for the Target or Competitor picture is less clear-cut than in adults. Children were also overall slower than adults in processing Which-object questions. This supports previous studies that reported a general slower processing for syntactic complex sentences in children compared to adults (e.g., Contemori & Marinis, 2013a, 2013b, Felser et al. 2003, a.o.).

Our results suggest that both groups have very similar looking patterns for the match and the mismatch conditions in S-WH and O-WH, and both groups display initially a preference for a subject interpretation when an O-WH is presented. However, adults override this preference quickly, both when there is a match and when there is a mismatch in number features between the first NP and the auxiliary. On the other hand, children's recovery from the subject preference in O-WH-SS is less efficient than that of adults. This seems to suggest that when the child parser encounters additional information compatible with the first subject interpretation (e.g., number agreement on the auxiliary), it commits more strongly than the adult parser to that analysis, and it is less flexible in revising it, in line with previous studies on filler-gap (Omaki et al., 2013), garden-path sentences (Trueswell et al., 1999), and passives (Marinis & Saddy, 2013). This hypothesis is also confirmed by the off-line accuracy results and the eye-movement data for incorrect sentences. The eye-movement patterns for the children's group in incorrect O-WH-SS seem to indicate that when children do not respond accurately to the comprehension question, their processing of O-WH-SS is very similar to that of S-WHs. This result indicates that children who answered incorrectly to the comprehension question never recovered from the first subject preference, and kept looking at the Competitor more than the Target picture for the whole length of the trial. Interestingly, the behavioural responses match the exact interpretation of the sentence, supporting the hypothesis that the child parser is less flexible than the adult parser.

To conclude, our data on the on-line processing of Which-questions in children indicate that children between 5 and 7;10 demonstrate similar processing reflexes with those observed in adults. Children rely on syntactic structure in their on-line sentence processing comparably to adults, and can successfully interpret also the harder object-which questions. When information disambiguating for a subject/object interpretation is provided early, children are more likely to interpret the O-WH correctly. On the other hand, when children have already committed to one of the interpretations, their reanalysis is less efficient compared to adults, and children are more likely to entertain the first (subject) interpretation.

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