

Elicited production of relative clauses in children with Williams syndrome

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5 Relative clauses have been implicated alternately as a strength and a weakness in the language of people with Williams Syndrome (WS). To clarify the facts, an elicited production test was administered to 10 people with WS (age 10–16 years), 10 typically developing children (age 4–7 years), and 12 typically developing adults. Nearly every WS participant successfully produced both subject gap (SG) and object gap (OG) relative clauses, and produced relative clauses in both right-branching and centre-embedded positions. However, OG relative clauses were produced less frequently than SG relative clauses, and trials targeting OG relative clauses often elicited contextually inappropriate responses. Critically, these two patterns were also observed in typically developing children, though at attenuated levels. It is argued that by late childhood people with WS know the structure and the meaning of relative clauses, but qualitatively normal processing factors cause unusually severe interference in some subprocesses of sentence production.

20 Williams syndrome (WS) is a congenital neurodevelopmental disorder with an estimated incidence of 1 in about 7,500 live births (Strømme, Bjørnstad, &

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This research was conducted by the author in partial fulfilment of a doctoral dissertation (awarded by Boston University; Zukowski, 2001). A sketch of some of the results of this study was provided in a recent review chapter (Zukowski, 2004). The pictures used in this study to elicit relative clauses were digitally altered versions of illustrations from *Everyday Words in German* (Litchfield, 1999). These illustrations were used by kind permission of Usborne Publishing Ltd.

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Ramstad, 2002). A hemizygous microdeletion on the long arm of Chromosome 7 affects at least 19 contiguous genes (Hillier et al., 2003; Osborne et al., 2001) with consequences for multiple physical and cognitive systems. Cognitively, WS is associated with mild to moderate mental retardation, including a particular weakness in visuospatial constructive cognition, as observed in tasks requiring freehand drawing, drawing to match a model, and constructing block patterns to match a model (see Morris & Mervis, 1999 for a detailed description of the full range of features associated with WS). Language development is typically delayed in WS from the earliest stages onward. First words and first productive word combinations are delayed in most people with WS, sometimes substantially (Mervis et al., 1995; Mervis, Robinson, Rowe, Becerra, & Klein-Tasman, 2003). The appearance of complex syntactic structures in spontaneous speech is also delayed, although the complexity of utterances is developmentally appropriate for utterance length, and particular complex structures appear in spontaneous speech in a developmentally normal sequence (Klein, 1995). Very little is known about ultimate attainment of knowledge of particular structures.

In the past decade or so, differing characterisations of the language of people with WS have been used to support differing theoretical claims about language modularity and innateness. One view holds that language, or minimally syntax, is essentially intact in people with WS (Pinker, 1994; Piatelli-Palmarini, 2001), despite the mental disability associated with the disorder. According to this view, WS represents one half of the double dissociation between language and cognition that is predicted if language is a domain-specific cognitive system (it has been argued that Specific Language Impairment represents the other half of the double dissociation; Clahsen & Almazan, 2001). Another view holds that language in people with WS is not intact, that it is merely superficially good, and that language development is atypical (Karmiloff-Smith, 1998; Thomas et al., 2001). This view has primarily been advocated by researchers who adopt a 'neuroconstructivist' framework, in which the domain specificity of cognitive systems is argued to emerge developmentally from the interaction of experience and 'domain relevant' mechanisms that characterise the infant brain. Subtle differences in the brains of infants with WS are argued to preclude normal cognitive systems from developing (see Karmiloff-Smith, 1998, for further discussion).

Relative clauses in people with Williams syndrome

Facility with relative clauses has played an important role in the characterisation of language in this disorder. One early paper on language and cognition in people with WS reported spontaneous production of embedded relative clauses (Bellugi, Marks, Bihrlé, & Sabo, 1988), suggesting knowledge

of complex syntax. This finding seemed at odds with the investigators' observations of people with Down syndrome, who have a roughly comparable degree of mental disability, and these contrasting language profiles were taken as an indication that language abilities surpass overall cognitive abilities among people with WS. However, this report was based on only three people, and the details about what types of relative clauses were produced were not provided. Thus, it is not clear how representative these cases are of the population generally, nor is it clear whether all types of relative clause are attested. More recently, there have been numerous reports of deficits in the comprehension of relative clauses embedded in main clauses among people with WS (Karmiloff-Smith, Grant, Berthoud, Davies, Howlin, & Udwin, 1997; Mervis, Morris, Bertrand, & Robinson, 1999; Volterra, Capirci, Pezzini, Sabbadini, & Vicari, 1996). All of these studies use the Test for Reception of Grammar (TROG; Bishop, 1983), and performance is inevitably worst for relative clauses containing object gaps that are in centre-embedded position within a main clause (e.g., *The man the elephant sees is eating*). These results, among others, have been cited as evidence favouring the view that language is not intact in people with WS (Karmiloff-Smith et al., 1997, Karmiloff & Karmiloff-Smith, 2001). Results from one recent study that used the method of elicited imitation showed that older children and young adults with WS exhibit normal patterns of difficulty in processing relative clauses, but that the absolute level of performance does not exceed that of typically developing 5-year-old children (Grant, Valian, & Karmiloff-Smith, 2002).

It makes a great deal of difference to the debate whether the problems reflected in poor comprehension of relative clauses by people with WS are due to deficient knowledge of relative clauses or to impaired processing of these structures. It is important to recognise that these are orthogonal questions. Unimpaired adults, who have fully intact grammatical knowledge, have difficulty comprehending object gap relative clauses and read them more slowly than other types of relative clauses, and this is particularly true for individuals with abnormally limited processing resources such as low working memory capacity (Gibson, Desmet, Grodner, Watson, & Ko, 2005; Just & Carpenter, 1992; Traxler, Morris, & Seely, 2002; Wanner & Maratsos, 1978). Language processing cannot rightly be said to be 'intact' or not, but varies as a function of the structures being processed and the processing resources of the speaker. The question of whether WS language is intact or not is most meaningful with respect to grammatical knowledge. If people with WS are able to acquire normal grammars despite the fact that their brain development is slightly atypical, this would contradict expectations that have been articulated by some researchers working within a neuroconstructivist framework (Karmiloff-Smith, 1998; Thomas et al., 2001). On the other hand, if poor comprehension of relative clauses by people with WS is

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105 due to difficulty processing structures that are nevertheless part of the
grammatical competence system, this would not bear on the debate.
Therefore it is crucial to determine whether the problems that people with
WS have with relative clauses reflect impaired knowledge of relative clauses
or impaired processing of these structures.

110 What is currently known about both knowledge and use of relative clauses
among people with WS is still relatively coarse. In terms of production, it is
not known whether the ability to produce relative clauses is rare or
commonplace within the WS population. It is also not known whether
115 those structures produced are restricted to easier types of relative clauses or
whether they include more difficult types of relative clauses. In terms of
comprehension, it is clear that people with WS have difficulty comprehending
some types of embedded relative clauses, especially under rigorous testing
conditions. However, poor results on comprehension tests do not reveal the
120 source of the difficulty (deficient knowledge or impaired processing). In fact,
even good results on comprehension tests can be difficult to interpret.
Comprehension tests often require the participant to point to one picture
from an array that matches a spoken utterance, but it is not practical to
include distractor pictures that violate every grammatical detail relevant to
125 relative clauses, and thus children could get the right answer even while
lacking knowledge of some grammatical details. Results from the elicited
imitation study of Grant et al. (2002) are similarly inconclusive with respect
to knowledge of relative clauses. In order to successfully imitate a sentence of
moderate structural complexity, a listener must first comprehend it success-
fully. Poor imitation performance could therefore stem entirely from
130 comprehension difficulty, which as discussed above, does not conclusively
implicate deficient grammatical knowledge.

The goal of the study reported here was to substantially broaden the
empirical base of information regarding relative clause knowledge and use
among people with WS. An elicited production task was used to investigate
135 whether young people with WS are able to produce noun phrases with
restrictive relative clauses of two types (subject gap and object gap) in three
types of syntactic contexts (centre-embedded, right-branching, and in
freestanding noun phrases). Elicited production was chosen because
successful production of unmodelled relative clauses provides the clearest
140 evidence of knowledge of those structures. The technique places participants
in communicative situations that are designed so as to make structures of
interest highly appropriate, and to make alternative responses inappropriate
or insufficient. When this contextual manipulation is successful, rates of
production of structures that are rare in spontaneous speech can increase
145 dramatically. Complete failure to produce target structures under these
conditions is more meaningful than in spontaneous speech contexts, and it
strengthens the possibility that those structures are unavailable to the

150 speaker. Furthermore, if normally rare structures are attempted in response
to the elicitation protocol, their incidence and quality can be analysed, and
these can in turn reveal how easy or difficult it is to produce different
structures, whether the structures are used appropriately, and which
155 grammatical details, if any, are problematic. A sketch of some of the results
of this study was provided in a recent review chapter (Zukowski, 2004).
However, this paper presents the first comprehensive presentation and
analysis of the results, including results of the critical embedding manipula-
tion, an examination of individual differences, and comparison data from a
group of typically developing adults. As a point of comparison for this study,
160 the next section reviews results from previous studies that have used elicited
production to examine English relative clauses in young unimpaired
children.

Relative clauses in young unimpaired children

165 Many studies have used elicited production to examine facility with relative
clauses among young English-speaking children, but, surprisingly, very few
report rates of correct production of different relative clause types. Among
those published reports that do provide this information, a consistent pattern
has been observed. In studies with children as young as age 3 years (Bar-
Shalom, Crain & Shankweiler, 1993; McDaniel, McKee, & Bernstein, 1998;
170 McKee & McDaniel, 2001), rates of production of subject gap (SG) relative
clauses (e.g., *the elephant that is flying*) are very high (75–100%) in trials
designed to elicit these structures. By comparison, rates of production of
object gap (OG) relative clauses (e.g., *the one who the boy is kissing*) are
consistently lower (no higher than 55%) in trials designed to elicit these
175 structures, and some children fail to produce any OG relative clauses at all in
a testing session. In these studies, responses in OG target trials are sometimes
passive SG relative clauses (e.g., *the one who's being/getting kissed*, rather
than *the one who the boy is kissing*). Note that this alternative response is not
available in SG target trials (e.g., one cannot passivise *the elephant that is
180 flying*). Thus, the SG/OG asymmetry observed repeatedly in these studies
may be due in part to the availability of alternative means for expressing the
meanings associated with these different structures.

A surprising gap in the literature on children's (non-imitative) elicited
production of relative clauses is that no studies have been designed
specifically to investigate children's ability to embed relative clauses inside
of a main clause. A few studies have led children to produce sentences like
185 *Pick up the elephant that is flying on a plane* (Hamburger & Crain, 1982;
McKee & McDaniel, 2001; McKee, McDaniel, & Snedeker, 1998). In all of
these cases the relative clause appears in a right-branching context (i.e., the
relative clause modifies the NP to the right of the verb – the main clause

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object). However, because the embedding of children's responses was not a focus of these studies, rates of successful embedding of relative clauses even in this simple invariant context were not reported in any of these studies.

The grammatical well-formedness of relative clauses produced by typically developing children was examined in detail in a study of toddlers acquiring English (McKee, McDaniel, & Snedeker, 1998). In this elicited production study with children age 2–3 years, although one third of all relative clauses produced contained some type of error, the majority of these errors involved components of syntax that are not specific to relative clauses (e.g., omission of an auxiliary, number agreement). Those errors that were specific to relative clause syntax included the use of the wrong relative pronoun, as in *'The potato what she's rolling'*, the use of resumptive pronouns, as in *'Pick up those two what the dinosaur is eating them'*, which has a resumptive pronoun ('them') in object position as well as the wrong relative pronoun, omission of a head noun, as in *'That the monkey's petting'*, and 'wrong head' errors, which are described below.

Production errors like those that McKee et al. (1998) called 'wrong head' errors have not been widely reported in the extensive literature on first language development of relative clauses, but they are reviewed here because of their relevance to the results reported in this paper. In a wrong head error, the child's answer to the experimenter's question modifies the wrong head noun. For example, when one child in the study by McKee and colleagues was asked 'Which lemon should I pick up?' the child responded with 'The boy that's jumping on it' (*'it'* refers to a lemon), and further questioning made it clear that the child correctly understood that her response was supposed to direct the experimenter to pick up a lemon, not a boy (McKee et al., 1998, p. 594). The error was rare in this study, occurring only 9 times among 26 children who each responded to 12 elicitation attempts, but all 9 occurrences came from OG target trials, and one child's individual rate of production of this error among OG target trials was 50% (3/6). Unlike resumptive pronoun errors, which are contextually appropriate but grammatically ill-formed (according to most accounts of English, but cf. McKee and McDaniel, 2001), wrong head errors are contextually inappropriate despite being grammatically well-formed. Interestingly, wrong head errors have also been observed to occur in adult second language learners. Specifically, native English speaking adults acquiring Korean as a second language make wrong head errors in both their comprehension and production of Korean relative clauses (O'Grady, Lee, & Choo, 2003; O'Grady, Yamashita, Lee, Choo, & Cho, 2000). Such errors are particularly common when the target structure is an OG relative clause. Precisely how such errors should be characterised will be addressed in the discussion section.

235 A major drawback of previous studies of relative clause production in
children is that none were designed specifically to investigate children's
ability to embed a relative clause inside of a main clause. It is critical to
attempt to elicit these more complex structures, since these structures were
used in previous comprehension tests used to evaluate language in WS.
240 Therefore in the current study a new method was designed that elicits relative
clauses inside of a main clause, without the use of imitation. This necessary
design change will also help to fill the gap in the literature on typically
developing children's ability to produce relative clauses in these more
complex syntactic contexts. Thus in addition to the primary goal of
expanding our understanding of relative clause knowledge and use among
people with WS, a secondary goal of this study is to determine how the
performance of typically developing children scales up when they have to
produce relative clauses in embedded sentence contexts.

245 A second accommodation of the present study to previous findings is to
include a large number of opportunities for OG relative clause production.
Since OG target trials sometimes elicit legitimate non-OG structures (e.g.,
responses containing passive SG relative clauses), the inclusion of many OG
target trials will give every participant ample opportunity to produce an OG
250 relative clause.

Questions for this study

To summarise, the empirical questions addressed in this research include the
following. Do people with WS produce both SG and OG relative clauses? If
so, are they well-formed or do they have grammatical errors? Are they used
255 appropriately or inappropriately? Do they appear in both centre-embedded
and right-branching positions inside main clauses? Are these production
abilities common or rare among people with WS? And how do these abilities
compare to typically developing children of similar mental age?

260 If relative clauses with certain gap types (SG or OG) are never produced
by individuals with WS, and if these structures are produced by typically
developing children in similar elicitation contexts, this would support the
possibility that these structures are simply unknown; they are not part of the
grammatical competence system of these individuals.¹ If these structures are
produced, but the rate of production is very low or varies as a function of
265 embedding context, this would suggest that these structures are part of the
grammatical competence system, but producing these structures in real time

¹ Unfortunately it is difficult to prove this conclusively, because targeted structures could fail to be produced for other reasons too. For example, certain individuals or groups might respond differently to the contextual pressures that successfully elicit these structures from other participants. Fortunately, this is not an issue, given the results of the study reported here.

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is difficult. If these structures are produced robustly, are well-formed, and are used in appropriate contexts, this would implicate both intact knowledge of relative clauses and ease of producing them.

270 The embedding results will be most relevant to the question of the
processing difficulty associated with producing relative clauses in certain
embedded positions, rather than to the question of syntactic knowledge. This
is because, based on the widespread assumption that children have an
275 abstract representation of clauses as consisting of a subject noun phrase
(NP) and a verb phrase containing a verb and an object NP, any individual
who knows how to produce a relative clause in a freestanding NP 'knows'
that relative clauses can also occur in centre-embedded and right-branching
positions within another clause. However, such knowledge does not
guarantee the ability to produce relative clauses in these positions. Previous
280 research with people with WS and typically developing children has shown
that comprehension of centre-embedded OG relative clauses is particularly
poor, but that comprehension of centre-embedded SG relative clauses is
comparatively quite good (Karmiloff-Smith et al., 1997). A similar pattern in
production would suggest that the processing difficulty associated with
285 centre-embedding is not enough by itself to interfere with language
production in young people with WS and with typically developing children,
but that the combined processing difficulty associated with centre-embed-
ding and with OG relative clauses renders the production of this combina-
tion particularly problematic.

290 METHOD

Participants

Eleven children and adolescents with WS were examined in this study.
However, the youngest child with WS (age 8;4) could not complete the task
due to immature 'theory of mind' understanding; when asked to tell a
295 listener which of two characters a change had happened to, she repeatedly
pointed to the character and said 'this one', even though the listener could
not see what she was pointing to. The remaining group of 10 WS participants
ranged from age 10;0 to 16;3, with a mean age of 12;5. Diagnosis of WS was
confirmed in each of the WS participants with a positive confirmation of
300 deletion of the elastin gene. The participants with WS lived within a few
hundred miles of the University of Delaware. Also included were 10 typically
developing children (age 4;6 to 7;6, $M = 6;0$). These children were recruited
from the Newark, DE community. A second comparison group consisted of
305 12 typically developing adults (7 female and 5 male), who were students at
the University of Maryland.

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Each participant with WS was paired with a typically developing child on the basis of raw scores on the Matrices subtest of the Kaufman Brief Intelligence Test (KBIT; Kaufman & Kaufman, 1990). For each matched pair, KBIT Matrices raw scores were within 3 points of each other. It was not deemed important for subject pairs to be similarly matched on the Verbal subtest of the KBIT, since this subtest primarily assesses vocabulary knowledge and knowledge of word spellings; nevertheless, the subject pairs were often closely matched on Verbal raw scores because they were participating in additional studies that did require this. Tables 1 and 2 provide raw scores and standard scores for both subtests of the KBIT and for the TROG (Bishop, 1983) for each group. Pooled *t*-tests demonstrated that the raw scores for these two groups did not differ for either subtest of the KBIT (for Matrices raw scores, $t(18) = .25$, $p = .80$; for Vocabulary raw scores, $t(18) = .64$, $p = .53$). However, there was a near-significant difference in TROG raw scores, due to better performance by the TD children, $t(18) = 2.02$, $p = .06$. Thus, the TD children are probably advanced in sentence comprehension skills relative to the WS group. Two subtests of the Differential Abilities Scale (Elliot, 1990) were also administered to the WS group. The mean age equivalent on the Block Construction subtests was 4;2 (range 3;4 to 5;7), and the mean age equivalent on the Digit Recall subtest was 5;2 (range 4;4 to 7;4). These results are typical for WS children and adolescents (Bellugi, Wang, & Jernigan, 1994; Mervis et al., 1999; Udwin & Yule, 1991).

TABLE 1
Subject profiles: WS participants

Subject ID	Age	KBIT		TROG raw score	KBIT	
		Matrices raw score	Vocabulary raw score		Matrices standard score	Vocabulary standard score
1	15;0	24	46	10	73	74
2	10;5	22	27	16	87	58
3	11;3	21	40	11	80	79
4	10;0	21	32	15	47	71
5	14;2	20	31	11	63	44
6	14;0	19	35	8	59	53
7	10;5	18	30.5	9	74	65
8	10;4	17	42	6	70	90
9	12;8	16	40	8	56	71
10	16;3	14	31	8	40	40
<i>M</i>	12;5	19.2	35.5	10.2	64.9	64.5

TABLE 2
Subject profiles: TD children

<i>Subject ID</i>	<i>Age</i>	<i>KBIT</i>		<i>TROG raw score</i>	<i>KBIT</i>		
		<i>Matrices raw score</i>	<i>Vocabulary raw score</i>		<i>Matrices standard score</i>	<i>Vocabulary standard score</i>	
1	7;6	21	45	16	99	144	104
2	6;2	25	32	16	125	112	110
3	7;0	21	41	16	103	132	104
4	7;5	22	33	10	104	104	80
5	4;6	20	35	14	129	146	122
6	7;2	20	37	17	100	116	111
7	5;7	17	28	16	103	107	124
8	4;6	16	27	14	112	119	122
9	4;10	13	26	5	98	112	87
10	5;6	13	33	10	90	120	91
<i>M</i>	6;0	18.8	33.7	13.4	106.3	121.2	105.5

Materials

Two measures of relative clause abilities were used. The first measure consisted of the three trial blocks from the TROG (Bishop, 1983) that include relative clauses embedded in a main clause. The second measure consisted of a new elicited production task that was designed to answer the questions raised in this paper. The goals of this study required that the production task offer many contextually felicitous opportunities for the production of both SG and OG relative clauses in both freestanding NPs and inside of main clauses in both subject NPs (i.e., centre-embedded) and object NPs (i.e., right-branching). A 2 (target gap) \times 3 (target embedding) within-subjects design was used. The six resulting conditions are shown in Table 3, along with examples of target responses. Note that in the OG condition, the gap in the target structures sometimes corresponded to the object of a simple transitive verb (e.g., the TV that the boy is watching), and sometimes corresponded to the object of a verb+spatial preposition combination (e.g., the boy who the girl is jumping over). Here and throughout, structures of both of these types are referred to as 'OG relative clauses'.

The materials consisted of computerised images that satisfied all of the features of previous elicited production studies that are known to facilitate the production of relative clauses: two identical tokens of a character or object are presented side by side, and the token that the experimenter will ask the participant to individuate for a naïve observer is depicted as participating

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TABLE 3
Experimental conditions with target responses

<i>Target gap and target embedding</i>	<i>Target response</i>	<i>No. of trials</i>	<i>No. of Target structures expected per trial</i>
Subject gap, freestanding NP	The boy who __ is waving.	16	1
Subject gap, right branching	Max is looking at the boy who __ is waving, and Bill is looking at the boy who __ is washing his hair.	8	2
Subject gap, centre embedded	The boy who __ is waving turned red, and the boy who __ is washing his hair turned green.	8	2
Object gap, freestanding NP	The boy who the dog is jumping over __.	16	1
Object gap, right branching	Max is looking at the boy who the dog is jumping over __, and Bill is looking at the boy who the girl is jumping over __.	8	2
Object gap, centre embedded	The boy who the dog is jumping over __ turned red, and the boy who the girl is jumping over __ turned green.	8	2

in an event, which is thereby available to be mapped onto a restrictive relative clause.

In order to facilitate the production of relative clauses embedded inside main clauses, a few minor but critical changes were made to the materials and procedure. First, both tokens of the character or object that the experimenter intended to ask the participant to individuate were depicted as participating in events, and these two events were minimally contrastive. Second, after the experimenter examined a picture with the participant and described the two events with simple active declarative clauses, both tokens underwent a change (e.g., one turned red and the other turned blue). Finally, the experimenter asked the participant to tell a naïve observer which token had undergone which change. This request was presented as one question, as in ‘Which girl turned red, and which girl turned blue?’ It was the posing of a double question that provided the critical context that required participants to embed their NPs containing relative clauses inside a main clause. This is because it would be inappropriate to reply ‘The one who’s jumping over the truck and the one who’s sitting on the truck’. The double question requires that each of the NPs containing a relative clause be attached to the appropriate main clause, as in ‘The one who’s jumping over the truck turned red, and the one who’s sitting on the truck turned blue’. As can be seen in this example, an unavoidable consequence of asking double questions is that target responses contain not one but two

375 examples of the target gap relative clause in the target embedded position. Centre-embedded relative clauses were always elicited by having the two
tokens change colour, as in the example above. Right-branching relative
380 clauses were always elicited by having two small animals (a blackbird called Bill and a mouse called Max) appear in the picture and 'look at' different
tokens. This was intended to elicit responses such as 'Max is looking at the
girl who's jumping over the truck, and Bill is looking at the girl who's
sitting on the truck'.

385 Eight pictures were designed to elicit SG relative clauses, and another eight pictures were designed to elicit OG relative clauses. For the pictures
designed to elicit SG relative clauses, it was the agent of the event depicted in
the stimulus picture that underwent a subsequent change. For the pictures
designed to elicit OG relative clause, it was the patient that underwent a
subsequent change. A description of the 16 pictures prior to the change that
390 provoked the experimenter's question is given in Appendix A. The pictures
were created by manipulating digitally scanned pictures from a child's
reference book (Litchfield, 1999).

Each of the 16 pictures was presented four times to each participant (not
consecutively). For each picture, on one of the presentations, two characters
changed colour, and the target response consisted of two examples of centre-
395 embedded relative clauses. On another of the presentations, Max the mouse
looked at one character and Bill the blackbird looked at the other character;
in this case the target response consisted of two examples of a right-
branching relative clause. Two additional presentations involved just a single
change, and the target response for both was a freestanding NP containing a
relative clause. An example of the picture sequence seen in all four trials
400 created from one of the 16 original pictures is provided in Figure 1.

The 16 pictures \times 4 presentations resulted in 64 trials, 32 with NP-only
405 targets, and 32 with full sentence targets. Since each full sentence trial yielded
opportunities for 2 relative clauses (embedded in 2 conjoined main clauses),
this resulted in 96 total opportunities for relative clauses for each participant:
48 for SG and 48 for OG, with a third of each (16) targeted to appear in a
freestanding NP, another third to appear in a RB context, and the final third
to appear in a CE context.

The 64 trials were presented on a computer one at a time. Each trial
410 consisted of presentation of the original picture followed by one of the four
change pictures. There were three orders of presentation of the 64 trials.
For each order, the first 16 trials all targeted a freestanding NP containing
a relative clause. These trials served to familiarise participants with the task
and the stimulus pictures before they were confronted with trials that
required the production of multiple main and embedded clauses. These 16
415 trials were randomly mixed into three different orders. The remaining 48
trials in each order consisted of the remaining 16 freestanding NP trials

and the 32 embedded trials. These trials were mixed together and ordered pseudorandomly; there was a minimum of three trials intervening between presentations of the same pre-change picture. Each matched WS–TD child pair was presented with the same order of presentation.

Also for each order a binder was prepared, which contained printed copies of the 64 pre-change pictures. These were prepared for use by the naïve observer who could not see the changes on the computer screen. Transparent colour patches and pictures of a small mouse and a small bird were also prepared so that the naïve observer could place them on the binder pictures in response to the participant's description of the change.

Procedure

The task was introduced to each participant as a 'test' that she and the experimenter would jointly administer to a third person. The third person was either an accomplice of the experimenter (when a second experimenter was available) or a parent. The participant and the experimenter sat on one side of a table looking at pictures on a laptop computer, while the 'test-taker' sat on the other side of the table looking at a binder containing pictures that matched the trial pictures prior to the change. The participant was told that when the spacebar was pushed, a change would occur in the picture she was looking at: either a little mouse ('Max') would appear in the picture and would look at one of the characters or objects, or one of the characters or objects would change colours. The participant was prompted to tell the test-taker what change had occurred, so that he or she could place a picture of a mouse or a colour patch over or near the appropriate character. A representative opening description to one child went as follows:

So here's how this game works. We're going to look at these pictures. And your mom has a picture just like ours. So there are two girls, and they are both playing with trucks. One girl is jumping over her truck, and the other girl is sitting on her truck. And what's going to happen is, my friend Max the mouse is going to show up, and he's going to look at one of the trucks. And we have to tell your mom which truck Max is looking at, so she can put a copy of Max on her sheet. And then she'll show it to us and we'll tell her whether she got it right or not. Ok? So this girl is jumping over the truck, and this girl is sitting on a truck. Let's see where Max shows up. (picture changes) Can you see Max? Ok, tell your mom, which truck is Max looking at?

As the sample task introduction demonstrates, the two events in each picture were described to the participant by the experimenter with simple active declarative sentences. The experimenter never produced relative clauses in her descriptions of the pictures, so that there would be no models of relative clause syntax available in the immediate context. When parents

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participated as the 'test taker', they were instructed to restrict their feedback to indicating that they did not yet have enough information to guess what change had occurred.

The full test took between 25 and 75 minutes to complete; the younger TD children typically took much longer than the older TD children and the participants with WS. Several participants from both of the child groups needed two visits to complete the test, due to time constraints or fatigue. All other participants completed the test in a single visit.

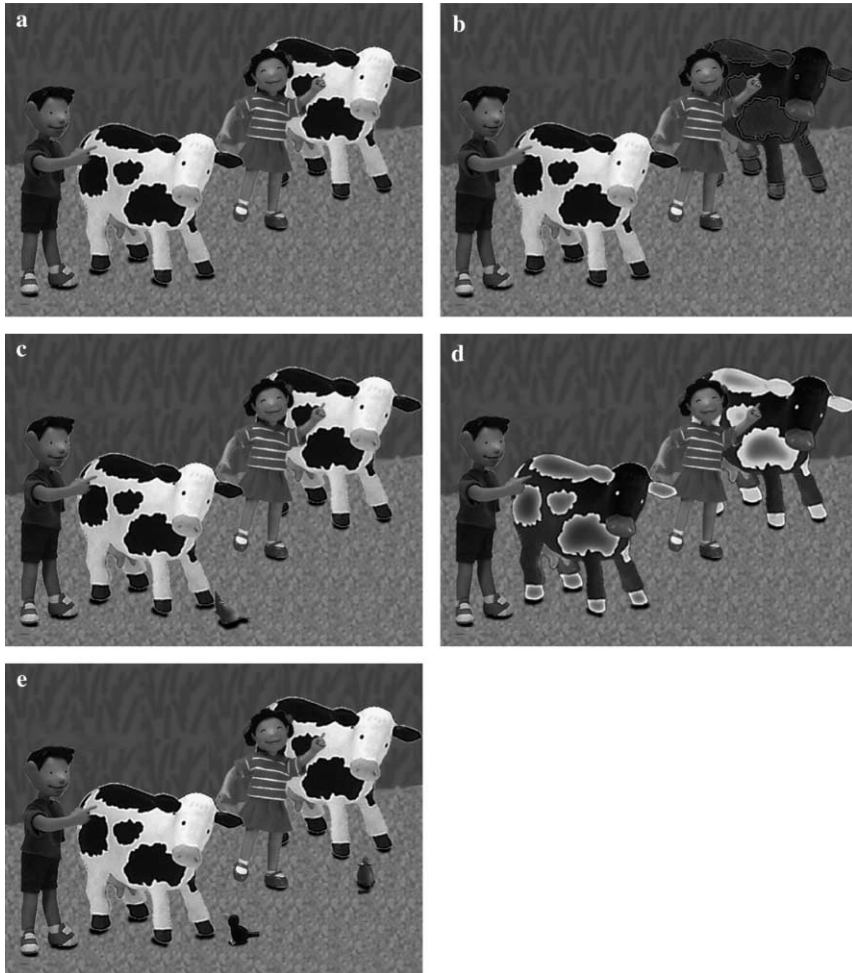


Figure 1. (continued)

RESULTS

TROG relative clause comprehension results

Figure 2 shows rates of per cent correct comprehension of different types of sentences containing relative clauses from the TROG for three groups: the TD child group, the WS group, and, for comparison, the WS group tested by Karmiloff-Smith et al. (1997) (the only previous paper reporting TROG results that included these details). The overall pattern of comprehension difficulty is similar for the three groups. Centre-embedded OG relative clauses are the most difficult for every group; given that chance performance on this test is 25% correct, the two WS groups in Figure 2 are essentially guessing for sentences of this type. Subject gap relative clauses yield much higher rates of successful comprehension. Interestingly, centre-embedded SG relative clauses are not more difficult than right branching SG relative clauses. The TROG does not include items with right branching OG relative clauses. Importantly, the WS group examined in this study performed at least as poorly at comprehension of relative clauses as the WS group examined by Karmiloff-Smith et al. (1997). To help determine whether this poor performance reflects a deficit in knowledge or processing of relative clauses, the next section turns to the results of the elicited production task.

Figure 1. Sample materials for elicited production task: (a) original picture prior to change, (b) and (c) pictures used to elicit a relative clause in a freestanding NP, (d) picture used to elicit a relative clause in centre-embedded position, (e) picture used to elicit a relative clause in right-branching position.

1a. Original Picture

Description: Here are two cows, and a girl is pointing to one cow, and a boy is pointing to the other cow. Let's see what happens.

1b. NP Condition (subject question)

Prompt: Which cow turned blue?

Target: The cow that the girl is pointing to.

1c. NP condition (object question)

Prompt: Which cow is Max looking at?

Target: The cow that the boy is pointing to.

1d. Centre-embedded condition

Prompt: Which cow turned red and which cow turned yellow?

Target: The cow that the girl is pointing to turned yellow, and the cow that the boy is pointing to turned red.

1e. Right branching condition

Prompt: Which cow is Max looking at, and which cow is Bill looking at?

Target: Bill is looking at the cow that the boy is pointing to, and Max is looking at the cow that the girl is pointing to.

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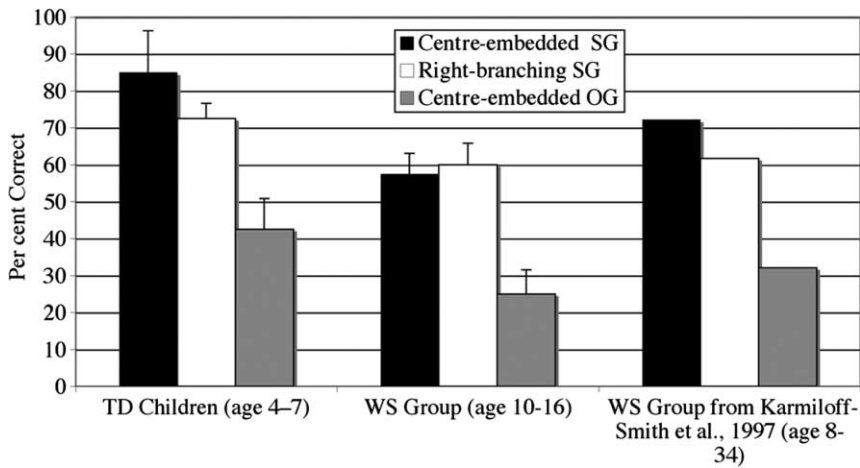


Figure 2. TROG results.

Elicited production results

A concise overview of responses from the elicited production task is shown in Table 4. Responses in Table 4 are classified into three basic categories: those containing an SG relative, those containing an OG relative, and all others. For purposes of this classification, SG and OG relatives are defined as clauses modifying a head noun and containing a gap in either subject or object position respectively (a 'gap in object position' refers to either a gap corresponding to the object of a simple transitive verb, as in 'the TV that the boy is watching', or to a gap corresponding to the object of a verb + spatial preposition, as in 'the boy who the girl is jumping over'). 'Other' responses are all responses that did not contain a relative clause with a gap. The results in Table 4 show that the task was highly successful at eliciting relative

TABLE 4

Overview: Per cent production of major responses by target gap condition

Response type	Target gap condition and group					
	SG (<i>n</i> = 48 trials)			OG Target (<i>n</i> = 48 trials)		
	TD Adults	TD Children	WS	TD Adults	TD Children	WS
SG relative	95.4 (595)	82.3 (395)	76.7 (368)	15.5 (97)	22.9 (110)	46.9 (225)
OG relative	0 (0)	3.1 (15)	.4 (2)	53.5 (334)	51.0 (245)	10.0 (48)
Other	4.6 (29)	14.6 (70)	22.9 (110)	31.1 (194)	26.0 (125)	43.1 (20.7)

Note. Numbers in parentheses reflect actual counts.

clauses, and that the corpus of data on which the forthcoming analyses are based is substantial. Examples of SG and OG relative clauses produced by WS participants are shown in Table 5.

The values in Table 4 indicate the mean per cent production of the three basic response types as a function of target gap condition (SG or OG) and group. Results from all three embedding contexts are collapsed here, and thus for each column the number of total responses that the percentages are based on is $48 \times$ the number of subjects in the group. Grey cells in Table 4 represent responses containing a relative clause with a gap in the targeted position. Responses in non-grey cells of the table did not contain the targeted gap. 'Other' responses were, in the majority of cases, appropriate alternatives for describing the picture changes that participants observed. Details about these responses are provided in Appendix B, and will not be discussed further here, with the exception of the small number of 'other' responses that may contain a relative clause with a filled gap.

The next section provides details about the grammatical well-formedness of all responses from the WS and TD child groups containing a relative clause with a gap (first two rows of Table 4), in addition to responses from the 'other' category that appear to contain an illicit filled gap within a relative clause. This is followed by a more detailed examination of the distribution of target gap responses (grey cells in Table 4), and then by an examination of the large number of SG relative clauses produced in the OG target condition.

Grammatical details

The analysis of grammatical details is confined to responses from the WS and TD child groups, since the TD adult group made a negligible number of errors.

Grammatical errors in responses containing a relative clause with a gap. The total number of relative clauses with a gap that were produced

TABLE 5
Sample responses *containing* relative clauses from the WS group

<i>Participant characteristics</i>	<i>Elicited response</i>
Female, age 10;5	Bill is looking at the, the horse that the other kid is sitting on.
Male, age 10;7	The one that's looking at the horse is green.
Female, age 11;5	The one that's turning yellow is the girl that's jumping over the man.
Male, age 12;10	Max is looking at the cow who um the boy's pointing to.
Female, age 14;3	The one that's jumping over a dog turned blue.
Male, age 16;5	Bill is looking at the cat that the girl's chasing.

525 by the WS group is 643. Of these, 92 (14.3%) contained a grammatical error
of some kind. However, two-thirds of these errors (62) were produced by a
single WS participant (no. 5, see Table 1). Since this participant was an
outlier with respect to errors, his data were removed from this corpus (his
errors are discussed in Appendix C). This left a corpus of 570 gap-containing
530 relative clauses produced by nine WS participants. The rate of grammatical
errors for this corpus is 5.3% (30/573). Only six of these errors involve
grammatical details specific to relative clauses: three relative clauses were
lacking a head, and three had a problem with the relativising pronoun.

535 A highly similar pattern was observed in the group of TD children. Out of
765 gap-containing relative clauses produced, 46 (6.0%) contained a
grammatical error of some kind, but 46% of these (21) were produced by a
single TD child (no. 9, see Table 2). His data were removed (see Appendix C),
leaving a corpus of 683 gap-containing relative clauses produced by 9 TD
540 children. The rate of grammatical errors for this corpus is 3.7% (24/683).
Only nine of these errors involved grammatical details specific to relative
clauses, and the types of errors were similar to those observed in the WS
group. It should be noted that even after the removal of WS participant no. 5
and TD child participant no. 9, the WS and TD child groups are still closely
545 matched on both the non-verbal and verbal measures that were used for
matching: for KBIT Matrices raw scores, $t(16) = -.21, p = .84$; for KBIT
Vocabulary raw scores, $t(16) = .49, p = .63$.

550 *Possible filled gap errors.* A small portion of 'other' responses from Table
4 (those classified as 'gapless that clauses' in Appendix B) appear to be filled
gap errors, as in the TD child response 'Bill is looking at the one that the
girl's jumping over the dog' (target structure: *Bill is looking at the one that the
girl's jumping over*). Although these responses may, in some cases, be lexical
errors (i.e., the choice of *where* in place of *that* would make them fully
grammatical), it will assumed for conservativity that they are all attempted
relative clauses with an erroneously filled gap. As shown in Appendix B, the
WS group produced 18 such errors, while the TD child group produced 48.

555 Distribution of target responses

In this section, only responses that contained a relative clause with a gap in
the targeted position (grey cells in Table 4) are considered.

560 *Rates of target gap relative clause production.* In Table 4, the values in
the grey cells for the SG target gap condition show that all of the groups were
highly successful at producing SG relative clauses in the SG target condition
(rates between 77% and 95%). By contrast, the grey cells for the OG
condition show that a smaller percentage of responses contained relative

clauses with the targeted (OG) gap (rates between 10% and 54%). This SG/OG asymmetry is shown pictorially in Figure 3, which plots, for each group and target gap combination, the mean number of relative clauses produced with the target gap (out of 48). A two-way mixed design ANOVA with group as the between-subject factor and target gap (SG vs. OG) as the within-subject factor revealed significant effects of both group, $F(2, 30) = 9.84$, $p < .001$, and target gap, $F(1, 30) = 85.59$, $p < .001$. Scheffé post hoc tests revealed significant differences between the WS group and the TD adults ($p < .001$) and between the WS group and the TD children ($p < .05$). There was no difference between the TD children and the TD adults. There was a significant interaction between group and target gap, $F(2, 30) = 4.05$, $p < .05$, due to the fact that none of the groups differed from each other reliably in the SG condition, but in the OG condition the WS group differed from both of the TD groups ($p < .001$ for Scheffé tests of both comparisons).

The effect of embedding. Figure 4 plots, for each group, target gap, and target embedding combination, the mean number of relative clauses produced with the target gap in target embedded position (out of a maximum of 16). A three-way mixed design ANOVA with group as the between-subject factor and target gap (SG vs. OG) and embedded position (CE vs. RB) as the within-subjects (repeated measures) factors revealed a main effect of target gap, $F(1, 30) = 78.31$, $p < .001$, and a main effect of group, $F(2, 30) = 7.65$, $p < .01$. Scheffé post hoc analyses revealed that the WS group performed reliably worse than the TD adults ($p < .01$), but no differently than the TD children ($p = .41$); the difference between the TD

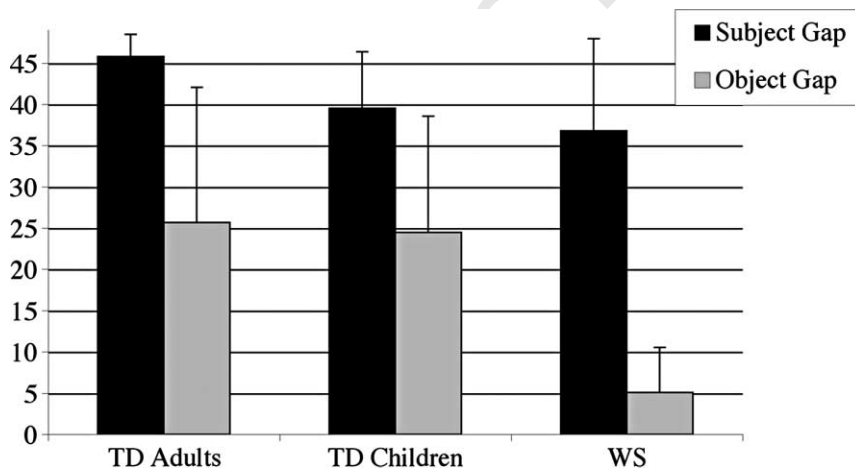


Figure 3. Mean number of relative clauses produced with the target gap.

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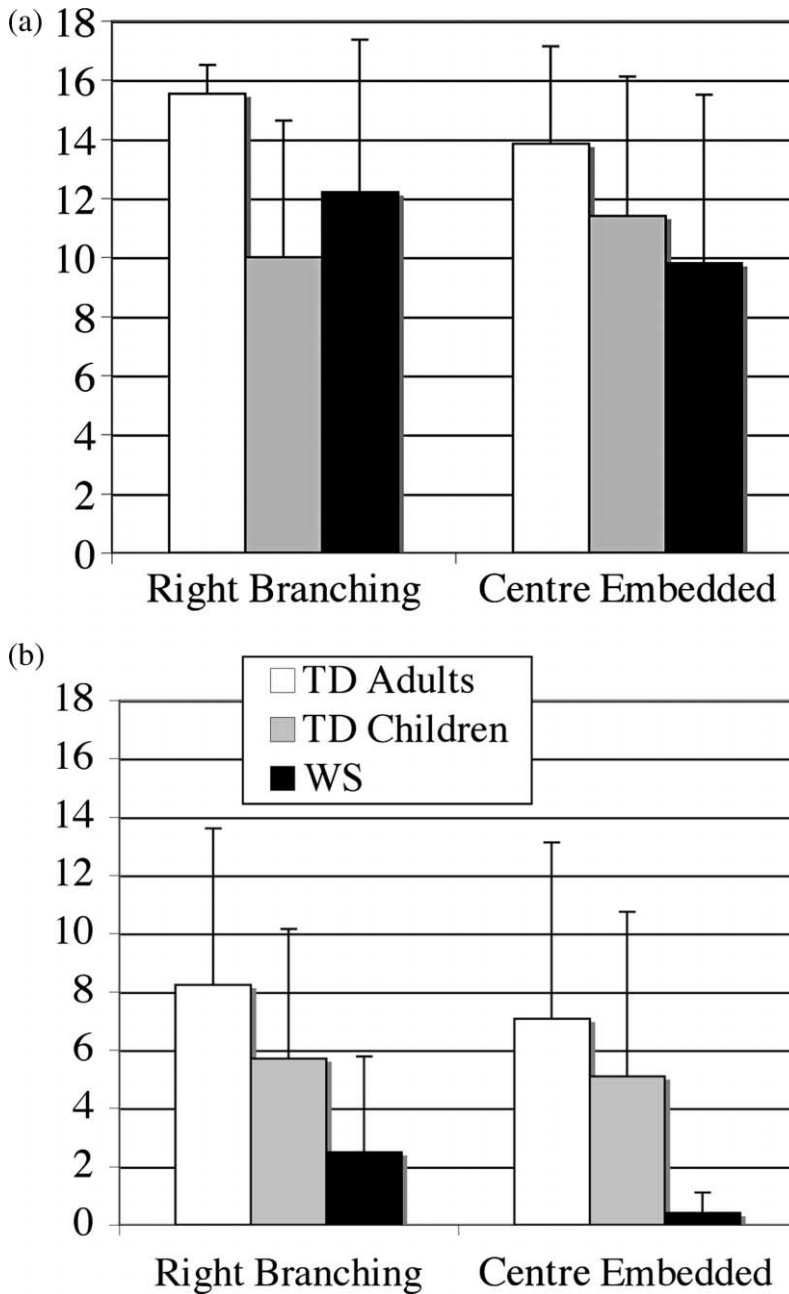


Figure 4. Mean number of relative clauses produced with the target gap in target embedded position: (a) SG condition, (b) OG condition.

children and the TD adults was marginally significant ($p = .07$). There was a trend toward an effect of embedding type, $F(1, 30) = 2.9$, $p = .1$. There were no interactions (all $F_s < 1.4$).

Individual results. This section addresses the question of how commonplace or rare it is for people with WS to be able to produce SG and OG relative clauses and to be able to embed them in both right branching and centre-embedded positions within a main clause. For this analysis, the target embedding was ignored. This was done because sometimes when the prompt did not necessitate a full sentence response (NP-only conditions), participants nevertheless embedded their relative clauses inside full sentences. By including examples like this in these counts, individual participants are given credit for every example of centre-embedding or right-branch embedding of SG and OG relative clauses that they were able to produce.

Table 6 shows, for each individual in the two child groups, how often out of the 48 SG target trials an SG relative clause was produced in a freestanding NP, a RB context, and a CE context, regardless of what the target embedding was. A total of all of these is also provided for each participant. Table 7 shows the corresponding information for the 48 OG target trials.

It is clear from the data in Table 6 that the ability to produce SG relative clauses is commonplace among older children and adolescents with WS and among young, typically developing children. Furthermore, it is commonplace for individuals in both groups to be able to embed SG relative clauses in both right branching and centre-embedded positions. The single exception

TABLE 6
Incidence of SG relative clauses by individual for all 48 SG trials

Subject ID	<i>Williams syndrome</i>				<i>TD children</i>			
	<i>NP-only</i>	<i>RB</i>	<i>CE</i>	Total	<i>NP-only</i>	<i>RB</i>	<i>CE</i>	Total
1	14	16	12	42	28	8	4	40
2	15	11	4	30	18	10	11	39
3	13	14	2	29	16	17	15	48
4	21	3	15	39	13	12	16	41
5	25	4	7	36	13	8	15	35
6	16	17	9	42	16	16	16	48
7	11	0	0	11	22	4	4	30
8	11	17	19	47	18	4	9	31
9	7	21	20	48	19	15	14	48
10	10	18	16	44	12	10	13	35
Mean	14.3	12.1	10.4	36.8	17.5	10.4	11.7	39.5

TABLE 7
Incidence of OG relative clauses by individual for all 48 OG trials.

Subject ID	<i>Williams Syndrome</i>				<i>TD children</i>			
	<i>NP-only</i>	<i>RB</i>	<i>CE</i>	Total	<i>NP-only</i>	<i>RB</i>	<i>CE</i>	Total
1	1	4	0	5	22	6	0	28
2	2	0	2	4	14	2	4	20
3	0	2	0	2	13	10	1	24
4	3	3	1	7	17	8	7	32
5	0	0	0	0	11	8	18	37
6	1	1	0	2	16	14	8	38
7	0	1	0	1	10	2	1	13
8	1	3	1	5	19	7	18	44
9	1	3	0	4	7	1	1	9
10	3	13	0	18^a	0	0	0	0
Mean	1.2	3.0	.4	4.8	12.9	5.8	5.8	24.5

Note. WS Participant no. 10 produced two OG relative clauses that were modifiers of the main clause subject, but the relative clause itself was extraposed after the main clause predicate, as in 'The cat turned yellow that the girl's trying to chase' (such extraposition is grammatical in English; McCawley, 1988). Thus, the embedding of these two OG relative clauses is neither right branching nor centre-embedded; nevertheless, since they contain an OG relative clause, they are included in the total count of OG relatives for this participant.

was a WS subject (ID no. 7) who failed to embed an SG relative clause in either of the two target embedded positions. This participant successfully produced 12 SG relative clauses during the first 16 trials of the experiment (all 16 of which targeted a freestanding NP), but then she switched to an alternative response that did not contain a relative clause, and produced this type of response consistently for the remainder of the testing session.²

The individual data in Table 7 show that although OG relative clauses are produced at lower rates than SG relative clauses, nearly every individual (9 out of 10 participants in each group) was able to produce one or more

² The response was odd, but it successfully conveyed the picture change (e.g., target structure: *The cat that the girl is chasing turned yellow*, child's response: 'That cat turned yellow because that girl is chasing it'). This participant's test session was curtailed midway. When she returned a week later to finish the test, she persisted with the alternative response that she had used the week before, and never produced another relative clause of any kind. Cases like this raise an important point. If this child had happened to produce her alternative response on the first trial rather than the 13th, she may never have produced a single relative clause, and this might have led to the incorrect conclusion that her grammar does not generate such structures at all. This highlights the difficulty of definitely proving lack of knowledge, even with elicited production. In cases where elicited production does fail to elicit a structure of interest, it is always wise to seek corroboration from other sources. Spontaneous speech could be examined, or sentence completion could be used as a method of precluding certain response possibilities.

620 examples of this structure. Most of the TD children produced many
examples of OG relative clauses and thus they had many opportunities to
embed them in main clauses. Table 7 shows that nearly every TD child did
successfully embed an OG relative clause in right-branching position (9/10
625 children) and centre-embedded position (8/10 children). Most participants
with WS produced very few instances of OG relatives of any kind, so they
had fewer opportunities to embed them in a main clause. A complete list of
the 49 OG relative clauses produced by the WS participants is provided in
Appendix D. Despite the small number of OG relatives produced by the WS
630 participants, an asymmetry in embedding was still observable. There were
many fewer examples of centre-embedded OG relatives overall ($n = 4$) than
right-branching OG relatives ($n = 30$), and only three WS participants
produced centre-embedded OG relative clauses, while eight WS participants
produced right-branching OG relative clauses.

635 A comparison of the data from Tables 6 and 7 reveals that one child (WS
participant no. 7) failed to produce a centre-embedded relative clause of
either gap type. This participant did produce one example of a right-
branching relative clause. Every other participant produced at least one
example of both a centre-embedded relative and a right-branching relative,
640 of one gap type or another.

In summary, every participant with WS (10/10) was able to produce an SG
645 relative clause, all but one (9/10) was able to produce an OG relative clause,
all but one (9/10) was able to produce a relative clause in centre-embedded
position, and every participant (10/10) was able to produce a relative clause
in right branching position. The variation observed was just in how often
they were able to successfully produce these structures.

Subject gap responses in the object gap target condition

650 In Table 4, it was shown that in the OG target condition, a large portion of
responses from the TD child and WS groups contain SG relative clauses:
nearly half of WS responses and nearly one quarter of TD child responses.
Some of these responses were semantically and pragmatically appropriate to
the event being described, while others were inappropriate.

655 Table 8 provides the distribution of different types of SG responses that
were produced in the OG condition for each of the three groups. The number
in each cell represents the percentage of responses of that type out of all OG
Target trials; numbers in parentheses are the raw counts. For example, adults
produced 67 passive sentences out of 624 OG target trials (48 object gap
660 target trials \times 12 subjects), which represents 10.7% of their responses in OG
target trials. Appropriate responses include those containing a passive (e.g.,
'Bill is looking at the cat who's being chased by a girl'), those containing a
has clause (e.g., 'Bill's looking at the one that has a cat jumping over'), and a

TABLE 8
Per cent of different types of SG relative clauses produced in OG target condition

Response type	Group		
	C-Adults	C-Children	WS
Appropriate responses			
Passive	10.7 (67)	1.0 (5)	1.0 (5)
Has Clause	1.3 (8)	1.3 (6)	2.5 (12)
Other appropriate	1.8 (11)	6.9 (33)	6.5 (31)
Inappropriate responses			
Wrong head	1.6 (10)	13.1 (63)	35.8 (173)
Other inappropriate	0.2 (1)	0.6 (3)	0.8 (4)
Total	15.5 (97)	22.9 (110)	46.9 (225)

Note. Numbers in parentheses reflect actual counts.

variety of others (e.g., ‘Max is looking at the cat that’s running from the dog’). Inappropriate responses consist primarily of ‘wrong head errors’, in which the head of the relative clause does not match the queried head (e.g., Experimenters: Which cow is Max looking at? Participant: ‘The boy that’s pointing at it.’). Since wrong head errors make up the bulk of inappropriate responses in the OG target condition, further details about the distribution of these errors within the three groups is shown in a box-and-whiskers diagram in Figure 5.

For adults, the majority of SG relative clauses produced in the OG condition were appropriate responses, and these primarily consisted of passivised structures. By contrast, for both of the child groups, the majority of SG relative clauses produced in the OG condition were inappropriate responses, and these consisted almost entirely of wrong head errors. For the WS group, 36% of all responses in OG target trials (173/480) contained wrong head errors. In the TD child group, in addition to the 63 wrong head errors shown in Table 8, an additional 7 responses in OG target trials contained a wrong head error. These are not included in Table 8 because in all 7 cases the response also contained a successful OG relative clause, and thus these responses were included in the tally of OG responses in the OG target condition (e.g., instead of the target structure *Bill is looking at the cow that the boy is pointing to*, one TD child responded with ‘The one that Bill’s looking at is the boy that’s pointing to the cow’; this response contains an appropriate OG relative clause – *the one that Bill’s looking at* – as well as an inappropriate wrong head SG relative clause – *the boy that’s pointing to the cow*). Thus participants in the TD child group produced wrong head errors in 14.6% of their responses in OG target trials (70/480). Much to our surprise, ten wrong head errors were also produced by participants in the TD adult

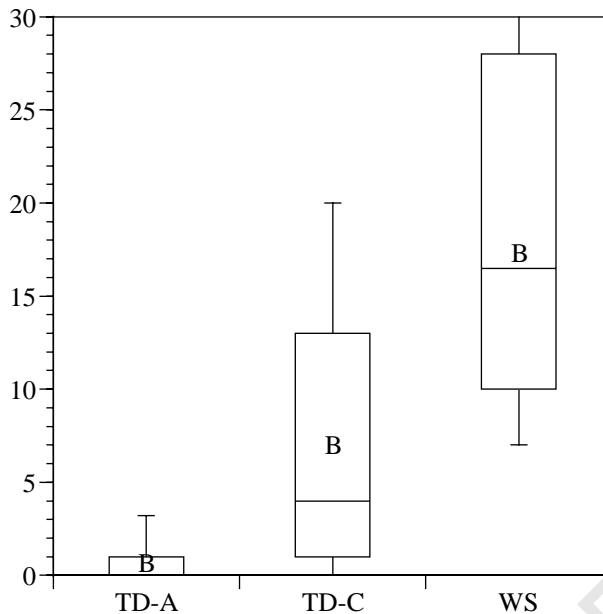


Figure 5. Distribution of wrong head errors within groups.

group. This is a rate of occurrence of 1.6% (10/624) of TD-A responses in OG target trials. These apparent group differences in rates of wrong head errors were shown to be reliable in a one-way analysis of variance, $F(2, 30) = 17.2$, $p < .001$. Planned comparisons demonstrated that the WS group made reliably more wrong head errors than either of the TD groups, and the TD children made reliably more wrong head errors than the TD adults ($p < .05$ for all three comparisons).

The TD child and WS groups both produced wrong head errors in large numbers in OG target trials, and almost never in SG target trials. Two additional analyses provide further evidence for a tight distributional similarity between the TD children and the WS participants in the production of wrong head errors. The first analysis was prompted by the observation that rates of these errors varied greatly among the 8 different OG target trials, but the inter-trial variation appeared to be similar for the two groups. This was confirmed by a significant correlation between WS rates of wrong head errors and TD child rates of wrong head errors among the 8 OG trials: $r(6) = .736$, $p < .005$. The second distributional analysis of wrong head errors showed that for both groups, these errors were produced in both types of embedding contexts, as well as in NP-only responses. For the WS group, 33% of wrong head errors were produced in a CE context, 31% were produced in a RB context, and 31% were produced in an NP-only

710 context; for the TD children, 21% of wrong head errors were produced in a CE context, 27% were produced in a RB context, and 35% were produced in an NP-only context (the remaining 5% of WS wrong head errors and 18% of TD children's wrong head errors occurred in other embedding contexts).

715 An informal examination of the collection of wrong head errors suggested that at least some of them probably reflect a problem at the level of message preparation. This is because in some cases, the response failed to include any reference whatsoever to the queried noun (the *x* in the experimenter's 'Which *x* ...' question). This type of error is illustrated in examples (1) and (2). In cases like this, it is unlikely that such errors are due to incorrect grammatical encoding of an appropriate message, because an appropriate message should 720 minimally contain some reference to the queried noun.

1. Experimenter: This boy is standing on a horse and this boy is sitting on a horse. [picture changes] Which horse turned purple?
TD Child no. 10: *The guy who's standing.*
- 725 2. Experimenter: This boy is standing on a horse, this boy is sitting on a horse. [picture changes] Hey, this time Max is looking at a *horse*. Which horse is Max looking at?
WS no. 4: *The one that's sitting down.* (NB: Both horses are standing.)

730 For other wrong head errors, the response did contain a reference to the queried noun, either via the presence of the noun itself or via a pronoun. An example of a wrong head error containing the queried noun itself is shown in (3), and an example with a pronoun that plausibly refers to the queried noun is shown in (4). Examples like these are more plausible candidates for cases in which the speaker prepared an appropriate message, but encoded that message incorrectly – either because of a deficit in knowledge or because of a 735 misstep in the process of grammatical encoding.

3. Experimenter: This girl is jumping over a truck, and this girl is sitting on a truck ... (picture changes) Which truck is Max looking at?
WS no. 9: *The girl that's sitting on the truck.*
- 740 4. Experimenter: A girl is pointing to this cow, and a boy is pointing to this cow. Which cow is Max looking at?
TD Child no. 3: *The boy that's pointing at it.*

745 Since these different types of wrong head errors could implicate different problem areas (message preparation vs. grammatical encoding), all utterances containing a wrong head error were analysed for the presence or absence of the queried noun (or a pronoun that plausibly refers to it) anywhere in the utterance. This analysis showed that in the WS group, 23.8% of wrong head errors contained no reference to the queried head noun

anywhere in the utterance, as in examples 1 and 2. In the TD child group, the corresponding figure was 34.4%. None of the 10 wrong head errors produced by the TD adults were of this type. Thus, a sizeable portion of wrong head errors produced by the WS and TD child groups apparently do not reflect a grammatical encoding problem, but rather a problem with an earlier message-forming component of utterance planning. The question of how to interpret the remaining wrong head errors is addressed in the discussion section.

DISCUSSION

This study has shown that it is commonplace for young people with WS (age 10 to 16) and for typically developing children (age 4–6) to be able to produce both subject gap (SG) and object gap (OG) relative clauses, and to be able to produce relative clauses in both right branching and centre-embedded positions within a main clause. The study has also shown that it is common for these groups to have command of the grammatical details associated with relative clauses. This includes an understanding that a *wh*-relativiser or complementiser is required in some relative clauses, an understanding of the acceptable forms of these relativisers, and an understanding that there must be a gap in the position that is referentially linked to the head of the relative clause. However, this study has also shown that, when tested with identical materials and methods, people with WS produce OG relative clauses less frequently than their typically developing mental-age-matched counterparts, despite evidence that they do know these constructions. Williams syndrome participants produced fewer OG relative clauses than TD children in all embedding contexts – even in freestanding NPs – although the difference was particularly acute in centre-embedded contexts. However, centre-embedding per se was not difficult for the WS participants, since they produced SG relative clauses at high rates in this embedded context. The main reason for the group asymmetry in OG relative clause production was that participants with WS were nearly three times more likely than typically developing children to produce a ‘wrong head error’ in OG target trials. Wrong head errors occurred when children produced a grammatically well-formed but contextually inappropriate SG relative clause in the OG target condition. Wrong head errors were not expected because, with just one exception (McKee, McDaniel, & Snedeker, 1998), they have not been reported in previous studies of elicited production of relative clauses among young children learning their first language. Although participants with WS produced wrong head errors much more frequently than typically developing children, the errors were still produced in large numbers by typically developing children.

Is language 'intact' in people with WS?

790 In addressing the question of whether language is 'intact' in people with WS,
it is important to distinguish language processing from knowledge of
language. The knowledge question is more pertinent to the question of
whether people with WS are capable of acquiring an intact system of
795 grammatical knowledge despite their cognitive limitations and slightly
atypical brains. But the 'non-intact' label has also been used to describe
difficulty in comprehending and imitating sentences containing relative
clauses in recent work (Grant, Valian, & Karmiloff-Smith (2002). In this
section, the evidence from this study bearing on the knowledge vs. processing
question will be discussed, first with reference to embedding, and then with
reference to relative clauses of different gap types.

800 *Embedding.* Regarding clausal embedding, the evidence from this study
suggests that people with WS have intact knowledge of how to embed
relative clauses in both right branching and centre-embedded positions
within a main clause. However, while SG relative clauses were produced in a
centre-embedded position frequently and with great ease, OG relative clauses
805 only very rarely appeared in this position, suggesting processing difficulty
specific to this gap by position combination. It has been claimed in the
literature that people with WS have trouble with left-branching (centre-
embedded) relative clauses (Karmiloff-Smith et al., 1998). This claim has
been based on results demonstrating poor comprehension of centre-
810 embedded OG relative clauses (Karmiloff-Smith et al., 1997). Yet, compre-
hension results from both this and previous studies have now consistently
shown a pattern similar to the production results reported here: centre-
embedded OG relative clauses are difficult to process, but centre-embedded
SG relative clauses are not. Therefore, the evidence from this study and
815 previous studies suggests that, by late childhood, centre-embedding is a
functioning component of the grammars of people with WS, and further-
more that centre-embedding in and of itself is well within their processing
abilities by this age.

820 *Relative clauses.* Regarding relative clauses with subject gaps and object
gaps, the bulk of the evidence reported in this paper suggests that knowledge
of both of these types of relative clauses is intact in people with WS. The WS
participants were able to produce grammatically well-formed relative clauses
with both subject gaps and object gaps. Since these achievements occurred in
the absence of models in the experimental context, this suggests that these
825 structures, together with their grammatical details, were generated by the
internal grammars of these participants.

Nevertheless, there are two important objections to consider in evaluating whether the results reported in this paper warrant the conclusion that grammatical knowledge of relative clauses is entirely intact in people with WS. First, does the relatively small number of OG relative clauses successfully produced by the WS participants genuinely reflect grammatical knowledge of these structures, or is it possible that these are actually mis-productions of other intended structures? Second, does the frequent production of wrong head errors observed in the WS group suggest that wrong head errors are due to impaired knowledge of the possible meaning of SG relative clauses?

Do the WS participants really have grammars that generate OG relative clauses? Is it correct that the small number of OG relative clauses produced by the WS participants ($n = 48$) were intended OG relative clauses that were generated by their grammars? Might they instead be production accidents, resulting from a misstep during the planning and production of some other structure? If so, then presumably the intended structure would have been a SG relative. But an extensive literature on relative clause processing in unimpaired adults has shown that SG relative clauses are very easy to comprehend and produce. Additionally, in English, SG relative clauses preserve the canonical word order of main clauses, while OG relative clauses disrupt this word order. In light of these facts, it is difficult to make a case for how the production of a SG relative clause could go wrong in such a way that a more difficult structure (an OG relative clause), would be accidentally produced. More concretely, there is distributional evidence from the study reported here to suggest that the OG relative clauses produced by the WS participants are not accidents. If they were merely production accidents, it would be highly unlikely that such accidents would happen exclusively in OG target contexts, which was indeed the case. That is, if people with WS are prone to making such errors some portion of the time that they are intending to produce SG relative clauses, then surely during the 480 SG target trials that the 10 WS participants responded to, they would have produced some of these errors, and yet OG relative clauses almost never occurred (only twice) in SG target trials.

Another possible analysis of the 48 OG relative clauses produced by the WS participants is suggested by the fact that a majority of them ($n = 33$, 30 from the RB condition and 3 from the NP condition) were produced in response to an object extraction prompt question (e.g., Which horse is Max looking at?). Could the object extraction prompt questions have led, accidentally, to the production of structures resembling OG relative clauses, even in the absence of a grammar that generates such structures? Again, there is distributional evidence to suggest that this is not the proper analysis of these responses. If an object extraction prompt question can 'accidentally'

870 lead to the production of an apparent OG relative clause, even in the absence
of a grammar that generates OG relatives, you would expect to see such
accidents happening in the SG condition when the prompt question is an
object extraction question. However, OG relative clauses were almost never
produced (only twice) by the WS participants during the 240 SG target trials
that involved an object question prompt.

875 Given these arguments and distributional facts, if it is correct that object
extraction question prompts somehow facilitated or 'primed' the production
of OG relative clauses, it is unlikely that this could have occurred in the
absence of a grammar that does not already represent the OG relative clause
880 structure. If it is the case that in the experiment, object extraction prompt
questions did indeed prime OG relative clause structures that are already
represented in the grammars of people with WS, then this priming must have
occurred at quite an abstract level, given how very different the prompts and
their associated target responses were (e.g., prompt: Which horse is Max
885 looking at?; target: The horse that the guy is sitting on.) Furthermore, if it is
the case that the gap of a relative clause can be primed at all, then given how
very many SG relative clauses each of the WS participants produced during
the test (mean = 36.8), then for every OG relative clause that they
successfully produced, they must have had to overcome significant activation
890 of a SG structure. In light of this, each occurrence of an OG relative clause
would be all the more impressive.

*Do wrong head errors show that TD children and WS participants know the
structure of SG relative clauses without knowing their meanings?.* Turning to
the issue of wrong head errors, it is important to consider the possibility that
wrong head errors are due to impaired knowledge of the possible meaning of
895 SG relative clauses by both people with WS and also by typically developing
children as well, since they too produced such errors. Adult grammars allow
only one interpretation of an SG relative clause like 'the girl who's jumping
over the truck'; this expression picks out a girl who can be identified on the
basis of her participation as the agent in an instance of someone jumping
900 over a truck. The study reported here has shown that typically developing
children and people with WS correctly use an expression like this when the
task requires them to pick out a particular girl, but they also sometimes
incorrectly use the identical expression when the task requires them to pick
out a particular truck. This might suggest that these speakers mistakenly
905 believe that an SG relative clause has not one meaning but two, one of which
is not possible for adults. If this is true, it would seem to support the notion
expressed in the literature that, although people with WS produce speech
that is mechanically well-formed, this superficial well-formedness belies
fundamental language problems (Karmiloff-Smith, 1997; Karmiloff &
910 Karmiloff-Smith, 2001). Importantly, if it is correct to characterise wrong

915 head errors as reflecting incorrect knowledge about SG relative clauses, this deficit would be in juxtaposition with completely intact knowledge of OG relative clauses, since the participants in this study almost never used an OG relative clause like ‘the truck that the girl is jumping over’ to refer to a girl; OG relative clauses were only produced when they were appropriate to the context.

920 There are several problems with the ‘SG knowledge deficit’ analysis of wrong head errors. The first is that it would incorrectly predict that in comprehension tests there should be more errors for sentences containing SG relative clauses than OG relative clauses. The opposite finding has been observed in both typically developing children and people with WS, as measured by TROG comprehension results in both this study and others (Grant et al., 2002). Second, if children’s knowledge of possible SG relative clause interpretations is impaired, it is surprising that no corresponding impairment is observed for OG relative clauses. This is because a grammatical system that allowed an expression like ‘the girl who’s jumping over the truck’ to refer to either a girl or a truck would be one that has misanalysed the basic head-modifier structure of NPs containing relative clauses (cf. Arnon, 2005). But a system that has misanalysed the basic head-modifier structure of NPs containing relative clauses would be expected to make wrong head errors with relative clauses of all gap types. This expectation is not upheld. A third problem with an ‘SG knowledge deficit’ analysis of wrong head errors is that such an analysis fails to account for the existence of wrong head errors that do not include the queried head noun anywhere (e.g., Prompt: Which TV turned blue?, Response: The boy that is watching). It seems clear that errors like these are not the result of mapping a contextually appropriate message onto an inappropriate sentence structure; rather, these errors implicate a problem at the level of message preparation. If participants are prone to making errors at the level of message preparation, as evidenced by this subset of wrong head errors, then perhaps these problems can explain the production of other wrong head errors as well (see ‘Possible sources of wrong head errors’ below for further discussion). In light of these problems, it seems unlikely that wrong head errors reflect a deficit in grammatical knowledge.

940 If it is correct, as argued above, that wrong head errors do not reflect a deficit in grammatical knowledge, and that those OG relative clauses produced by the WS participants are not mis-productions of other intended structures, then there is no evidence from this study to contradict the basic generalisation that by the age of 10–16 years, most people with WS have intact knowledge of both the structure and meaning of subject gap and object gap relative clauses.

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Is language or language development atypical in people with WS?

955 **AQ1** There has been a debate over the question of whether language is atypical in people with WS (Brock, 2006; Karmiloff-Smith, 1998; Thomas et al., 2001). This study provides little or no evidence for the claim that WS language is atypical. The pattern of performance observed in the WS participants shows the same contrasts that are found in typically developing children of the same mental age: SG relative clauses are produced more frequently than OG relative clauses, and attempts to elicit OG relative clauses sometimes result in wrong head errors. Even the particular OG trials that yield the highest rates of wrong head errors are similar for the two groups. This suggests that wrong head errors likely have the same source for both groups.

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965 However, there is one sense in which it might be said that WS language development is atypical. Wrong head errors are produced more frequently by people with WS and they are probably developmentally longer lasting in this population. Preliminary evidence from a small number of WS adults whose performance is not reported in this paper suggests that at least some people with WS continue making wrong head errors into adulthood. Failure to recover from this error would be an atypical developmental outcome. If this result is confirmed, it is important to consider its significance in light of theories that predict atypical language in WS. The most explicit prediction has come from neuroconstructivist accounts of WS. In particular, Karmiloff-Smith (1998) and Thomas et al. (2001) have argued that small differences in the brains of infants with WS are expected to lead to abnormal development from the earliest stages. These early differences are expected to eventually lead to enormous differences in the cognitive systems that are developed. These predictions do not seem to match the findings in the domain of WS grammatical development. The results of this study, in conjunction with results from studies of early grammatical development (Klein, 1995; Mervis et al., 1999; Mervis & Klein-Tasman, 2000) suggest that people with WS proceed along a normal but delayed path in their syntactic development, and that they may never progress beyond some developmentally normal errors. How precisely non-recovery from wrong head errors should be interpreted will ultimately depend on understanding what causes such errors to begin with, and how typically developing children manage to recover from them.

Possible sources of wrong head errors

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990 If it is correct that wrong head errors do not reflect a deficit in knowledge of relative clause syntax or semantics, then it is important to ask what is the source of such errors. This question is important to consider for several reasons. First, typically developing children produce wrong head errors, but

adults (speaking their native language) do not. Therefore an understanding of their cause might reveal features of children's early sentence production mechanisms that are poorly understood at present. Second, people with WS make wrong head errors more frequently than typically developing children. Therefore, an understanding of the source of the errors would help to characterise the effects of this disorder on language performance. Third, adult English speakers acquiring Korean make wrong head errors in both their comprehension and production of Korean relative clauses. Perhaps there is a common explanation for why child first language learners, adult second language learners, and people with WS are all susceptible to such errors.

One possibility is that wrong head errors are the result of accidental slips of the tongue that convert would-be OG relative clauses to SG relative clauses because of timing differences in the availability of lexical material during grammatical encoding. According to this account, sometimes the lexical material for expressing the subject of the relative clause becomes active before the head noun (the noun that is being modified) has been pronounced, and occasionally when this happens, a slip of the tongue occurs in which the subject material is inappropriately inserted in the head noun position. This analysis presupposes that there is an early stage in the planning of a response to the experimenter's question during which the speaker has prepared the basic noun plus relative clause structure of the response, but not all of the corresponding lexical material has been retrieved. This analysis also presupposes that lexical material for the subject of the relative clause is usually retrieved prior to material for the rest of the clause, a reasonable assumption given English word order. If these presuppositions are correct, then this account correctly predicts that the opposite type of conversion (conversion of would-be SG relative clauses into OG relative clauses) is not likely to occur, since the head noun is likely to be pronounced before lexical material for the object of the relative clause has been prepared. Thus the pre-conditions for making a slip of the tongue of this type do not occur, or occur much less frequently when planning to produce an SG relative clause.

An alternative account of wrong head errors is that they reflect message level confusion about the focus of the response to the experimenter's question. On the one hand, the experimenter's question directly asks the participant to individuate a particular character/object (i.e., 'Which *truck* turned red?'). The answer should therefore pick out one character of the queried type (i.e., one truck) from the set of two that are depicted in the picture. On the other hand, the successful individuation of the queried character/object requires the speaker to indicate which of two different events the character/object is participating in (i.e., the one in which a girl is sitting on a truck, vs. the one in which a girl is jumping over a truck).

1035 According to the message level explanation of wrong head errors, speakers
may sometimes get confused in the OG condition due to a conflict between
the need to pick out a particular character/object, as requested in the
1040 experimenter's question, and the need to pick out a particular event which is
focused on an agent that is distinct from the queried character (since, in the
OG condition, the queried character/object is always the patient in the
depicted events). Because of this confusion sometimes speakers intend at the
message level for their answers to pick out one of the two agents from the set
1045 of two contrasting events rather than the queried character. This is an
understandable but inappropriate message choice; however, this inappropriate
message is subsequently correctly mapped onto a SG relative clause
during grammatical encoding. Thus according to this analysis, the error is
confined to the message level stage of language production. This account,
1050 like the slip of the tongue account, correctly predicts that wrong head errors
should not occur in the SG condition, because in this condition the queried
character that needs to be picked out is the same character as the agent of the
modifying event that must be used; that is, the two contrasts that are both
relevant to the task of individuating the queried character/object (the queried
character itself, and the modifying event) are both focused on the same
1055 character, and thus there is no confusion about which contrast to focus the
response on.

The message level explanation of wrong head errors offers several
advantages over the slip of the tongue analysis. First, this analysis offers a
natural explanation for why a large portion of responses containing wrong
1060 head errors make no reference at all to the queried head noun: since the
speaker has chosen to focus her message not on the contrasting queried
nouns, but on the contrasting events, the resulting response may or may not
happen to make reference to the queried noun (whose role in the critical
modifying event is the relatively minor role of the patient). Second, the
message level analysis provides a natural explanation for why wrong head
1065 errors have not been observed in previous elicited production studies.
Previous studies have only targeted freestanding NPs containing a relative
clause, and consequently, in the eliciting scenes, it has been the case that only
one of the two characters indicated by the queried noun is participating in an
event. In this case, the speaker has no need to pick out one event from a set
1070 of two, so there is no competing focus that might distract attention away
from the focus of the experimenter's question. The slip of the tongue analysis
predicts no difference in the frequency of slips between studies as a function
of whether there is a competing event.

1075 A third advantage of the message level analysis is that it may account for a
comprehension equivalent of wrong head errors that has recently been
reported in child speakers of Hebrew, age 4-5 years (Arnon, 2004). In a
representative OG target trial, children viewed a picture that included two

grandmothers, each with a girl on her lap; in one case the grandmother was kissing the girl, and in the other case the girl was kissing the grandmother. Children were asked to point to a particular character, as in the Hebrew equivalent of 'Show me the grandmother who the girl is kissing'. Children sometimes mistakenly pointed to the girl who was kissing the grandmother – the right kissing event, but the wrong character. Wrong head comprehension errors occurred 22% of the time in OG target trials; they did not occur in SG target trials. The stimuli in Arnon's comprehension task share with the production task used in the current study the feature that gives rise to the informational prominence of the agent in OG target trials: the two tokens of the queried noun are participating in contrasting events. In the elicited production task reported here, the informational prominence of the agent of the modifying event leads the child to formulate a message that individuates an agent, despite being asked to pick out a character whose role is a patient. In Arnon's comprehension task, the same feature leads the child to point to an agent, despite being asked to point to a character whose role is a patient. According to the slip of the tongue analysis, wrong head errors reflect a purely mechanical misstep that arises due to temporal differences in the availability of lexical material during the production process, and thus they are not expected in a comprehension task. The existence of this comprehension error would therefore require an independent explanation, and the parallels between the comprehension error and the production error would be purely accidental.

Despite these several advantages of the message level account of wrong head errors, there is one serious problem with it. If a speaker intended at the message level for an NP like 'the girl who's jumping over the truck' to pick out a girl, and if she also knew that it was a truck that had turned red rather than a girl, she would not produce this NP in an embedded context (e.g., The girl who's jumping over the truck turned red), because this would be a factually incorrect statement. There is no reason to believe that participants experienced any problems in understanding which objects changed colour. In fact, if they had, the problem would not have been confined to OG target trials. Given this, wrong head errors are not predicted to appear in embedded contexts, and yet they do. The solution may be that wrong head errors are caused by a combination of the processes that have been proposed to be at play in the message level and slip of the tongue analyses. In OG target trials, material planned for the subject position of the relative clause may be inadvertently placed in the head noun position not just because the lexical material is available early, but also because of its informational prominence as the agent of one of two contrasting events. In other words, the informational prominence of the agent of the modifying event may increase rates of anticipatory slips of the tongue involving the agent relative to their baseline rate of occurrence. Alternatively, or additionally, it may be the case

1125 that people with WS and young children are not able to monitor their own
utterances as well as adults. In addition to experiencing confusion in the
elicited production task about what the focus of their own messages should
be, they may not be aware of what the outcome of the confusion was in their
own utterances. Indeed, recent psycholinguistic work with unimpaired adults
has shown that the ability to catch and correct errors in one's own speech
(i.e., to 'self-monitor') is adversely affected by an experimentally induced
1130 reduction in resource limitations (Oomen & Postma, 2002). If self-monitoring
ability is partly responsible for the production of wrong head errors, this
could potentially explain why adult second language learners are also prone
to making such errors. Since the production of sentences in a newly learned
second language is quite effortful, this ought to reduce the resources available
to self-monitor. Future research will help to establish which, if any, of these
explanations of wrong head errors is correct.

1135 Since people with WS are more prone to making wrong head errors than
young typically developing children of similar mental age, these different
explanations of the source of these errors would lead to different conclusions
about how the disorder impacts sentence production. One possibility is that
1140 people with WS are more likely than young typically developing children to
make slips of the tongue. This prediction has never been tested. Another
possibility is that people with WS are less able than typically developing
children to resolve conflicts that arise at the message level about the focus of
an utterance, perhaps because of inhibition problems. Although inhibition
has not been examined at the cognitive level in this disorder, several features
1145 of WS that have been documented are potentially compatible with the
possibility of reduced inhibition. These include extreme overfriendliness to
strangers (Einfeld, Tonge, & Florio, 1997; Gosch & Pankau, 1994; Mervis et
al., 1999; Sarimski, 1997), hyperactivity (Gosch & Pankau, 1994; Einfeld,
Tonge, & Florio, 1997; Sarimski, 1997; Udwin & Yule, 1991), distractability
1150 (Tomc, Williamson, & Pauli, 1990), and inattentiveness (Dilts et al., 1990;
Einfeld, Tonge, & Florio, 1997; Greer, Brown, Pai, Choudry, & Klein, 1997;
Pagon, Bennett, LaVeck, Stewart, & Johnson, 1987). If inhibition is found to
be impaired at a cognitive level in this disorder, then degree of inhibition
impairment may predict rates of wrong head errors. Finally, it may be that
1155 resource limitations associated with mental retardation in people with WS
may lead to reduced self-monitoring ability in this population.

CONCLUSION

1160 The evidence and the arguments presented in this paper suggest that by the
early teenage years or before, people with WS have intact knowledge of the
structure and meaning of several types of relative clauses, and intact

1165 knowledge of how to embed relative clauses in both right-branching and
 1170 centre-embedded positions. In this, they completely resemble typically
 1175 developing mental-age matched children. Nevertheless, children in both
 groups sometimes produce a grammatically well-formed but contextually
 inappropriate type of response in a tightly restricted subset of elicitation
 contexts. The distribution of this error suggests that it reflects impaired
 processing rather than deficient knowledge. Several candidate proposals for
 the nature of the processing deficit were outlined; the error might reflect
 problems in grammatical encoding that occur when lexical material becomes
 available too early, problems in successfully choosing between two competing
 messages at the level of message planning, limitations in self-monitoring of
 speech, or some combination of these factors. People with WS make this
 error much more frequently than typically developing children, but the
 vulnerable contexts are exactly the same for the two groups. Thus, neither
 knowledge nor processing of relative clause structures is qualitatively
 atypical in people with WS. Nevertheless, qualitatively normal processing
 factors can lead to unusually severe interference in some subprocesses of
 sentence production in this population.

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APPENDIX A

Table A1 Descriptions of stimulus pictures prior to the change.

<i>Subject gap</i>	<i>Object gap</i>
1 A boy is waving A boy is washing his hair	9 A girl is sitting on a truck A girl is jumping over a truck
2 A boy is pointing to his elbow A boy is pointing to his finger	10 A bird is sitting on a car A bird is flying over a car
3 A man is kicking a ball A man is catching a ball	11 A boy is watching TV A woman is watching TV
4 A girl is singing A girl is drawing	12 A helicopter is flying over a house An airplane is flying over a house
5 A boy is pointing to cow A boy is pointing to a horse	13 A girl is pointing to a cow A boy is pointing to a cow
6 A girl is chasing a cat A girl is chasing a bunny	14 A girl is chasing a cat A dog is chasing a cat
7 A girl is jumping over a man A girl is jumping over a dog	15 A girl is jumping over a boy A cat is jumping over a boy
8 A boy is sitting on a horse A boy is standing on horse	16 A boy is sitting on a horse A boy is standing on a horse

APPENDIX B

'Other' responses in the elicited production task

'Other' responses include those that either did not include a relative clause at all or they included a clausal modifier with no gaps. The table below provides a breakdown of the incidence of all types of 'other' responses that occurred at least 20 times by at least one group of subjects in either the SG target or OG target condition. An example of each of these types is shown in (A)–(F) below Table B1.

- (A) *'That girl turned red because that girl is jumping over that dog.'* (WS)
 (B) *'Max is looking at the dude with the girl jumping over it.'* (WS)
 (C) *'Bill's looking at the one where the girl's chasing the cat.'* (TD child)
 (D) *'The one that the boy was pointing to his finger turned blue.'* (TD child)
 (E) *'The one with the horse is turning green.'* (WS)
 (F) *'The cat one.'* (WS)

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TABLE B1
 'Other' responses: incidence of major types

Response type	SG target			OG target		
	TD-A	TD-C	WS	TD-A	TD-C	WS
A. Full sentence with no relative clause	10	2	48 ^a	18	12	60 ^a
B. Gapless with-clause	2	8	7	122	27	36
C. Gapless where-clause	0	17	2	5	21	5
D. Gapless that-clause (possible filled gap relative clauses)	2	26	2	3	22	16
E. Locative	3	4	12	29	16	31
F. NP (simple NP, compound, genitive phrase)	12	2	4	2	7	24
G. All other types	0	11	35	15	20	35
Total no. of 'other' responses	29	70	110	194	125	207

^a 37/48 and 39/60 of these WS responses were from a single participant.

APPENDIX C

Grammatical errors made consistently by two children

WS participant no. 5 produced 62 grammatical errors, and virtually all of them consisted of the same two errors. This is best illustrated with an example. When the target sentence was *the dog that's chasing the cat is purple and the dog that's chasing the bunny is red*, this child said 'one's chasing the kitty cat is purple, and one's chasing a bunny is red.' These responses exhibit two grammatical problems: a missing determiner before the head noun *one*, and an ungrammatical form of reduction (deletion of just the relativiser *that*, without deletion of the auxiliary too). Interestingly, although the determiner was consistently dropped for the head of the noun phrase containing the relative, this child almost always successfully produced grammatically required determiners elsewhere in the sentences (as shown in the example), suggesting that this child was familiar with both the forms and the structural positions of determiners, and that his omissions were not arbitrary.

TD child no. 9 also consistently (21 times) made a single error. An example is 'The one that chasing the cat turned purple.' This error could be analysed in a variety of ways. It is missing the auxiliary that is required for the progressive aspect, and because it is missing this auxiliary, the relative clause also incorrectly lacks tense. But this error could also be analysed as an ungrammatical reduction of the relative clause that is complementary to the reduction error made by WS participant no. 5. While the WS participant reduced the relative clause by deleting the *that* but failing to delete the auxiliary, this TD child deleted the auxiliary but failed to delete the *that*.

APPENDIX D

Complete list of OG relative clauses produced by the WS participants

Right-branching position WS no. 1: Max is by the TV that the boy is staring at.

WS no. 1: Max is looking at the car that the pigeon is standing on.

WS no. 1: Max is looking at the cow that the girl is at.

WS no. 1: Bill is looking at the car that the bird is flying. (missing preposition)

WS no. 3: Bill is looking at the man the woman's catching over. (odd verb change)

WS no. 3: Max is looking at the horse that the boy's standing on.

WS no. 4: Bill's the one that the bird is flying over.

WS no. 4: Bill's the one that the girl's sitting on.

WS no. 4: Max is the one the boy's sitting on.

WS no. 6: The one that's turning pink is the one that the girl's like jumping over.

WS no. 7: Max is looking at THAT house that the plane's flying over.

WS no. 8: Nicole, um, the mouse um is looking at the TV that the girl is looking at with the brown hair.

WS no. 8: Bill is looking at the, the horse that the other kid is sitting on.

WS no. 8: Max is looking at the horse who's, the kid is standing on.

WS no. 9: Max is looking at the cow who um the boy's pointing to.

WS no. 9: Bill's looking at the the girl, the truck who the girl's sitting on.

WS no. 9: Max is looking at the horse who a boy's standing on.

WS no. 10: He's pointing at the horse that the boy's sitting on.

WS no. 10: Max is looking at the cow that the boy's pointing at.

WS no. 10: Bill is looking at the boy that the cat's jumping over.

WS no. 10: Bill is looking at the cat that the girl's chasing.

WS no. 10: Bill's looking at the cow that the boy's pointing. (missing preposition)

WS no. 10: Max is looking at the boy that the girl's jumping over.

WS no. 10: Max is looking at the cat that's the dog chasing.

WS no. 10: Max is looking at the cow that the girl's pointing at.

WS no. 10: Bill's looking at the truck that the girl's sitting on.

WS no. 10: Bill's looking at the TV that the girl's watching.

WS no. 10: Max is looking at the car the bird's standing on.

WS no. 10: Max is looking at the truck that the girl's jumping over.

WS no. 10: Bill is looking at the car that's the bird's flying over.

Centre-embedded position

WS no. 2: The one that Max is looking at, is uh the boy one.

WS no. 2: The one that the cat is jumping over is blue.

WS no. 4: The one the girl's looking at, and the boy's looking at, is green.

WS no. 8: The ... the ... the car ... that the fly ... the bird is flying over, is green.

Freestanding NP

WS no. 1: The horse that the guy is sitting on.

- 1380 WS no. 2: The one that the airplane is looking over.
WS no. 2: One that the bird is flying over. (missing determiner)
WS no. 4: The one that the girl's jumping over.
WS no. 4: The one the girl's pointing to.
WS no. 4: The one that bird's sitting on.
WS no. 6: It's the one that the boy's looking at.
1385 WS no. 8: The car, the car that the bird sat on.
WS no. 9: Um, the horse that the guy's standing on.
WS no. 10: The car that the bird's flying over.
WS no. 10: The house that the airplane is flying over.
WS no. 10: The guy that turned pink that the girl's jumping over.
1390 Extraposited position
WS no. 10: The cat turned yellow that the girl's chasing.
WS no. 10: The cat turned purple that the dog's trying to chase.

UNCORRECTED PROOF