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ARTICLE

Ordinals are not as easy as one, two, three: The acquisition of cardinals and ordinals in Dutch

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ABSTRACT

This study argues that the pattern and timing of ordinal acquisition differs substantially from that of cardinals and is influenced by different language-specific factors, such as (ir)regular ordinal morphology, superlative morphology, and the singular-plural distinction. We discuss data from a Give X task (Wynn 1992) administered to 77 Dutch monolinguals (2;11–6;04) that support a so-called knower-level acquisition pattern (e.g., Le Corre & Carey 2007) for Dutch cardinals but show a more complex picture for ordinals, which are acquired around the time a child masters the necessary counting principles and becomes a CP (cardinal principle) knower. Not only is the tiered pattern absent in regular low ordinals, we also see that it takes time for children to link *drie* 'three' to irregular *derde* 'third.' We take this as evidence that ordinals are acquired via rules, rather than being stored lexically one by one.

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1. Introduction

A recurring finding in developmental psychology is that children slowly discover the exact meanings of cardinals *one* through *four* in a tiered fashion before becoming fully competent counters (Le Corre & Carey 2007). Linguistic knowledge is argued to play an important role in this process, both in the initial stages and in helping children overcome the limitations of innate, nonverbal, number systems (e.g., Carey 2009; Izard et al. 2008). Something similar applies to ordinal numerals as well: Children need to learn which counting principles to apply and they need linguistic cues and forms to do so, which is not necessarily a straightforward process. However, the role of linguistic knowledge is potentially different in the ordinal situation, as the morphological complexity of ordinals may help (or hinder) children to grasp ordinal meaning, whereas the linguistic form of cardinals offers nothing to help children acquire cardinal meaning.

This raises the question of whether the pattern and timing of ordinal acquisition also differs from that of cardinals, and if so, whether these differences can be related to linguistic factors. The goal of this study is to answer these questions by comparing Dutch children's understanding of cardinals and ordinals: Not only has ordinal acquisition received little attention in general, but such a systematic comparison to cardinals is absent from the literature altogether (Colomé & Noël 2012; Fischer & Beckey 1990; Trabandt et al. 2015; Miller et al. 2000).

On the basis of a Give X task administered to 77 Dutch children, we show that cardinal and ordinal comprehension patterns develop differently, both with respect to their pattern and their timing. Whereas cardinals are acquired lexically and in a stepwise fashion, our data suggest that ordinals are acquired via rules: Though children do find lower ordinals generally easier than higher ones, it seems the morphosyntactically irregular *derde* 'third' is the hardest of all. At the very least,

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this suggests that a transparent relationship with the corresponding cardinal is beneficial, but we take an even stronger stance, arguing it is indicative of rule-based learning. We also show that earlier stages of ordinal acquisition are influenced by the singular-plural distinction and superlative morphology.

2. Developing numerical and linguistic knowledge

Various studies have shown that humans and animals alike are equipped with two innate systems that can be used for representing numerical concepts: a so-called Approximate Number System (ANS) for imprecise representations of large numerical magnitudes and an Object Tracking System (OTS) that allows for exact representations of up to three or four individual objects (e.g., overviews in Feigenson, Dehaene & Spelke 2004; Spelke & Kinzler 2007). However, these systems do not provide us with the means to reason about exact quantities beyond that upper boundary. It seems children employ another uniquely human capacity to overcome the boundaries of the initial state of these number systems and develop adult-like numerical concepts: language (Hurford 1987; Carey 2009).

This begs the question: Which aspects of language (e.g., the count list, quantifiers, grammatical number) are relevant here, and how do they help to bring the ANS and OTS together? This question has been a recurring topic in the literature for decades (see e.g., Carey 2009; Le Corre & Carey 2007 for overview and discussion) and is not something that we can address in detail here. However, assuming that language does play some important part, we may wonder whether we expect cross-linguistic differences to affect the development of number (in other words: Is it the language capacity that drives this development or specific properties of a given language?) and whether we might see effects of the interplay between language and core knowledge of number beyond the scope of cardinals—in the current study, in the ordinal domain.

2.1. *Cardinal acquisition*

To address the first question, we need to know what the pattern and timing of cardinal acquisition typically looks like. Various studies have shown that children need time to acquire the exact meanings of cardinals and master verbal counting (e.g., Condry & Spelke 2008; Huang, Spelke & Snedeker 2010; Le Corre et al. 2006; Le Corre & Carey 2007; Le Corre et al. under revision; Li et al. 2003; Sarnecka & Gelman 2004; Sarnecka et al. 2007; Wynn 1992). From a so-called knower-level perspective, children progress through different stages before becoming fully competent counters. Children start this process by reciting a count list, though they may not do this correctly and do not understand the exact meaning of each number word. They begin to grasp these exact meanings in a slow and stepwise fashion, first distinguishing between *one* and the other numerals. In this stage, children advance from so-called pre-knowers (pre-number knowers, with an inexact understanding of cardinals) to 'one-knowers,' who know that *one* means precisely one and that the other cardinals are more than that. Next they learn the meaning of *two*: 'Two-knowers' have exact representations of *one* and *two* but will give a random larger number when asked to give other numerosities. Likewise, 'three-knowers' can answer correctly when asked for up to three items and 'four-knowers' (though not found in all studies) for up to four. Together, children in these stages are referred to as 'subset-knowers,' since they know a subset of the numerals in their count list.

After four, however, children are able to infer the meanings of all the other numerals in their count list and become cardinal principle (CP-)knowers. These children answer a question of *how many* by replying with the last-named cardinal after counting, indicating knowledge of at least three counting principles: the one-to-one correspondence principle (every cardinal belongs to one counted item, object, sound, etc.), the stable order principle (the count list has a strict order), and the cardinality principle (the numerosity of the set is equal to the last number counted). Gelman & Gallistel (1978) also name two other principles that are not necessarily crucial here: the order-

irrelevance principle (the order in which the items themselves are counted does not matter) and the abstraction principle (that counting can be applied to all sorts of modalities and situations).

Though the evidence for this slow and sequential process of cardinal acquisition is robust, it is also quite clear that the start and duration of each stage vary greatly, both between studies and between individuals. Children generally move through this pattern somewhere between the ages of 2 and 4, with the lower subset-level stages typically being the longer ones (potentially lasting six to nine months) and the higher ones the shortest. Most American English-speaking children become CP-knowers between the ages of 3;06 and 4;0, though these same studies also show that children well into their fours can still be in the lower subset-knower stages (e.g., Huang, Spelke & Snedeker 2010; Le Corre & Carey 2007).

In order to become such fully competent counters, i.e., to map the meanings of early numerals to exact cardinalities, children may rely on different linguistic cues, such as knowledge of singular-plural marking (as argued in Carey 2004, 2009, but see Clark & Nikitina 2009; Barner et al. 2009; Barner, Lui & Zapf 2011 for a different perspective), given their ability to distinguish one versus more-than-one. Quantifiers, which are semantically close to cardinals (both denoting a quantificational property of a set), have been argued to play a role as well (Barner & Bachrach 2010; Barner, Chow & Yang 2009; Barner et al. 2009; Bloom & Wynn 1997). Quantifiers and cardinals in English also show similar syntactic behavior. They can both modify count nouns (*three boxes, some boxes*) and can occur in partitive constructions (*three of the boxes, some/all of the boxes, *big of the boxes*) but cannot appear between an adjective and the noun it modifies (**the big three boxes, *the big some boxes*, but *the big heavy boxes* is fine). A third cue may come from count (versus mass) syntax, given that individuation is relevant for counting (e.g., Barner & Snedeker 2005, 2006; Bloom & Wynn 1997; Li, Barner & Huang 2008). Granted, these properties and examples are not exhaustive and somewhat simplify the situation, but they nonetheless illustrate the types of information children may use in bootstrapping knowledge from one category to another (see also Syrett, Musolino & Gerlman 2012).

Because languages vary with respect to properties like those listed, the question now arises to what extent learners of different languages show the same patterns and timing in cardinal acquisition. Though the vast majority of research has focused on middle-class American children, some cross-linguistic work has also been done. The studied languages vary greatly (Japanese in Barner et al. 2009, Sarnecka et al. 2007; Russian in Sarnecka et al. 2007; Slovenian in Almoammer et al. 2013; Saudi-Arabic in Almoammer et al. 2013; Mandarin in Almoammer et al. 2013, Le Corre et al. under revision; and Tsimane' in Piantadosi, Jara-Ettinger & Gibson 2014) and are spoken in geographically and culturally different places, but what they have in common is that they all differ crucially with respect to the suggested linguistic cues. For example, they do not (obligatorily) distinguish singular and plural (Japanese), or they also mark dual (Slovenian, Saudi-Arabic) or inflect numerals for case (Russian). Yet despite these cross-linguistic differences, all of these studies succeeded in classifying children in terms of knower-levels, and all offer support for the idea that this pattern of cardinal acquisition is universal. The timing, however, varies, both within as well as across samples. Explanations for this variation have been argued to lie in differences in morphosyntax (i.e., precisely the reason why these languages were studied) and the quality of exposure. In other words, how and where a language marks number affects the speed of cardinal acquisition: Having rich numerical syntax helps, as does being able to combine numerals and nouns directly (as opposed to using a classifier), but frequency on its own does not seem to matter if the context in which numerals are used is less informative. This context may be interpreted as syntactic, but it may also very well be linked to explicit training (e.g., Almoammer et al. 2013). This potential effect of exposure makes it difficult to disentangle linguistic effects from cultural ones, precisely because these languages are both linguistically and culturally diverse. Therefore, focusing on a language more similar to English (minimizing the linguistic distance) with respect to the cardinal domain would provide us with a cleaner basis for investigating potential influential factors within the ordinal domain. We use Dutch,

for which (to our knowledge) cardinal acquisition has yet to be studied, for this purpose. We return to Dutch in section 2.3, and turn now to what is known about ordinal development.

2.2. *Ordinal acquisition*

Ordinal numerals are semantically similar to cardinals in the sense that counting principles and exact number are key. As in the cardinal situation, children must learn which counting principles to apply to determine ordinality, and they may use linguistic cues and forms to help them do so. Moreover, many of the counting principles that apply to cardinals (the stable order principle, the one-to-one correspondence principle, and the abstraction principle; see previous and, e.g., Gelman & Gallistel 1986) also apply to ordinals. The cardinality principle and the order irrelevance principle are exchanged for two others: The ordinality principle (that the ordinal refers to a specific item counted in the set rather than the whole set) is crucial in determining ordinality, and the order relevance principle (that the order in which elements are counted influences that element's ranking) is needed to do so correctly. Children also need a certain linguistic form to express the position of a referent relative to a deictic center. While they could also use cardinals to assess and express such a rank (i.e., *car one, car two*, etc.; see Wiese 2007), adult speech generally seems to favor synthetic ordinal numerals, which may be derived transparently from the corresponding cardinal (as in *four–th*) but do not have to be, especially in lower ordinals (*first, second, third*; see Hurford 1987; Veselinova 1998).

Despite this conceptual and linguistic relationship, and despite the hypothesis that language is key in numerical development, surprisingly little is known about how cardinal and ordinal acquisition compare. Systematic empirical work on the acquisition of ordinals is nonexistent, and the small handful of studies that have been carried out in the past few decades all focus on different languages (see Fischer & Beckey 1990 for English, Miller et al. 2000 for English and Chinese, Colomé & Noël 2012 for French, Trabandt et al. 2015 for German), different age groups (between 3 and 10 years), focus on limited numerals and employ different types of methods. This makes it difficult to draw any strong, meaningful conclusions from their results. For example, none of these studies tests all of the first four ordinals (making it impossible to distill a knower-level type pattern), none of them included more than two trials per numeral condition, and only Colomé & Noël (2012) tested the cardinals and ordinals in a minimally different way (i.e., matched the items and the method), though the lack of trials impeded comparison anyway. However, such shortcomings notwithstanding, it seems these studies might suggest a number of tendencies when put together.

First, perhaps unsurprisingly, it seems that ordinal acquisition begins later than cardinal acquisition. Not only can children count further using cardinals than ordinals (Miller et al. 2000), they also perform better on cardinal trials than on ordinal trials (Fischer & Beckey 1990; Colomé & Noël 2012). This cardinal advantage can also be seen by comparing cardinal and ordinal performance at set ages.[1] Around the age at which many children become or are CP-knowers, 4-year-olds still show difficulty comprehending ordinals: Only 35% of American children can identify the *fifth* (Fischer & Beckey 1990), just 41% of their French-speaking peers can find the *troisième* 'third' or *quatrième* 'fourth' (Colomé & Noël 2012), and a little more than half of the German 4-year-olds Trabandt et al. (2015) tested could find the *zweite* 'second' or *dritte* 'third.' This puts ordinal comprehension well below the cardinal level at these ages. Though performance improves with age in the French and German groups, with many children being at ceiling by age 5, American 6-year-olds still struggle with ordinals around 34% of the time (Miller et al. 2000). However, note that this final percentage is a mean score: In fact, 17 out 31 American 6-year-olds obtained a perfect score, meaning that a little

[1]Though not explicitly demonstrated, this observation could also be deduced from other studies that measured knowledge of *second* and *third* as a pretest for a different purpose. Matthei (1982) excluded 6 out of 41 children (roughly 15%) between the ages of 3;09 and 6;03 (mean 5;01, median 5;03) for failure to demonstrate knowledge of *second* and/or *third*. Hamburger & Crain (1984) excluded 14 out of 59 kids (24%) for this reason (average age failers: 4;11, range 4;05–5;09). The vast majority of the children in these studies should have been in the CP-knower stage.

less than half of the children must have performed well below chance. This suggests that ordinals are acquired all at once, rather than one at a time, and thus that we are looking at rule-based, rather than lexical, learning.

However, perhaps ordinal acquisition does follow some progression, as there is also some evidence that lower ordinals are easier than higher ones. Fisher & Beckey (1990) report that *third* is easier than *fifth* (31% and 25% correct respectively), Colomé & Noël (2012) show that *sixième* 'sixth' and *septième* 'seventh' are harder than *troisième* 'third' and *quatrième* 'fourth' in children aged 3 to 5, and Trabandt et al. (2015) report *zweite* 'second' being easier than *dritte* 'third' for some 4-year-olds (though this difference did not reach significance). None of the studies is able to report tiered patterns as found in cardinal acquisition (mostly due to the small selection of ordinals tested), but it appears that the place in the ordinal count list might influence a child's performance on a given ordinal in at least some way.

Another tentative conclusion is that the ordinal acquisition pattern is language specific. Of course direct comparisons are not possible on the basis of the existing results, but the previous studies at least hint at Chinese children being the quickest: They are at ceiling by age 6, even on higher ordinals up to *seventh* (Miller et al. 2000). Children acquiring English appear to be the slowest, lagging behind their (French-speaking) Belgian and German peers at age 4 and 5. While these timing differences could have to do with unrelated (e.g., cultural) factors, it seems plausible that morphology is the key factor—i.e., that regular ordinals are easier to acquire than irregular ones. Chinese ordinals, formed by adding prefix *di–* to a cardinal base, are nearly all regular. So are French ordinals (cardinal plus *–ième*), except for the suppletive *première* 'first.' German *erste* 'first' is also suppletive, and root allomorphy occurs in *dritte* 'third' (not **dreite*; regular ordinals are formed by adding suffix *–te* to a cardinal). English has the least transparent ordinal system in this group, since only *fourth* follows regular ordinal formation among the lower ordinals. French production data in Colomé and Noël (2012) also suggest that transparency is preferred in a different way: The authors report that most of the participants gave an analytic construction containing a cardinal numeral (such as the equivalent of *car three*) in an ordinal production task rather than an ordinal numeral. In other words, perhaps (in)transparency in the ordinal system affects acquisition, though whether this applies only to the linguistic forms or also influences understanding of the underlying concepts remains an open question (as also noted by Miller et al. 2000 and Colomé & Noël 2012). Equally unclear is whether the syntax of ordinals also plays a role (as does a rich numerical syntax in cardinal acquisition).

When taken together, these studies suggest that, besides age, three factors play some role in ordinal development: cardinal knowledge, the place of an ordinal in the count list, and the regularity of that ordinal. However, due to the methodological shortcomings mentioned, none of this can be said with certainty, and the exact contributions of each factor cannot be determined at all. To tease these potential influential factors in ordinal acquisition apart, we need to focus on this interplay within one language, rather than cross-linguistically. Hence, we need to study a language that has an ordinal system that is somewhere in between a highly regular and a highly irregular one. As mentioned, we use Standard Dutch for this purpose here.

2.3. *Dutch as a case study for cardinal and ordinal acquisition*

Though most languages that have been the focus of cardinal acquisition studies were selected precisely because they differed from English in crucial ways (e.g., a lack of plural marking or the use of duals), our goal is to minimize these differences to use cardinal acquisition as a type of "baseline" situation. Minimal linguistic differences should minimize differences in cardinal acquisition, giving us a stronger platform for studying ordinals, the main focus of this article. We take Dutch to be useful here, both given existing research and our present goals.

For one, the cardinal system is similar to English, but the knower-level acquisition pattern has (to our knowledge) not yet been verified for Dutch. Dutch is similar to English in other respects that have been suggested to be linked to the development of numerical concepts, such as number

marking, the mass/count distinction, and quantifiers (see references in section 2.1). Dutch distinguishes between singular (null suffix) and plural (typically suffix *–s* or *–en*) on count nouns. As in English, mass nouns and object mass nouns receive no special suffix; flexible mass nouns receive a count interpretation when pluralized. Both quantifiers and numerals modify count nouns (*sommige/geen/veel/drie dozen* 'some/all/many/three boxes') and can occur in partitive constructions (*sommige/geen/veel/drie van de dozen* 'some/none/many/three of the boxes'). Note that there are also differences between Dutch and English in quantification, such as universal quantifiers *iedere* and *elke* versus *each* and *every* (see Van Koert et al. 2015a, 2015b for how this plays out in acquisition), and measure phrase constructions (e.g., *a twenty-pound pumpkin* versus *een pompoen van twintig pond*, lit: 'a pumpkin of twenty pound'). However, the former have not been linked to cardinal acquisition, and the latter are acquired after cardinals (Syrett 2013).

For another, the Dutch ordinal system is more regular than English, yet less regular than ordinal systems of other languages previously discussed in ordinal acquisition (i.e., French and Chinese, and to a lesser extent even German). These two properties can be observed in Table 1, which shows the Standard Dutch cardinal and ordinal list through *twintig* 'twenty.'

Similar to English, the first 12 cardinals are monomorphemic, and the cardinals from *dertien* 'thirteen' to *negentien* 'nineteen' are formed by compounding with *–tien* 'ten.' *Twin–tig* 'twen–ty' follows from root allomorphy plus the suffix *–tig*. Ordinals are derived by adding either a suffix *–de* or *–ste* to a cardinal. Ordinals for up to and including *twaalf* 'twelve' receive *–de* (as for the other ordinals through *negentien* 'nineteen'), with the exception of ordinals for *één* 'one,' *drie* 'three,' and *acht* 'eight.' All higher ordinals end in *–ste* (e.g., *twintigste* 'twentieth'), as do indefinite ordinals (e.g., *zoveelste* 'umpteenth,' lit: 'so-many-th.')

The irregularities found in *eerste* 'first,' *derde* 'third,' and *achtste* 'eighth' differ crucially from each other. We take *achtste* to be regular, except that it takes the suffix generally used for higher ordinals, while *derde* is the result of root allomorphy in combination with the regular ordinal suffix *–de*. Though one might think *eerste* could be a product of both of these explanations (i.e., root allomorphy plus *–ste*), it seems more plausible to consider it a case of suppletion, in which a superlative is used. In other words, *–ste* is not an ordinal suffix here at all, but the (homophonous) *–ste* suffix that is also used to create superlative adjectives, such as *lang–ste* 'tall–est.' Not only do Hurford (1987) and Veselinova (1998) note that ordinals for *first* in many languages come from a temporal or spatial superlative adjective, Barbiers (2007) argues that *eerste* 'first' is a superlative for (synchronic) syntactic reasons. Unlike ordinals, Dutch *eerste* can modify plural nouns and can lose its final schwa (*eerst* 'first,' but **achtst* 'eighth') and can also be intensified by *aller–* 'very' (*allereerste* 'very first' but **allerachtste* 'very eighth'). These are all properties that *eerste*, but not other ordinals, shares with superlatives. Moreover, *eerste* arguably has a corresponding positive and comparative form: *eer, eerder* 'fore, former,' at least diachronically.

This contrast between *eerste* 'first' and other ordinals is important to point out. For one, this has implications for the effects of morphology that might play a role in acquisition: If *eerste* is acquired as superlative rather than an irregular ordinal, children may bypass potential negative effects of

Table 1. Cardinal and ordinal formation in Standard Dutch.

#	Cardinal	Ordinal	#	Cardinal	Ordinal
1	één	eer–ste	11	elf	elf–de
2	twee	twee–de	12	twaalf	twaalf–de
3	drie	der–de	13	der–tien	der–tien–de
4	vier	vier–de	14	veer–tien	veer–tien–de
5	vijf	vijf–de	15	vijf–tien	vijf–tien–de
6	zes	zes–de	16	zes–tien	zes–tien–de
7	zeven	zeven–de	17	zeven–tien	zeven–tien–de
8	acht	acht–ste	18	acht–tien	acht–tien–de
9	negen	negen–de	19	negen–tien	negen–tien–de
10	tien	tien–de	20	twin–tig	twin–tig–ste

irregular ordinal morphology and potentially benefit from existing superlative knowledge.[2] For another, ordinals cannot modify plural nouns (and thus only appear with singular nouns), whereas *eerste* 'first' can appear with both singular and plural nouns. As a result, it may be possible for children to deduce that ordinals refer to individuals rather than an entire set (as is the case with cardinals and sometimes *eerste* 'first'). Put differently, the syntactic context of *eerste*, like *laatste* 'last,' does not help to acquire ordinals as a class because *eerste* is not part of that class.

Another property that might influence acquisition and sets *eerste* 'first' apart from other ordinals is frequency. Table 2 presents frequency data from the SUBTLEX (Keuleers, Brysbaert & New 2010) and Corpus Gesproken Nederlands 'Spoken Dutch Corpus' (Oostdijk 2000) corpora.

The first database, SUBTLEX, consists of 44 million words from film and television subtitles. The second database (CGN) contains roughly 9 million words in 1,000 hours of speech files from the Netherlands and Flanders. The tallied frequencies in the A-columns are frequencies per million words for each corpus. Only fully spelled ordinals were counted (i.e., *tweede* was counted but not the abbreviated form 2^{e}). For *eerste*, both the forms with and without the *–e* were included, irrespective of how they were annotated syntactically. Compounds and cases with, e.g., *aller–* intensification were excluded. Still, *eerste* is clearly more frequent than all other ordinals in Table 2 combined, as it comprises more than half the attested cases in both corpora (B-columns). The crucial observation here is that while frequency may play a role in the acquisition of the lowest ordinals, it quickly becomes difficult to maintain effects of (token) frequency past *vijfde* 'fifth,' as the frequencies become marginally small and similar (all under 2.5% of the ordinals tallied).

2.4. *Research questions*

The literature on cardinal acquisition, ordinal acquisition, and Dutch ordinal formation brings us to three topics of inquiry. The first question is whether cardinal acquisition in Dutch follows the same pattern and timing as described for other languages, especially English. We expect that it does: Previous studies strongly suggest that the knower-level pattern is universal. Moreover, since Dutch is similar to English in many relevant respects, we also hope for a relatively clean comparison (linguistically speaking) to English. However, the studies discussed previously show that the timing of cardinal acquisition varies considerably both within and between samples, which makes it difficult to predict ages of acquisition for any knower-level in any exact terms.

Table 2. Frequencies of the first 20 ordinals in Dutch. The *Abs*-columns represent absolute frequencies per 1 million words per corpus; the *Rel*-columns represent the relative frequency within all the ordinals through *twintigste* 'twentieth' tallied in each corpus.

	SUBTLEX		CGN			SUBTLEX		CGN	
Ordinal	Abs	Rel	Abs	Rel	Ordinal	Abs	Rel	Abs	Rel
1^{e}	471.61	60.50%	1214.11	58.90%	**11^{e}**	2.42	0.31%	7.78	0.38%
2^{e}	129.82	16.65%	387.33	18.79%	**12^{e}**	3.84	0.49%	9.67	0.47%
3^{e}	76.49	9.81%	151.44	7.35%	**13^{e}**	2.63	0.34%	8.22	0.40%
4^{e}	25.61	3.29%	69.89	3.39%	**14^{e}**	2.06	0.26%	8.56	0.42%
5^{e}	17.88	2.29%	40.22	1.95%	**15^{e}**	1.72	0.22%	8.44	0.41%
6^{e}	11.02	1.41%	37.00	1.79%	**16^{e}**	2.38	0.31%	11.22	0.54%
7^{e}	9.01	1.16%	17.00	0.82%	**17^{e}**	0.75	0.10%	11.22	0.54%
8^{e}	5.97	0.77%	10.78	0.52%	**18^{e}**	1.23	0.16%	11.78	0.57%
9^{e}	5.21	0.67%	9.67	0.47%	**19^{e}**	0.91	0.12%	14.56	0.71%
10^{e}	7.27	0.93%	17.89	0.87%	**20^{e}**	1.65	0.21%	14.67	0.71%

[2]See Syrett (2016) for an overview of the acquisition of comparatives and degree constructions. Though there are differences between comprehension and production, and between different kinds of comparative constructions, it is clear that comparative and superlative acquisition begins around the age of 3 (i.e., before cardinals).

The second and primary goal of this study is to investigate the patterns and timing in ordinal acquisition and what factors play a role in this process. Specifically, we ask whether age, cardinal knowledge, (ir)regular morphology, and the place in the ordinal count list predict children's comprehension of given ordinals and how these factors interact. First, we expect older children to perform better than younger children and higher ordinals to be more difficult than lower ordinals. Second, the morphological complexity of ordinals suggests that children should acquire a cardinal before its corresponding ordinal. There are two ways in which ordinal morphology might affect acquisition, which we would like to refer to as the weak hypothesis and the strong hypothesis.

Under the weak hypothesis, ordinals are acquired lexically, much in the same way cardinals are: one by one in a truly tiered fashion. If ordinals are acquired lexically, higher ordinals are expected to be more difficult for the same reasons higher cardinals are (and because higher ordinals are less frequent than lower ones), the acquisition of ordinals would be progressive and not necessarily reliant on their derivation from cardinals. Irregular *derde* 'third' could be more difficult due to the lack of transparency, since the form provides no clues to its meaning. Put differently, a transparent relationship between cardinals and ordinals can be helpful in determining their meaning, but neither such transparency nor a full and exact understanding of cardinality is crucial. Perhaps this scenario is more easily imaginable for the English ordinal system, where the first ordinals are so irregular that children might learn ordinals one after another (but independently of their corresponding cardinals) rather than 'wait' for a rule.

Under the strong hypothesis, children use an ordinal formation rule to acquire all (regular) ordinals simultaneously; they use the form to acquire ordinal meaning. This would mean they acquire ordinals as a class, and ordinals would necessarily have to be acquired as or after children become CP-knowers: Without an exact understanding of the cardinal root, it is impossible to determine the contribution of the suffix to that root to reach ordinal meaning. Exceptions to this rule (like *derde* 'third') are then acquired later than regular forms like *vierde* 'fourth' because children cannot decompose the ordinal into recognizable parts. Higher ordinals may also be more difficult but for nonlinguistic reasons (though the slightly deviant suffix for *achtste* 'eighth' may also cause extra difficulty).

One question is whether subset-knowers can begin to acquire ordinals via a rule-based strategy. If they can, the prediction is that children would be able to apply the rule to cardinals that they know and then learn the remaining ordinals and cardinals in tandem. In such a situation, a tiered pattern in acquisition (as in the weak scenario) would be visible. However, the question is how children could apply a productive rule to an unproductive and limited cardinal system. Subset-knowers (perhaps with the exception of four-knowers, who are on the cusp of cardinal acquisition) have such an incomplete representation of cardinals and cardinality that we find it difficult to imagine how the ordinal formation rule would work in that case: Without the proper counting principles, without the knowledge that cardinals refer to discrete entities, without the proper semantics of the cardinal root—how are they to conceive of a productive and meaningful rule for the contribution of the ordinal suffix and thus ordinals? In other words, if the strong hypothesis predicts a tiered pattern at all, it would consist of three or four steps: First, children know no ordinals at all, then all regular ordinals (derived from cardinals that children already know), then irregular ordinals (lexically), with an optional tier to distinguish low (up to *fourth*) and high ordinals if the rule is acquired before children can put it into practice reliably in longer count lists. Note that while the weak (or lexical) hypothesis suggests that the acquisition of ordinals is likely better predicted by age than by cardinal knowledge specifically, the strong hypothesis suggests that ordinal acquisition is necessarily determined by cardinal knowledge: Regardless of age, ordinals cannot be acquired unless the relevant cardinal knowledge is in place.

Our third question is geared mostly toward children in earlier stages of ordinal development: Are there other linguistic factors (such as the singular-plural distinction or regular superlative morphology) that might help start ordinal acquisition? If number marking plays a role, we would expect children to take just one item when asked for any ordinal, regardless of whether they know the exact

meaning of that ordinal and regardless of their knower-level. If knowledge of superlatives is a factor (or if frequency helps), we expect *eerste* 'first' to be acquired before ordinals.

3. Method

Children's comprehension of cardinals has been tested in various studies using varieties of the 'Give-a-Number' paradigm, a selection task also known as a "Give me" or "Give X" task (e.g., most notably Wynn 1992, but also Almoammer et al. 2013; Colomé & Noël 2012; Condry & Spelke 2008; Huang, Spelke & Snedeker 2010; Le Corre et al. 2006; Trabandt et al. 2015; Li et al. 2003; Sarnecka & Gelman 2004; Sarnecka et al. 2007, among others). The present study adapted this paradigm to directly compare cardinal and ordinal acquisition.

3.1. *Participants*

In total, 77 children (40 boys, 37 girls) participated in this experiment. We divided children in three age groups during testing: 3-year-olds (N = 31, mean age = 3;06, SD = 3.5 months, range = 2;11–3;11), 4-year-olds (N = 26, mean age = 4;06, SD = 3.1 months, range = 4;0–4;11) and older kindergartners (N = 21, mean age = 5;06, SD = 5.13 months, age range = 5;0–6;04). All participants were typically developing monolingual Dutch children. An additional eight children were excluded from analysis because they did not complete both sessions of the task.

3.2. *Materials and procedure*

All children were tested on the cardinals *one* through *four* and *eight*, as well as on their corresponding ordinals (*first* through *fourth, eighth*). Because each numeral appeared three times, the initial task consisted of 30 critical trials.[3] We later incorporated items for *nine* to exclude the possibility that *achtste* 'eighth' was misheard as *achterste* 'backmost' and to check for general consistency within the higher ordinal trials. This version of the task contained 36 critical trials and was completed by 29 participants. The filler trials used were the degrees of comparison of *groot* 'big,' *klein* 'small,' *lang* 'long,' *dik* 'fat,' and *veel* 'many,' plus the indefinite ordinals *middelste* 'middle-est' and *laatste* 'last,' which together represented 41 items in the total task. We divided the task into two sessions: one for cardinals, and one for ordinals. In addition, children were asked to count to 20 at the end of each session. We presented items in one of eight pseudo-random orders within each session, and we counterbalanced which session was administered first between participants within each age group. We administered the second session within a week of the first. Sessions lasted approximately 15 to 20 minutes each.

The materials consisted of a stuffed animal (Jaap the monkey), two paper suitcases (printed on heavyweight craft paper, then cut and pasted together), and plastic containers that held the actual items: laminated cards (4.5 x 4.5 cm) with images of everyday objects and animals. For ordinal items, the pictures used had clear fronts or faces to emphasize the direction of the line. The number of items in line depended on the cardinal or ordinal: The lowest numerals (*one, two, first*, and *second*) all had four cards in line; numerals *three, four, third*, and *fourth* had six cards, and the higher numeral items consisted of 10 cards. The reason the length of the line varied was a practical one: Putting more cards on the table adds to the total testing time and increases the materials needed.

Children were tested individually at their school or day care center, either in a separate room or in a quiet corner of the classroom. They were seated to the left of the experimenter and to the right

[3]In other words, we did not use the titration method described in, e.g., Wynn (1992), Barner, Chow & Yang (2009), or Le Corre et al. (2006) but tested all children on all the numerals mentioned. Though one could argue that the titration method prevents testing children on higher items unnecessarily, it might also inherently reflect a tiered pattern in acquisition.

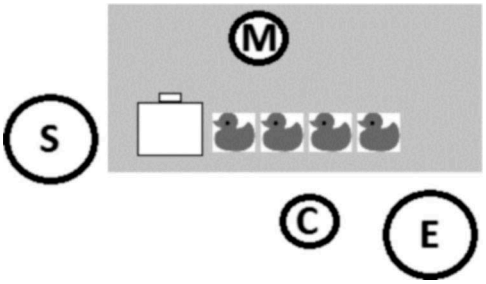

Figure 1. Experimental setup for *de tweede eend* 'the second duck.' M is Jaap the monkey, S is the score person, C is the child, and E is the experimenter. The image is not to scale.

of the monkey and his suitcases (see Figure 1), and introduced to the materials and the task by a short story, as translated in (1):

(1) Introductory story

> This is Jaap. Jaap is a very friendly monkey. And pretty soon he's going on a trip. He doesn't know where he's going (it's a surprise), but he's super excited about it. He told all of his things that he's leaving and guess what? Now all of his things want to come along! They're even getting in line to jump into his suitcase. [Experimenter demonstrates line with a gesture.] But Jaap has a little problem because look: He has a whole lot of things, and only two suitcases: a yellow one and a white one. [Experimenter points to each suitcase.] So not everything is going to fit, huh? So Jaap needs a little help, and I think the two of us would be really good at helping him out. What do you think? Do you want to help the monkey?

After the story, children were allowed to pick which of the two suitcases they wanted to begin with. Two practice items then helped to acquaint them with the task and the materials at the beginning of each session. For each item (both during and after the practice phase), cards were placed one by one in front of the child in a straight line, starting near the suitcase and working from left to right. This way, a child could access an ordinal interpretation both temporally (the *nth* placed on the table) and spatially (the *nth* in line). The experimenter pointed out the beginning of the line for both practice items, in which children had to find a certain object *vooraan* 'at the front' and *achteraan* 'at the back' of the line. Most children were able to do so. Those who failed on the practice items were asked to show the experimenter where the line began and/or in which direction the things were going to familiarize them with the general concept of the line. No children were excluded for failure to understand or physically perform the task.

For all further items, children were asked to pack a certain item or collection of items (e.g., *three t-shirts, the second rubber ducky, the last truck*, etc.) in the suitcase. Literal examples of how items and fillers were offered to the children are given in (2) through (5) for ordinals, cardinals, comparatives, and superlatives respectively.[4]

(2) De tweede eend mag mee. Kun je de tweede eend vinden en in de koffer doen?
The second duck may.SG with. Can you the second duck find and in the suitcase do.inf
'The second duck gets to come. Can you find the second duck and pack it in the suitcase?'

[4]Note that for comparatives, the experimenter pointed to an object on the table to make the comparison explicit. Only the comparative was offered overtly and not a full phrasal comparative (i.e., only *a cat that's fatter* rather than *a cat that is fatter than this cat*). An anonymous reviewer wondered about the acceptability of this type of comparative in Dutch. The comparative we used, such as in example (4), is perfectly acceptable in Dutch, although using the adjective attributively (e.g., *een dikkere poes* 'a fatter cat') would have also been grammatical.

(3) Er mogen acht stiften mee. Kun je acht stiften (tellen en) inpakken voor Jaap?
There may.PL eight markers with. Can you eight markers (count and) pack for Jaap?
'Eight markers get to come. Can you (count and) pack eight markers for Jaap?'

(4) Deze poes gaat niet mee. Kun je een poes vinden die dikker is?
This cat goes not with. Can you a cat find that fatter is?
'This cat isn't coming. Can you find a cat that's fatter?'

(5) De kleinste tv mag mee. Kun je de kleinste tv vinden en inpakken?
The smallest tv may.SG come. Can you the smallest tv find.INF and pack.INF
'The smallest tv can come. Can you find the smallest tv and pack it?'

Formulaic variations (e.g., *Jaap zegt dat* 'the monkey says that') occurred to keep the setting natural, but typical stimuli offered children the numeral (or filler) as part of a full subject DP; ordinals were often repeated with a definite article (e.g., *de tweede*, 'the second'), cardinals with a noun (e.g., *acht stiften*, 'eight markers'). Some children (typically the older ones) were quick to react and/or repeated (part of) the stimulus, in which case repetitions were often left out. The experimenter encouraged children to count aloud but did not always do so when asking for a given item. Follow-up questions (e.g., 'Can you check/count and make sure?' or 'Can you show me that's eight?') were asked to allow children to check and correct their responses.

Because we needed a design that emphasized the ordinal and filler contexts naturally, and because our test conditions led to a larger test set than in a standard Give X task, the modifications described previously were made to make the task more natural, less monotonous and to keep the children engaged throughout.[5] That being said, the monkey puppet played a limited role in the rest of the experiment itself. Jaap was introduced as an ice-breaker in the classroom environment and helped to provide some more context to the story. During the experiment, the experimenter could use the monkey to help keep the child engaged and to mediate situations in which the child was confused about an item. ("Really, so you think the third isn't in line, huh? But the monkey asked for the third car? Where do you think it could be?") In general, the experimenter behaved as the monkey's interpreter, asking the child for given items on his behalf. This puts less pressure on the child, since she could always resort to calling the monkey *silly* or *wrong* if he 'asked' for an ordinal she did not know or thought was ungrammatical, rather than going against (the authority of) the adult experimenter.

3.3. *Determining numeral knowledge*

We determined a child's knowledge of cardinals differently than for their knowledge of ordinals. For cardinals, we established a knower-level for each child by applying and comparing two separate measures. First, we took a common approach and considered a child a certain *n-knower* when he or she gave *n* cards at least two out of three times when asked for that number and gave *n* cards at most once when asked for a different number. These criteria are in line with those reported in, e.g., Le Corre & Carey (2007), but because they could be considered crude or ad hoc, we also estimated knower-levels using the tool provided by Negen, Sarnecka & Lee (2012), which approximates a Bayesian inference of a child's knower-level (see

[5]A reviewer worried that how full a suitcase was may have influenced the child's responses. We did consider this as a potential issue before testing, taking care to use appropriately sized suitcases for the materials (i.e., large enough so that more than the requested items would fit but not so large that a child felt he could have packed everything). We did not test whether children used the suitcase as a strategy anyway, though nothing in the way they behaved or responded suggested they did.

also Lee & Sarnecka 2010a, 2010b).[6] The outcomes of both methods were the same, and children were easily categorized in most cases. In the seven cases where the model was inconclusive and/or there was a difference between the two methods, we carefully evaluated the child's responses (including any notes the score person may have included on the score sheet) to categorize the child. There was never more than one knower-level difference. We chose the more conservative option in five cases.

Since ordinal comprehension is not as well studied, there are no established criteria or models for determining a child's knowledge of a given ordinal. Though we would have liked to maintain the same criteria for cardinals as for ordinals and compare them as directly as possible, we opted to treat the ordinal acquisition data differently: We depart from the 'knower' criteria that we used for the cardinal domain and apply a more elaborate analysis to the ordinals we tested that helps tease apart effects of age, cardinal knowledge, regularity, and the place in the count list. We then discuss *eerste* 'first' separately from the rest of the ordinals: Since *eerste* 'first' is a superlative, not an ordinal (see Barbiers 2007 and discussion in section 2), and hence, a conceptually different entity, discussing those results entirely within the ordinal set is inappropriate.

First, we have to address why the criteria for assessing cardinal knowledge should not be applied in the ordinal situation. The first issue at hand has to do with how errors are treated in determining a child's knowledge of numerals. Under the cardinal criteria, if a child answers incorrectly to a given cardinal (e.g., he gives *four* when asked for *three*), he is penalized on both the requested cardinal and the numeral he provides erroneously (*three* and *four*). This is fine as long as the expectation is that children will properly infer that cardinals are in competition with each other: If a child knows the meaning of *one* and *two*, and he knows that *three* refers to an exact quantity but is unsure of which quantity exactly, he should know that *one* and *two* items are not acceptable answers in that scenario, and he should therefore give a higher number of items in response to that request. The tiered pattern of cardinal acquisition reflects that this inference (or something similar to it) is indeed the case: Cardinals are acquired along the list, with errors going in one direction only.

For ordinals, the necessity of such a pattern is far less obvious. Say a child knows every ordinal except *derde* 'third' because his ordinal for *third* is *driede* 'lit: threeth.' Such reasoning would entail that every card a child chooses when asked for *derde* is incorrect or must overlap with an ordinal he does know. A child who then chooses systematically for any given card would be considered a non-knower of not only *derde* 'third' but also that other ordinal. Given that a child has six cards to choose from in this condition, the original knower-determination method would only allow the last two cards as 'safe' choices, but this is obviously task specific and unfair to the child. This is also the case for a child who chooses less systematically on *derde* 'third' but happens to get one item wrong elsewhere, selecting the same incorrect card twice.

Because the acquisition pattern of ordinals does not have to be (and, as we will argue, is indeed not) tiered in the same way as cardinal acquisition, we do not try to formulate analogous notions of 'first-knower,' 'second-knowers,' and so on. Instead, we discuss children's performance on ordinal trials in terms of (in)correct responses.

[6] A child's knower-level can be inferred using the probabilistic generative model developed by Lee and Sarnecka (2010a, 2010b) on the basis of a large amount of Give-*N* data. This model specifies a base rate (put crudely: chance performance) and then modifies this rate following Bayes's rule. It looks at children's responses and then predicts the probability of children belonging to a certain knower-level given those responses: i.e., when asked for *two ducks*, the probability for giving four is higher for a one-knower that for a three-knower, and the probability for giving two is higher for the three-knower than the one-knower. Hence, this allows us to infer in which knower stage a child most likely is. The tool created by Negen, Sarnecka & Lee (2012), an Excel spreadsheet, is an easy and accurate way to approximate the inference this model makes.

Table 3. Mean percentage of correct responses to comparatives and superlatives by age group.

	Preschoolers		4-year-olds		5- & 6-year-olds	
	Comparative	Superlative	Comparative	Superlative	Comparative	Superlative
M	97%	87%	100%	96%	98%	97%
SD	7.02%	10.33%	1.31%	7.29%	4.47%	6.31%

4. Results

Before going into the results from the cardinal and ordinal trials, it is worth taking a brief look at the filler items.[7] All children performed well on the positive, comparative, and superlative fillers we tested (namely, *big, small, long, fat*, and *many*). Five children (all between 35 and 40 months) scored four out of five of the positive fillers correctly, and all other participants answered correctly on all five. . Table 3 depicts the mean percentage of correct responses on the comparative and superlative items per age group.

As is immediately obvious, very few mistakes were made on comparatives and superlatives in general. Children did well on an individual level too, as all participants scored at least 11/15 items correctly, and most were near ceiling. This high performance rate shows us that children, even those who performed near floor level on cardinal and ordinal trials, understood the task and were engaged throughout each session.

4.1. *Cardinals*

Table 4 displays children's ages at each knower-level, as well as performance on the counting task, for which the highest count of the two sessions was used for each child. Figure 2 is an area plot of the knower-levels by age.

The data are not only in line with previous studies in that children do in fact seem to acquire the exact meaning of cardinals in stages but also in that children are typically able to count much further than they can comprehend. Nearly all the children could count to at least 10, which is high enough to have been able to answer all the items in this task correctly. Four-knowers onward generally counted to 20 (which is as far as we asked them to count).

Table 4 also shows that the children in our sample show a wide range of individual differences. Despite this variation, a Spearman's correlation test reveals that children's count lists increase with both age in months (r_s = 0.610, p < .001) and knower-level (r_s = 0.648, p < .001); older children also tend to be further along in cardinal comprehension (r_s = 0.745, p < .001). Gender did not seem to play a role. There was no significant difference in how far boys (M = 14.20, SD = 6.726)

Table 4. Knower-level, age, and count list length of all participants. Age ranges and means are given in years (year;month) and months, the standard deviations in months only.

		Age			Count List			
Levels	*n*	Range	Mean	*SD*	Mean	Range	*SD*	% count ≥10
Pre-knowers	3	2;0–3;04 (35–40)	3;01 (37.3)	2.5	8.33	5–10	2.89	67
One-knowers	9	3;0–4;03 (36–51)	3;05 (41)	4.9	9.89	1–20	6.15	56
Two-knowers	12	3;0–4;05 (36–53)	3;09 (44.5)	5.3	9.33	0–20	6.02	67
Three-knowers	1	3;08 (44)	3;08 (44)	–	14	14	–	100
Four-knowers	16	3;06–5;03 (42–63)	4;03 (52.1)	6.9	17	9–20	4.46	94
CP-knowers	36	3;07–6;0 (43–76)	5;0 (59.6)	8.9	18.5	6–20	3.62	97

[7]There was no significant difference on total test performance between children who took the cardinal sessions first (mean 79% correct, *SD* = 15%, *N* = 42) and children who completed the ordinal session first (mean 79%, *SD* = 13%, *N* = 35); t = 0.085, p = .448. We therefore report the results for both testing orders as a whole.

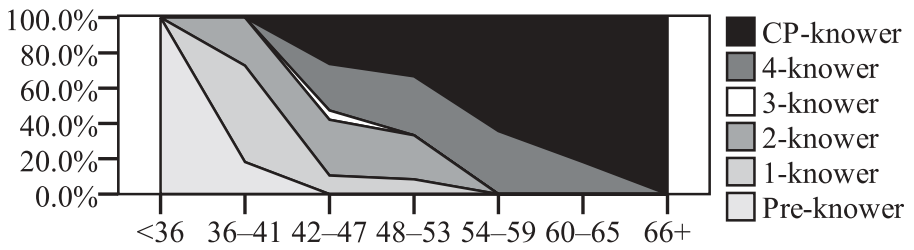

Figure 2. Area plot of knower-level distribution by age group (months).

and girls (M = 16.49, SD = 4.897) could count (Mann-Whitney U = 640.0, Z = –1.103, p = .270, two-tailed), nor was there evidence for knower-level differences between genders (Mann-Whitney U = 594.0, Z = –1.584, p = .113, two-tailed).

Though the children in the present study follow the knower-level pattern in acquisition discussed above, Figure 2 suggests Dutch children nonetheless differ slightly from children acquiring other languages. Dutch children seem, on average, slightly slower than other children to become CP-knowers. For example, Almoammer et al. (2013) report that 88% of Slovenian and 80% of American English-speaking children aged 3;0–3;06 knew at least the meaning of *two*, whereas 28% of children in the same age group meet that requirement in our sample. Most American English speakers know the exact meaning of at least *three* by age 3;06 (e.g., Le Corre & Carey 2007, Le Corre et al. under revision, Sarnecka & Carey 2008). Our sample included no children under 3;06 who were three-knowers or better, and by age 3;11 only 58% were. Dutch children make up for some lost time but seem on average slower to become CP-knowers. Huang, Spelke & Snedeker (2010) report most American English-speaking children to be CP-knowers around their fourth birthday, and all of American and Saudi children aged 4;06–5;0 reported in Almoammer et al. (2013) were indeed CP-knowers. Slovenian children are about evenly divided between four-knowers and CP-knowers at this age, whereas the majority of Dutch children are CP-knower from 4;06 on.

Another observation is that there is only one three-knower in our sample, as opposed to the relatively large group of four-knowers. However, the proportions of different subset-knowers vary from study to study, as do the ages of the children in these groups. Almoammer et al. (2013), for example, report small groups of both the higher subset-knowers in all languages they discuss, while Le Corre & Carey have more three-knowers than four-knowers. In the present study, there is a large gap between the mean age of the two-knowers and four-knowers and much overlap in ages between all knower-groups. We return to this later.

4.2. *Ordinals*

Though we used different methods to assess children's knowledge of ordinals than for cardinals, this does not mean that we cannot attempt to compare cardinal patterns to ordinal ones at all. For example, Figure 3 divides children's performance on ordinals by the same age groups depicted in Figure 2, the area graph for knower-levels.[8]

Unsurprisingly, the proportion of correct responses on ordinal trials is higher in the older age groups than in the younger ones. This is similar to the cardinal case, in the sense that older children

[8]Note that the ordinals included in this analysis, here and onwards, are *tweede* 'second,' *derde* 'third,' *vierde* 'fourth,' and *achtste* 'eighth.' As explained previously, *eerste* 'first' has been left out for a priori conceptual reasons. We also excluded *negende* 'ninth.' Not all participants were tested on *negende* 'ninth,' but those who were performed similarly on both *achtste* 'eighth' and *negende* 'ninth': 23 out of 30 children gave exactly the same number of correct responses for each of these ordinals, 4 children had one more correct on *achtste* 'eighth' than *negende*, three children had one more correct on *negende* 'ninth' instead. No children showed a greater difference in performance. Therefore, we take the outcomes for both ordinals to be the same, despite *achtste* 'eighth' taking *–ste* instead of *–de*, and thus take *achtste* to be regular.

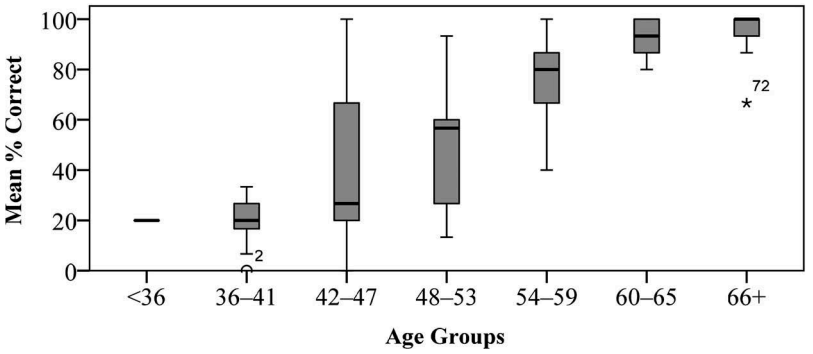

Figure 3. Percentage of correct responses to ordinals *tweede, derde, vierde and achtste* ('second,' 'third,' 'fourth,' and 'eighth' respectively) by age group.

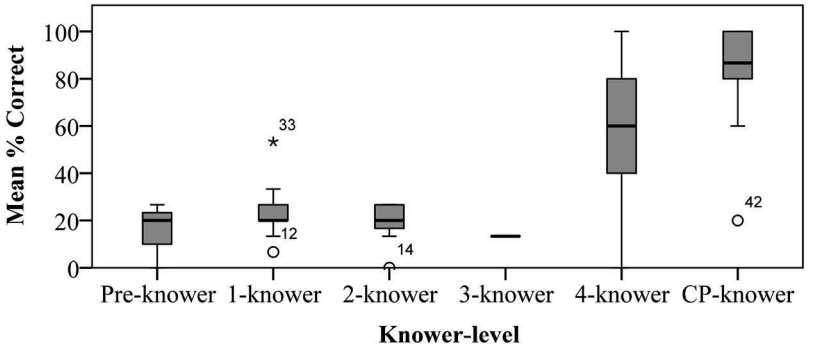

Figure 4. Percentage of correct responses to ordinals *tweede, derde, vierde and achtste* ('second,' 'third,' 'fourth,' and 'eighth' respectively) by cardinal knower-level.

are also more likely to provide correct responses on cardinal trials than younger children. Note that high scores on ordinals appear at a later age than on cardinals, with ceiling scores appearing after the age at which children become CP-knowers. This delay is more visible in Figure 4, which depicts the proportion of correct responses to ordinal trials per knower-level.

Figure 4 shows that the proportions of correct responses for children in the lower subset-knower levels hovers around 20%, whereas four-knowers provide correct responses roughly three times as often on average. CP-knowers do at least as well, with many showing at or near-ceiling performance. However, the figure only displays performance on all ordinals combined; Table 5 shows the percentage of correct responses on each ordinal per knower-level group.

Table 5 confirms that children in the pre-to-three-knower range show little knowledge of ordinals; note that chance performance is at 25% correct for *tweede* 'second' (as there were four cards to choose from); 17% on *derde* 'third' and *vierde* 'fourth,' and 10% for *achtste*

Table 5. Percentage of correct responses per ordinal by knower-level.

Knower-level	*tweede* 'second'	*derde* 'third'	*vierde* 'fourth'	*achtste* 'eighth'
Pre-knowers	11%	0.0%	0.0%	0.0%
One-knowers	33%	19%	7%	4%
Two-knowers	25%	11%	8%	0.0%
Three-knowers	33%	33%	0.0%	0.0%
Four-knowers	69%	48%	67%	21%
CP-knowers	95%	80%	91%	60%

'eighth.' The table also suggests that while both four-knowers and CP-knowers seem to do equally well on the regular low ordinals, irregular *derde* 'third' and high ordinal *achtste* 'eighth' may be more difficult. This is also reflected anecdotally in the ordinals children produced spontaneously in the course of the task: Both **driede* and **achtde* occurred. Of course, age and knower-level are obviously confounded in the figures and table: We need to determine what cardinal knowledge adds, if anything, to age. The same holds for the other factors we hypothesized to play a role—namely, the place of the ordinal in the count list (i.e., are lower ordinals acquired before high ones?) and the regularity of the ordinal (is irregular *derde* 'third' acquired after regular ordinals?).

To address these issues, we used R (R Core Team 2016) and the *lme4* package to fit a generalized linear mixed-effects logistic regression model (Bates et al. 2015) to the data described previously.[9] All fixed continuous factors (age in months, knower-level, place in the ordinal count list) were centered before analysis; the fixed categorical variable (ir)regularity was dummy-coded with explicit contrasts before analysis.[10] The dependent variable was whether a child's response was correct or incorrect. We included participant as a random intercept with random slopes for ordinal.

First, we wanted to determine the effects of age compared to cardinal knowledge. Because the two factors are correlated, we fit a model in which we included the regularity of the ordinal numeral (i.e., whether the ordinal numeral was irregular, as in the case of *derde* 'third,' or regular, as for, e.g., *achtste* 'eighth') and place in the ordinal count list (continuous) as well as knower-level (continuous) as fixed factors and compared that to a model in which knower-level was replaced by age (for which M = 51.76 months, SD = 10.44 months, range = 35–76 months). Including an interaction between knower-level on the one hand, and ordinal and regularity on the other hand, did not significantly improve the model (X^2 = 5.4552, df = 2, p = .06), and the second model would not converge with an interaction (Ordinal+Regularity)*Age included, so interactions were left out in both cases. Although age was a significant factor within the second model (z = 7.943, p < .0001), the AIC and BIC were lower for the first model (AIC: 673.86 vs. 676.79, BIC: 707.67 vs 710.59 respectively). We therefore conclude that, although age and knower-level are correlated, knower-level better predicts ordinal comprehension than age.

We then compared the first model to one in which root regularity was excluded and ordinal was a categorical (rather than continuous) variable, to see whether the place in the ordinal list better explains the data than morphological irregularity. The comparison reveals that this latter model (without regularity as a fixed factor) has a higher AIC (675.55) and does not differ significantly from the original (X^2 = 0.3141, df = 1, p = .5752). We therefore kept the original model as the final model, for which the results are summarized in Table 6.

Overall, the final model reveals main effects of ordinal, regularity, and knower-level. The direction and implication of these effects should all be clear at this point. First, we see that the

Table 6. Result summary for correct responses on 2nd, 3rd, 4th, and 8th: β coefficient estimates, confidence intervals, standard errors, associated Wald's z-score and significance level (p) for all predictors in the analysis.

Predictors	Estimate	CI	SE β	z	p
Intercept	−0.096	−0.68–0.49	0.300	−0.320	.749
Ordinal	−0.685	−0.85 – −0.52	0.082	−8.342	<.0001
Regularity (regular)	1.330	0.76–1.90	0.291	4.567	<.0001
Knower-level	1.795	1.35–2.24	0.227	7.906	<.0001

[9]We thank two anonymous reviewers for their detailed suggestions pertaining to the statistical analysis.

[10]Knower-level was treated as a continuous predictor due to modeling difficulties with knower-level as an ordered factor, given the relatively limited number of children within some knower-levels and the distribution of children across knower-levels. We believe it would be interesting to explore what, if any, added benefit there is per increase in knower-level, especially for the progression from 4-knower to CP-knower.

Table 7. Percentage of correct responses on *eerste* 'first' by knower-level.

Knower-level	Pre-	One-	Two-	Three-	Four-	Five-
% *eerste* 'first' correct	67%	56%	56%	100%	92%	100%

probability that a child comprehends a given ordinal decreases as the ordinal list progresses—i.e., that lower ordinals are more likely to be understood than high ones such as *achtste* 'eighth.' Second, we see that the morphological (ir)regularity affects the pattern of acquisition, such that regular ordinals such as *tweede* 'second, lit: twoth' and *vierde* 'fourth' are more likely to elicit a correct response than irregular *derde* 'third.' Finally, we see that an increase of cardinal knowledge also increases the likelihood of a correct response on the ordinal task. The comparison of the first two models further shows that knower-level matters more than age when it comes to comprehending ordinals.

4.3. *Eerste 'first'*

So far, we have not gone into the data pertaining to *eerste* 'first.' As argued previously, *eerste* is a superlative and not an ordinal (see also Barbiers 2007). This conceptual difference led us to the hypothesis that its acquisition would differ from that of ordinals. For one, superlative acquisition in general typically starts at a much younger age, and for another, *eerste* is much more frequent than other ordinals. Therefore, the expectation is that scores on *eerste* 'first' would be higher for those reasons, as opposed to if it were considered an irregular ordinal. At first sight, children do seem to do better on *eerste* 'first' than on other ordinals at an earlier stage. Table 7 provides the outcome per knower-level on children's correct responses only.

In contrast to children's performance on the ordinals discussed previously, where we see that children in the lower knower-levels are often unable to provide correct responses, here children actually do provide a correct response quite often. However, this does not mean that all children find the first card roughly half of the time; rather, we see a more bimodal distribution: some children systematically take the first card whereas others typically do not.

As it turns out, pre-to-three-knowers can be divided into two nearly equal-sized groups: children who did respond correctly when asked for the first in line (i.e., picked the first item, 14 out of 25 children) and children who did not (i.e., picked any card except the first, 11 out of 25 children). That this latter group constitutes floor performance on *eerste* 'first' needs no further explanation. However, that does not mean that the children in the former group understand the meaning of *eerste* 'first,' as these children not only select the first when asked for the first, but also in 72% percent of the cases when asked for a different ordinal. In other words, these children also select the first card in response to trials requesting the second, third, fourth, or eighth item. This indicates these children have a strong preference for the first card in line and makes it difficult to assume that children fully understand the meaning of *eerste* 'first'; at the very best, they are failing to infer that other ordinals are in a sense alternatives to *eerste* and therefore cannot refer to the first card in line. Note that this makes perfect sense if *eerste* is not part of the ordinal scale but on a scale including say *middelste* 'lit: middle–est' and *laatste* 'last.' For these forms, it is possible to refer to one and the same object with an ordinal and the superlative: The *last card* could also simultaneously be, e.g., the *tenth* in line. In this case, the first-preference could be ascribed to children's failure to see that the same cannot be said for *eerste* 'first.' These two groups of children (those with, and those without a preference for the first card) do not differ significantly in age (Mann-Whitney $U = 71.0$, $Z = -0.383$, $p = .702$, two-tailed) or gender (two-sided FET, $p = 1$), and there is no evidence that cardinal knower-level (pre-, one-, two-, or three-knowers) makes a difference in terms of a "first-bias" (Mann-Whitney $U = 69.0$, $Z = -0.533$, $p = .594$, two-tailed).

One other observation that has to do with children's errors is that children who give incorrect responses did do something crucially different in response to ordinal stimuli than cardinal ones: They nearly always took just one card when asked for an ordinal. Only two children packed multiple items on ordinal items, and they each only did so twice. This applies to children of all cardinal knower-levels, even those who were never able to identify ordinals correctly.

5. Discussion

5.1. *Cardinals*

We hypothesized that Dutch cardinal acquisition should not be qualitatively different from English. The previous results are largely in line with this expectation and offer support for the idea that the cardinal acquisition pattern is universal, providing evidence for all stages and observations within this pattern. First, we replicated the finding that children can typically count beyond what they can comprehend. Moreover, with textbook cases of children in every knower-level, our data support the idea that cardinal acquisition advances through different stages, in which children initially slowly acquire the exact meanings of cardinals *één* 'one' through *vier* 'four' one by one and are then suddenly able to infer the exact meanings of the higher cardinals in their count list all at once. These findings can be added to the growing body of evidence for a universal pattern in cardinal development: Children from different linguistic, cultural, and educational backgrounds seem to map the exact meanings of cardinals to underlying representations according to the same pattern. This lack of variation strongly suggests that this process and the underlying cognitive representations are not only shared but are also not qualitatively affected by, and are not artifacts of, the environment in which children grow up. Rather, this is a fundamental property of human cognition.

Still, this does not mean that there is no variability between children. On the contrary, many studies have shown that children within a given sample vary greatly and that there are also differences between groups. We hypothesized nonetheless that Dutch children should acquire cardinals similar to American children: As opposed to other studied languages, Dutch provides children with linguistic cues for discovering the meanings of numerals that are very comparable to English. However, our data show two noteworthy deviances. The first is that our sample includes only one three-knower. We take this to be accidental. The difference between the mean ages of two-knowers and four-knowers, who are two levels apart, is the same as the difference between stages that are just one level apart, i.e., between pre-knowers and one-knowers and one-knowers and two-knowers. This suggests that the three-knower stage is quite short (a claim that has been made elsewhere, see, e.g., Almoammer et al. 2013) and that it is difficult to capture children who are (quickly) moving through this phase.

This brings us to the second deviance—namely, that the children in our sample seemed somewhat slower than children reported in other studies. This was an unexpected result, and the question is therefore how this finding could best be explained. We can only speculate at this point about what may or may not be the case. As mentioned, this delay should not be attributed to linguistic factors like singular-plural marking, quantifier use, or differences in the number words themselves but could perhaps be linked to input (e.g., the frequency of numerals in child-directed speech). Unfortunately, we know of no studies that report such data in any language, and our own data do not provide such information either. Another possible factor (similar to the one put forward in Almoammer et al. 2013) is cultural in nature—namely, the education system. Dutch children typically do not go to school until age 4; preschool for younger children is optional for most typically developing children. The 3-year-olds we recruited attended day care centers without specific goals or programs for training children's linguistic or numerical skills, whereas American preschools are educational

institutions that strive to meet certain academic standards. It might also be that Dutch preschoolers are less used to tasks such as ours and that our modified Give X task was generally more difficult than more standard versions of Give X.[11] All of these differences might have put our participants at a disadvantage. This all remains open for future research in which direct comparisons to other populations (Dutch and otherwise) should also be sought out.[12] We reiterate, however, that the differences in timing are in themselves not problematic: As pointed out in earlier research, the pattern of cardinal acquisition is deemed to be universal across languages and cultures, while the timing and duration of (the phases within) this pattern are notoriously variable.

5.2. *Early stages of ordinal acquisition*

Prior to this study, ordinal acquisition had only been studied minimally. Findings from previous studies suggested a number of possible factors that might influence ordinal acquisition; however, none of them properly and explicitly compared cardinal acquisition patterns to those for ordinals. Our data show that multiple factors are of influence when it comes to acquiring ordinals: Age, cardinal knower-level, the place of the ordinal in a count list, and the irregularity of the ordinal all play a role. We go into these factors (and especially the latter two) in section 5.3. Here, we focus on the earlier stages of acquisition and the effects of age, cardinal knowledge, and linguistic knowledge in these stages.

Children who have a limited understanding of cardinals also have difficulty with ordinals. The pre-to-three-knowers in our study cannot be considered to have exact knowledge of any ordinal we tested: Their scores are consistently low on all tested ordinals and typically at floor for *eerste* 'first' as well. However, this does not mean that they know nothing at all or behave randomly. These children all have in common that they only selected one card when asked for any given ordinal. We take this to mean that children are able to use morphosyntactic cues to conclude that one and only one item is requested. Ordinals combine with singular nouns, and the DPs in our stimuli appeared in subject position, triggering singular agreement on the finite verb as well. Children at this age are able to comprehend the relevant inflectional morphology on nouns and verbs and are sensitive to number agreement (e.g., Polišenská 2010). However, we are not making any hard claims about the status of this knowledge with respect to its application to ordinals. Children may be responding to different parts of the stimulus. For example, perhaps they respond to the absence of plural marking on the noun (and agreeing verb) in the stimulus, or perhaps they take the whole DP into consideration.

Though the present study does not allow us to draw conclusions about how general their knowledge is, this question is testable. For example, we offered children a full DP in the stimulus (e.g., *De tweede eend mag mee. Kun je de tweede eend inpakken?* 'The second duck can come. Can you pack the second duck?'). If children have genuine knowledge that ordinals are singular, then children should also provide one duck if explicit cues for number were missing from the stimulus, i.e., if the stimulus were *Kun je de tweede inpakken?* 'Can you pack the second (one)?' Note that *one* is obligatorily absent in Standard Dutch, and the definite article appears with both plural nouns and common singular nouns. If children are responding to the subject-verb agreement, then children should do worse if the ordinal modifies the object. If they truly know that ordinals modify singular nouns, or if they truly know what a given ordinal means, they should not do worse on such trials.

[11]We thank an anonymous reviewer for providing the latter two suggestions.

[12]Hamilton, Plunkett & Schafer (2000) describe large and consistent differences in vocabulary development (both production and comprehension) between children aged 1;0–2;01 acquiring English in the United States and the United Kingdom. Communicative Development Inventory (CDI) data show that British children's vocabulary development is delayed compared to the American group. The reason for this delay is uncertain, but the authors report that socioeconomic status did not significantly affect vocabulary development in either group. They speculate about culture and cultural expectations and the influence of day care as potential causes instead. An anonymous reviewer points out that the CDI differences may also reflect differences in parents' perception of their child's vocabulary as much as the actual differences in their vocabulary, which makes the cross-cultural comparison even more difficult.

That said, regardless of whether the pattern we found in our data reflects an answering strategy (i.e., on-the-spot-inference based on knowledge of the singular-plural distinction) or solid knowledge of ordinals, it does suggest that children are sensitive to cues from the input and are able to actively use this to infer meaning. Similar factors have, as mentioned in section 2, been proposed to play a role in acquiring cardinals, as well as in deciphering (flexible) mass and count nouns (Barner & Snedeker 2005, 2006; Carey 2009; Sarnecka et al. 2007). We suggest that our ordinal data add evidence for the idea that children pick up on (a lack of) plural marking and use this to determine whether a DP refers to a mass, a set, or an individual.

When children do start to give correct responses, this seems to happen on *eerste* 'first' first. Lower subset-knowers still have difficulty, but both four-knowers and CP-knowers performed at ceiling in response to *eerste* 'first'—even if their performance on subsequent ordinals was less robust. This finding would be consistent with the observation that *eerste* 'first' is a superlative in adult Dutch (cf. Barbiers 2007) and with the observation in our data that children were able to comprehend the superlative filler item in the vast majority of cases. This suggests that children at least have the option of interpreting *eerste* as a superlative and do not need any kind of ordinal rule to know what *eerste* means. Such a superlative analysis would also help to explain why some children exhibited some type of 'first-bias,' i.e., gave the first item in line in response to all ordinals.[13] It is possible that these children do understand the meaning of *eerste* 'first' but have yet to comprehend that, unlike with *last*, ordinals can be in competition with *first*. Another explanation has to do with frequency: *Eerste* is roughly 50% more frequent than the following 19 ordinals combined (see section 2.3), and perhaps this overrides any effects of morphological irregularity.

However, if superlatives are easy, and *eerste* is extremely frequent, the question becomes why many lower subset-knowers were unable to interpret *eerste* correctly. Knowledge of cardinals and cardinality is not necessarily relevant from this perspective. One suggestion may be that *eerste* 'first' has less transparent degrees of comparison, making (acquisition of) the relationship between the positive and/or comparative and the superlative more complex. (This would mean that the key factor here is not so much knower-level as it is age or more general development.) For one, *eer* 'fore' almost never occurs in modern Dutch, although it can be used as a complementizer in certain constructions like *eer je dat gedaan hebt* 'by the time you have done that' and as a bound morpheme in words like *eerdaags* 'soon'/'one of these days,' *eertijds* 'in former times,' *eergisteren* 'the day before yesterday' (Barbiers 2007). The comparative form *eerder* is used in a wider range of contexts than the superlative, as it can be translated in a number of different ways (as *sooner, previously, before, earlier, rather, more likely)* not necessarily related to those of the superlative.

5.3. *Later stages of ordinal acquisition: Regularity and place in the count list*

The data reveal that *tweede* 'second' and *vierde* 'fourth' soon follow the acquisition of *eerste* 'first' but that it takes more time for children to acquire irregular *derde* 'third' and regular higher ordinals. Our statistical analysis suggests that two factors (in addition to a child's age and knower-level) play a role here: Irregularity delays *derde*, and place in the count list delays *achtste* 'eighth.'

For one, poor behavior on *derde* 'third' (relative to *tweede* 'second' and *vierde* 'fourth') is related to its irregularity: Whereas most ordinals are derived from cardinals quite transparently, root allomorphy is present in *derde* 'third' (the regular form would have been **driede* 'lit: threeth').

[13]Our data provide no real clues to help interpret this error in pre-to-three-knowers in any other fashion. We can rule out that children simply select the item closest from them, as the experimenter took care to distribute the cards such that the child could reach both ends of the line equally well. Even though this makes the ends of the line furthest away, a more general "furthest bias" should have led to a more or less equal preference for the last card, which we do not see. The pattern might reflect a bias unrelated to ordinals, but what this could be and how it would work remains an open question. What is clear, however, is that the four-and-CP-knowers we tested did not seem to fall back on such a default response. Instead, many of the errors fell around neighboring numerals. These children likely have a different analysis of *first* and ordinals that excludes such a default strategy from a more pragmatic perspective of scalar implicature.

The question is why this irregularity should be a problem: If children hear *derde* in the input, and they hear it more often than, e.g., *vierde* 'fourth,' then they should be able to acquire this form lexically early on. That they do not appear to do so could either be explained by the weak hypothesis or the strong hypothesis in section 2.4. The weak version entails lexical learning of ordinals, in which transparency helps but is not crucial in acquiring their meaning. *Derde* 'third' might be more difficult to store because the form reveals no clues to its meaning. The strong hypothesis entails rule-driven learning, in which children decompose the ordinal form to arrive at its meaning. The question is to what extent our data reflect a task-specific answering strategy or actual employment of a rule. Within the context of the experiment, it is relatively easy for children to see both the resemblance between *vier* and *vierde* ('four' and 'fourth') and their differences (the extra morphology, singular agreement) and thus to apply an answering strategy that fails when the cardinal root is not recognizable (and there is also no lexical knowledge for the child to fall back on). Our data do not allow us to see whether children are able to use or comprehend ordinals outside the context of the task, but if children can use linguistic structure within the task, this could be indicative of a bigger process in acquiring these ordinals 'in the wild.' We therefore take our data as evidence in favor of the strong hypothesis.

That ordinals are productive in adults is obviously uncontroversial, but we argue that ordinals actually start out that way as well. This is atypical: Not only are most derivational affixes acquired at a later age (than inflectional morphology and ordinal morphology), the usual pattern observed in the acquisition of derivational morphology is that children initially store individual items and later, after collecting sufficient evidence, analyze these items as complex morphological units and generalize over these examples to form a productive rule (Clark 2014). However, the difficulty with *derde* 'third' suggests this item is not stored lexically as a single unit with a certain meaning but that children actually make productive use of an ordinal rule (informally: cardinal + *–de* = ordinal) in order to acquire these ordinals.

Our claim here is that ordinals are formed by rules all along, and children must decipher the exceptions later. Put differently, to determine the meaning of an ordinal, children first decompose it: They apply the counting principles necessary to determine the meaning of the cardinal and apply the relevant contribution of the ordinal (namely, picking out an individual rather than the entire set) to that cardinal root. Such a strategy is supported by the fact that children would often count in response to an ordinal item, e.g., when asked for the *vierde* 'fourth,' they would count to four and then pack the fourth. Obviously, such a strategy fails on *derde* because of the root allomorphy: There is no cardinal *der*. Moreover, for such a strategy to be plausible, the counting principles would have to be (largely) in place to be used for ordinals, and the timing in acquisition seems to reflect that.

5.4. *Questions and tests for the current proposal*

Note that the previous raw data do not necessarily exclude the possibility that ordinals could be acquired in the same stepwise fashion that cardinals are acquired. After all, there is some evidence that *eerste* 'first' precedes at least *tweede* 'second,' evidence that *tweede* precedes *derde* 'third,' and that higher ordinals are acquired after lower ones. Moreover, we also see that children begin to acquire ordinals before cardinal acquisition is complete, suggesting that application of the relevant counting principles for ordinals comes in as children are still discovering how those for cardinals work. Hence, it could be that a tiered acquisition pattern is viable in some languages but is not (or at least is not visible) in languages like Dutch, where morphology intervenes in this process. We think, however, that this may be unlikely.

For one, we would need some further details with respect to the hierarchy in responses: In cardinal acquisition, knowledge of *four* must entail knowledge of *three*, as understanding *three* is a conceptually necessary and more primary step compared to *four*. If ordinal acquisition were tiered, we would expect to find a similar hierarchy of knowledge, e.g., where knowledge of *vierde* 'fourth'

would entail knowledge of *derde* 'third.' Our data show that this is not the case and thus that the hierarchy is in fact absent.

A second and more important challenge for the view that ordinal acquisition is tiered has to do with where to look next. Say it is true that there is a tiered pattern in ordinal acquisition but that it just happens to be hidden in the Dutch case—then what language *should* exhibit a clearly tiered pattern? Is it more likely for such a tiered pattern to be visible in a language in which all ordinals are regular or one in which irregularity is the norm? Under our analysis, it is the morphology that helps the child acquire the ordinals in the first place, eliminating the need for storage and step-by-step patterns: The child can simply apply the ordinal rule to all the numerals available in the count list. Perhaps then irregular cases would be better cases for tiered patterns, as children might then fall back on strategies used for acquiring cardinals (where they have no computation benefit to lean on and must initially depend on storage). Having a highly irregular count list would also be more similar to the cardinal situation. The rule-based approach is by definition not applicable to cardinal acquisition: There are no morphological cues, and there is no system to the lexical items denoting (lower) cardinal numerals, such that they can compute the meaning of these numerals; they must learn them one by one.

Fortunately, the role of morphology in ordinal acquisition is testable, and the potential outcomes can easily be made concrete. If failure on irregular *derde* 'third' is indeed linguistic in nature, i.e., a result of not being able to apply a rule, we expect children who fail on such forms to perform better when the irregularity or opacity is resolved. In other words, if children actively derive ordinals via morphological rules, children who fail on *derde* should be able to pass on the ungrammatical yet regular **drie–de* (lit: 'three–th'), as well as on the analytic form *auto drie* 'car three.' Moreover, we expect (similarly to Miller et al. 2000) that children are quicker to acquire ordinals in a language with a transparent ordinal system (e.g., French), than in a language in which ordinals (especially lower, more frequent ordinals) are less transparent (e.g., English). We also expect such differences to affect the pattern of acquisition. For example, French children should not experience more difficulties with *troisième* 'third' than with its neighboring ordinals. English children, however, must learn the rule via less frequent ordinals and may therefore have difficulty with all of the first five ordinals. If English learners acquire regular ordinals before irregular ones, this would be evidence for rule-based learning; irregular forms would have to be acquired individually (and independently of their corresponding cardinal). If English learners acquire irregular ordinals before regular ones, this would point more in the direction of our weak hypothesis. In any case, the prediction is that more irregular forms lead to a longer acquisition process.

Recall that the existing literature tentatively points in this direction: American English-speaking kindergartners performed relatively poorly on ordinals (Fischer & Beckey 1990; Miller et al. 2000), whereas the French-speaking children (Colomé & Noël 2012) seemed to do better. The German children might also have a similar difficulty with *dritte* as the Dutch with *derde*, but Colomé & Noël (2012) mention no such troubles in the French-speaking group.

There is one final observation that we have so far left undiscussed. If it is indeed the case that children are applying a rule to derive ordinals, then why do CP-knowers, who obviously know higher cardinals and who know regular low ordinals, fail on higher ordinals? Multiple explanations could account for this finding. For one, it might be they have not acquired a rule after all but rely on frequency in the input or some other mechanism to acquire ordinals. This, however, would leave unexplained (i) why *vierde* 'fourth' is acquired at roughly the same time as *tweede* 'second' and (ii) why frequency is not enough for *derde* 'third,' making this solution no less problematic.

Alternatively, this issue could be partially explained by inconsistence in performance. Children were tested on cardinal and ordinal items at two different times, and it might be the case that children who were classified as CP-knowers on one day performed worse on the ordinal testing day and vice versa. That would mean, however, that ordinal performance was underestimated quite often and more often than the reverse scenario (given that scores on *acht* 'eight' are so much higher than on *achtste* 'eighth'). That suggests that the inconsistency is not as big of a problem as the ordinal

itself, especially if we consider that higher ordinals were also more demanding for children in general: The further children have to count, the more taxing the task becomes, both in terms of working memory and in terms of motor skills (it is simply easier to collect three cards than eight cards). If we add in that ordinal comprehension requires yet another step (namely, deriving ordinal meaning form the cardinal), then that again would increase the likelihood of an error in a situation when the child is already taxed.

6. Conclusion

This study compared the timing and pattern of acquisition of two numeral types in Dutch: cardinals and ordinals. The goal of the study was to investigate which factors play a role in ordinal acquisition and to what extent these factors or this pattern differ from the cardinal situation. For cardinals, we expected the Dutch acquisition pattern to mirror the well-attested development found for other languages. There are no such robust patterns reported in the literature for ordinals, as little work has been done in the domain of ordinal acquisition to begin with. Going by the few studies we did encounter (cf. Fischer & Beckey 1990; Miller et al. 2000; Colomé & Noël 2012; Trabandt et al. 2015), we hypothesized that children's comprehension of ordinals would not only be affected by children's ages but also by their knowledge and the place of the ordinal in the count list. Moreover, we expected language would play a role, both in the initial stages of ordinal acquisition (i.e., discovering that ordinals refer to an individual item rather than a set) and in the later stages (i.e., regular ordinals may help and/or irregular ordinals may hinder acquisition). Our results are in line with these expectations.

First, we found that the tiered pattern of cardinal acquisition also holds for Dutch, as it does for Japanese (Barner et al. 2009; Sarnecka et al. 2007), Russian (Sarnecka et al. 2007), Slovenian (Almoammer et al. 2013), Saudi-Arabic (Almoammer et al. 2013), Chinese (Le Corre et al. under revision), and Tsimane' (Piantadosi, Jara-Ettinger & Gibson 2014). This supports both the knower-level theory and the claim that this development is universal and relies on shared cognitive representations and processes rather than on cultural (educational) artifacts. Somewhat unexpectedly (as Dutch does not differ from English in relevant ways here, e.g., with respect to its cardinals or number marking), we did find that Dutch children acquire cardinals somewhat later than their English-speaking peers. However, as various other studies point out, there are important differences between populations and individuals with respect to the timing and duration of the knower-stages. Further research is necessary to determine the nature and severity of the Dutch delay.

As for ordinals, we found that age and cardinal knowledge each contributed to children's ordinal performance independently and that ultimately cardinal knowledge better predicts ordinal comprehension than age. Children in pre-to-three-knower stages have at least understood that they should only take one card when asked for an ordinal. We suggest that children make use of morphosyntactic cues, i.e., that ordinals combine with singular nouns, to grasp the notion that an ordinal refers to an individual item rather than a set, which is a prerequisite for the ordinality principle. Later, as four-knowers or CP-knowers, children acquire exact meanings of ordinals. *Eerste* 'first' has a (slight) advantage in this process, given its status as a superlative (Barbiers 2007) and its sheer frequency. For true ordinals, we see effects of irregularity as well as the place of the ordinal in the count list (higher is harder): Regular low ordinals are acquired before irregular *derde* 'third' and higher ordinals.

The difficulty with *derde* 'third' suggests that ordinals are not simply stored: If they were, the irregular ordinal should be acquired before less frequent, regular forms, and its irregularity would not necessarily be an issue. We argue that morphological compositionality is crucial in grasping ordinal meaning. In other words, children acquire ordinal meaning via an ordinal formation rule: They decompose the ordinal into the cardinal root and the ordinal suffix and then use that structure to compute the meaning of the ordinal. This makes regularity crucial in acquisition (the strong hypothesis in section 2.4) rather than simply helpful (the weak hypothesis in section 2.4). If transparency was merely beneficial in acquisition, ordinal development could in principle start

before children master cardinals; after all, nothing about the ordinal counting principles is more difficult than the cardinal ones. However, our data suggest that being able to find *twee* 'two' is not nearly enough to decipher the meaning of *tweede* 'second,' lit: 'twoth.' If the acquisition is rule based, ordinals have to be acquired as or after children become CP-knowers to have a sufficient foundation for their rule: Without a full, exact understanding of the cardinal root, it is impossible to determine the contribution of the suffix to that root to reach ordinal meaning.

One less straightforward outcome under this view is that *achtste* 'eighth' was noticeably harder than *tweede* 'second' and *vierde* 'fourth' for the children in our sample. If ordinal acquisition is rule based, then the expectation would be that all regular ordinals are acquired at once. This delay of higher ordinals can be explained in part by the requirement that a child must be a reliable CP-knower to perform well on these items (some children who performed well on many ordinal items were classified as four-knowers) and in part by more general performance difficulties due to increasing task demands.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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