



Rule and Order. Acquiring Ordinals in Dutch and English
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Summary

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This dissertation investigates how and when ordinals are acquired in both Dutch and English. The main finding is that children acquire irregular ordinals (e.g., Dutch *derde* ‘third’) after regular ones (e.g., *vierde* ‘fourth’), and after analytic ordinals such as *auto drie* ‘car three’. This holds for comprehension and production and for Dutch as well as English. Put differently, ordinal numerals that can be formed by a rule are more readily understood and produced than ones that cannot. Children also overgeneralize their rule, producing **twoth* or **driede* ‘threeth’, for example. Clearly, children cannot simply copy such forms from the language they hear around them; they create these forms themselves after learning that ordinals are made by adding a suffix (*-de* and *-th* in these examples) to a cardinal numeral, like *two* or *drie* ‘three’.

This may seem obvious or trivial at first sight. For one, a topic as basic as number words must have received ample attention in the literature. For another, many studies have shown that children prefer regular forms over irregular ones and that children are known to make overgeneralization errors (e.g., Pinker 1999). Could ordinal numeral acquisition contribute to any scientific discussion? The answer, I argue, is *yes*. Not only is the data collected here the first to provide a systematic overview of ordinal acquisition, the account for this data is neither the only nor the most straightforward hypothesis. The short version of this account is that children use morphosyntactic structure to acquire the meaning of ordinal numerals. What makes this interesting, however, is that they do not seem to go through a stage of lexical learning before acquiring that rule. This makes the ordinal acquisition pattern unlike the cardinal pattern (where lexical learning plays a key role, especially at first), and unlike patterns in inflectional or derivational morphology (where children initially store morphologically complex forms, before learning that *worked*, for example, consists of the stem *work* and a past tense suffix *-ed*, and *worker* of the same stem and the agentive suffix *-er*). Ordinary as it may seem, ordinal acquisition proves to be a curious case study that can only

be understood when insights from language acquisition, developmental psychology and numerical cognition are combined.

The introduction of this dissertation briefly touches on each of those perspectives and highlights a uniquely human property of our cognition: the ability to conceive of large, exact numbers such as *4733* (Carey 2009, Dehaene 1997, Dehaene 2009, Spelke & Kinzler 2007). We share, however, the foundations of number, as both animals and humans have been argued to have access to two core knowledge systems of number. The first, the Object Tracking System or OTS, is not strictly numerical but can be used for keeping track of individual objects up to a limit of three or four — not even close to *4733*. The second, the Approximate Number System or ANS, is sensitive to ratios rather than individuals, and works best with larger quantities. The ANS would be able to tell that it is more than *3123* or less than *7171*, but not that it differs from *4732* or *4734* by exactly one. Obviously, however, human adults have no difficulty discerning these numbers, and various scholars have argued that we can combine these two systems and overcome their boundaries thanks to language (most notably Carey 2009; Hurford 1987; Spelke 2011, 2017).

I use that claim as a springboard to discuss patterns in the development of cardinal numerals (*one, two, three*) before shifting the focus to ordinal numerals (*fourth, fifth, sixth*). Cardinals have been in the spotlight of numerical development for decades (starting with Wynn 1990), but ordinals have received strikingly little attention in the literature, despite them having the same conceptual foundation as cardinals. Not only are the same core knowledge systems presumed to be involved, the counting principles necessary to use ordinals productively are almost identical. This is therefore the starting point in Chapter II, where I ask whether the pattern and timing of ordinal acquisition differ from that of cardinals, and if so, whether these differences can be related to linguistic factors, since they are typically derived from cardinals. As a result, answering that question requires understanding cardinal acquisition first.

Cardinal acquisition entails learning that cardinals refer to exact, discrete quantities, and learning how to determine which cardinal to use. Children slowly acquire the meanings of the numerals *one* through *four* in a slow and stepwise fashion. As pre-knowers, children know numerals refer to quantities, though they do not know which ones exactly, and they might not be able to recite the count list in the correct order. As one-knowers, they know that *one cookie* refers to exactly one cookie, and that any other number must be more than that. Knowledge of *two, three* and

four, is subsequently accrued in that order, before a conceptual leap happens. They progress from being ‘subset-knowers’ (children who only comprehend a subset of the numbers in their count list) to CP-knowers, i.e., children who know the necessary counting principles (hence CP) and are able to distill the meanings of other numerals. These principles are the one-to-one correspondence principle (each numeral refers to a single item), the stable order principle (numerals have to be recited in a particular order) and the cardinal principle (the numeral assigned to the last item counted reveals the cardinality of the set). Ordinals require the first two of these principles, but the cardinality principle is replaced by the ordinality principle: the last numeral counted now refers to the position or rank of an individual item.

To compare ordinals to cardinals, I adapted a classic cardinal comprehension task known as a ‘Give Me’ task (Wynn 1992, Le Corre & Carey 2007). In this version, children had to help a monkey pack his suitcase by correctly identifying the right (number of) objects from a line. I tested 77 children acquiring Dutch as their first language on the cardinals and ordinals for one, two, three, and four (to see if there was evidence for a tiered pattern in ordinals), as well as eight and nine (to see what happens with higher numerals and to categorize CP-knowers). I also tested their knowledge of the degrees of comparison for *veel* ‘many’, *weinig* ‘few’, *groot* ‘big’, *klein* ‘small’ and *lang* ‘long’ as a type of control condition.

Though I could have investigated any language, the focus here is on Dutch. Dutch is similar enough to English to predict comparable patterns in cardinals, but has an ordinal list that differs from the few languages that have been studied in the ordinal literature (Fischer & Beckey 1990 and Miller et al. 2000 for English; Miller et al. 2000 for Chinese, Colomé & Noël 2012 for French; Trabandt et al. 2015 for German). Dutch has two ordinal suffixes: *-de* for most ordinals under twenty, and *-ste* for most other ordinals that do not end in a cardinal under twenty, and a mostly regular ordinal list. The exceptions are *eerste* ‘first’ (though actually a superlative, not an ordinal, cf. Barbiers 2007), *derde* ‘third’ (root allomorphy, but regular suffix) and *achtste* ‘eighth’, which has an easily identifiable cardinal root but takes the suffix typically used for higher ordinals.

As expected, the data from this first study reveal nothing surprising in the cardinal domain. Dutch children acquire cardinals in the same stepwise fashion children acquiring other languages do, albeit roughly six months slower. Most children acquiring English in the United States

become CP-knowers at about 3;06, while Dutch children reach that point around their fourth birthday.

The pattern and timing for ordinals, however, is considerably different. For one, children start acquiring ordinals much later: only four-knowers and CP-knowers exhibit understanding of any ordinals. Their knowledge of cardinals is more telling than just their age. For another, there is no evidence for a tiered acquisition pattern. Though some children do understand only *eerste* ‘first’, the ordinals *tweede* ‘second’ and higher do not follow in order. Instead, there are children who comprehend the regular ordinals *tweede* ‘second, lit: twoth’ and *vierde* ‘fourth’, and sometimes also *achtste* ‘eight’ and *negende* ‘ninth’, but not irregular *derde* ‘third’. Some children did know all the lower ordinals (through *vierde* ‘fourth’) but not the higher two, which I argue later in the dissertation is reminiscent of the cardinal pattern, where the OTS boundary also marks a drop in performance. I return to this later.

The difficulties with *derde* ‘third’ and similarities between regular ordinals would be hard to explain from a lexicalist or frequency-based perspective. The outcome of this study instead suggests transparency is important in ordinal acquisition; a stronger hypothesis would be to say that children deduce the meaning of ordinals by means of a rule. This raises three questions that are investigated in Chapters III and IV. The first pertains to production, the second to different kinds of ordinals, and the third to ordinal acquisition in different languages. Chapter III therefore compares comprehension and production, and also includes forms that are regular but ungrammatical in the comprehension test. The questions addressed are how the development of ordinal production compares to the development of ordinal comprehension, and whether children generalize an ordinal formation rule. Chapter IV compares synthetic ordinals (e.g., *de tweede slee* ‘the second sled’) to analytic ordinals (e.g., *jas zes* ‘coat six’) in Dutch and English. All experimental setups are similar to the one in Chapter II, modified such that they answer the questions at hand.

Chapter III presents data from 68 Dutch children (mean age: 5;0) that confirm two key results from the previous chapter. First, CP-knowers did better than the four-knowers, meaning cardinal knowledge is important. Second, CP-knowers could comprehend nearly all ordinals, even the overgeneralized forms **eende* ‘one-th’, **eenste* ‘one-st’, **driede*, ‘threeth’. The only notable exception is *derde* ‘third’, for which the correct response was given 69% of the time. If children fail to understand an

irregular form but can comprehend a regular counterpart that is not in the input, this suggests children are learning by rule, not rote. **Driede* ‘threeth’ can be decomposed into an ordinal suffix and a cardinal root. Decomposition of *derde* ‘third’, however, leads children to something they know must be a cardinal, but one they do not recognize, as evidenced by responses like *Hoeveel is der?* ‘How many is *thir?*’

Chapter III also shows that (i) ordinal comprehension precedes production, especially when it comes to irregular forms, and (ii) children overgeneralize the rule in their own speech. Not all irregularities are equal, however: though children produce both **driede* ‘threeth’, and **achtde* rather than *achtste* ‘eighth’ (with the other ordinal suffix), *achtste* is notably harder to get right. I argue that this is because the exact suffix is less crucial for arriving at the correct interpretation, whereas the root is fundamental for comprehension. Ordinals occur in NPs, where they always modify a singular noun. This morphosyntactic context (plus whatever other contextual information in the discourse) could lead you to the appropriate interpretation, as long as you recognize the cardinal root in this complex form, and understand what the cardinal means. In production, however, the rule apparently defaults to *-de*, and use of *-ste* has to be acquired separately.

Chapter IV looks at productivity and frequency in the input in two ways: it compares Dutch learners to children acquiring English in the United States, and it compares synthetic ordinals (*the fourth chapter*) to analytic ones (*chapter four*). The first comparison tells us something about acquiring less regular ordinal lists, which provide less evidence for the rule. The second allows us to see if it is the synthetic ordinal rule that matters, or whether a syntactic solution will also suffice. These analytic forms are always transparently related to the cardinal, but are admittedly different from synthetic ordinals in when and how they are normally used. Chapter IV goes into all the relevant differences, but they do not really matter: the type of ordinal was not found to play a significant role in ordinal comprehension, as long as we were comparing analytic ordinals to regular synthetic ordinals. Put differently, *kabouter vier* ‘gnome four’ elicited similar responses to *de vierde bus* ‘the fourth bus’, but *the second sled* and *the fifth plane* elicited fewer correct responses than e.g., *mouse two* or *cat five*. Again, the most important factor here is regularity: irregular forms elicited fewer correct responses than regular ones.

These findings not only hold for Dutch learners (2;08–4;11, M = 4;05, N = 70), but also for children acquiring English in the U.S. (3;3–5;3, M =

4;03, N = 35). That is actually quite surprising, because it entails that children acquiring English also use a rule and are not tempted to acquire ordinals lexically, despite the more difficult ordinal count list. *Fourth* only starts to resemble a rule in the company of *sixth* and higher ordinals, and irregular ordinals are more frequent than most regular ones. Perhaps this is why Dutch children outperform children acquiring English: Dutch children are late to acquire cardinals, but ordinals are much easier to acquire once the cardinal knowledge is in place.

The evidence children can consider could be linked to a more fundamental difference between both groups of learners. Some Dutch children had difficulty with the higher ordinals in the experiment, i.e., *zesde* 'sixth', *achtste* 'eighth' and *negende* 'ninth', but not with the lower regular ordinals *tweede* 'second' and *vierde* 'fourth'. This difference between lower and higher ordinals did not appear in the English-speaking group, but it did arise in the Dutch group discussed in Chapter II. I point out in Chapter IV and V that this difference between low (≤ 4) and high ordinals is reminiscent of the effect of the OTS boundary reported for cardinal acquisition, where the incremental lexical acquisition of cardinals stops at *four* and a generalization occurs.

Integrating (co-activating) OTS and ANS is presumably hard, and the ordinal data would suggest overcoming the boundaries of these systems is not something that happens once (as children become CP-knowers), but is something that happens iteratively. If this is true, then this could help us understand the difference between Dutch and English above. The hypothesis is then that Dutch children can make use of evidence for an ordinal rule within the OTS boundary, making it relatively easy for them to acquire lower ordinals: the counting principles, OTS, and the ordinal rule suffice. Higher ordinals, on the other hand, require integrating OTS and ANS as well, and this additional process proves to be too hard for some children. English learners face a different challenge, because sufficient evidence for the rule only appears after the OTS boundary, meaning that they must have overcome the cost of integrating their number systems before they can acquire the rule.

Chapter V concludes this work with a discussion of why children make use of a rule and why the ordinal rule cannot be acquired like other better-studied types of morphology, such as past tense *-ed*. The why-question is relatively easy to answer: because acquiring ordinals lexically is less economical. We know from the cardinal literature that number word learning is extremely trying, despite the explicit training children receive

and despite the overall prevalence of numbers in the input. Children receive much less (salient) input for ordinals, but ordinals do come with an added benefit, namely a clear morphosyntactic environment. Hence, I propose that children would rather use the lexical (cardinal) knowledge they already have, and combine that with morphosyntactic knowledge (agreement, nominal modification, the ordinal affix), instead of storing individual ordinals one by one. Transparency helps children identify ordinals as complex forms, and perhaps allows them to store these otherwise unanalyzed forms until they can be used as input for the rule. The rule is what helps them grasp the meaning of the ordinal as a whole. The cardinals are acquired via storage, ordinals via computation.

This is incompatible with what is typically described for the development of morphological productivity in children, where it is generally assumed that children store forms such as *washed* before decomposing them into *wash* and *-ed* for the past tense (cf. Pinker 1999, Yang 2016, Lignos & Yang 2016). Irregular forms such as *ate* and *went* are also stored. Discovery of the rule then leads to a so-called U-shape: children temporarily overgeneralize the rule in forms they previously produced correctly: **eated*, **goed*, et cetera. If this pattern applied to ordinals, *derde* would be expected to be produced (and thus comprehended) before the **driede* stage, but overgeneralization errors in ordinals (e.g., **driede* ‘threeth’) co-occur in children who do not understand *derde*. It seems unlikely that a child would forget the meaning of a word he previously used correctly. Hence, the ordinal pattern is more of a “J-shape”, where there is no comprehension or production, and thus no storage, before the rule becomes productive. A storage account would also not predict simultaneous acquisition of multiple (regular) forms at once, making an initial storage phase less likely.

As a result, ordinal acquisition may seem intuitive and straightforward at first, but turns out to be more than atypical on second thought. This dissertation thus makes a meaningful contribution in two ways, the most concrete of which is the developmental pathway proposed in (1), copied from Chapter V.

(1) Stages in ordinal acquisition

- (i) Children use morphosyntactic cues (such as the fact that ordinals combine with singular nouns whereas most cardinals combine with plurals) to discover that ordinals refer to individuals, not sets. They

can give you one item when asked for e.g., *the vierde* ‘the fourth’, but it might be the second or the ninth in line.

- (ii) Children, when they are at least four-knowers, acquire *eerste* ‘first’ first. This form is acquired relatively early for three reasons. It does not require true counting competence, it is roughly 50% more frequent than *tweede* ‘second’ through *twintigste* ‘twentieth’ combined, and it has been shown to be a superlative (rather than an ordinal) in Dutch (Barbiers 2007), which are acquired early (cf. Syrett 2016). Something similar holds for English.
- (iii) Children subsequently acquire the ordinal formation rule (informally: cardinal + suffix = ordinal). Children in this stage can reliably find at least low, regular ordinals if the lower ordinals provide sufficient evidence for the rule, such as in Dutch *tweede* ‘second, lit: two–th’ and *vierde* ‘fourth’. If higher ordinals are needed for the generalization, CP-knowers should comprehend both lower (≤ 4) and higher (> 5) regular ordinals.
- (iv) Performance on higher, regular ordinals is (by definition) limited to CP-knowers only, since children who cannot count beyond *four* cannot be expected to count to higher ordinals either. CP-knowers may have difficulty with higher ordinals due to task demands (the further one has to count and maintain one-to-one correspondence, the more demanding the task becomes) but also due to the extra challenge of combining the two core number systems (OTS and ANS) with the ordinal formation rule. For lower ordinals, the ANS need not be recruited, but for higher ordinals, both systems are necessary.
- (v) Performance on irregular forms (such as *derde* ‘third’ in comprehension and production, and *achtste* ‘eighth’ in production) follows at some point after acquisition of the rule. Note that this might be before or after performance on higher ordinals improves.

More generally, these data show us how taking different perspectives is important. For one, the pathway above would be less complete without production data complementing comprehension, without the analytic ordinals in comparison with synthetic ones, or without the cross-linguistic angle. For another, the finding that seemed straightforward and obvious turned out to be quite surprising, showing our intuition can be right for the wrong reasons.