Word Initial Clusters in Acquisition

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Abstract
In this paper, I study the acquisition of consonant clusters by testing the production of Greek-speaking children. Using a non-word repetition task, I tested the order of acquisition of word initial and word medial s-obstruent (sT), obstruent-obstruent (TT) and obstruent-sonorant (TR) clusters in 59 children. The data presented here shed new light on the nature of word initial clusters that violate the Sonority Sequencing Generalisation (sT and TT). The experimental results provide evidence against any analysis that assigns identical syllabic status to word initial sT and word initial TT, such as models of extrasyllabicity. For example, there is a clear tendency for sT clusters to be produced before TT clusters. Moreover, sT clusters were produced before TR by some children and after TR by others, in line with findings from other languages, while TT clusters were acquired later. A comparison of the initial clusters with their word medial counterparts also shows differential behaviour. Specifically, word initial TT was produced after word medial TT, while no such difference was found in sT acquisition. In the light of these findings, I explore an alternative analysis of initial cluster acquisition, based on Lowenstamm’s (1999) initial ON hypothesis.

1 Introduction

Though consonant clusters have been studied extensively by acquisitionists (e.g. Barlow 1997; Demuth & Kehoe 2006; Freitas 2003; Jongstra 2003; Kirk & Demuth 2005; Pan 2005; Vanderweide 2005) the focus of the research on the word initial position has been on obstruent-sonorant clusters (TR) and s+consonant (sC) or s+obstruent (sT) clusters. Other word initial clusters, such as obstruent-obstruent clusters (TT) have been largely ignored. These clusters (for example ft, xt, which are attested in Greek) are problematic for phonological theory as they do not respect the regular rising-sonority pattern associated with the beginning of a syllable, a fact which has led phonologists to the assumption that these clusters are extrasyllabic. Word initial TT is generally assumed to share the same structure as sT clusters, which are problematic not only in phonological theory, but also in the study of language acquisition. Consequently, studying the acquisition of TT clusters alongside sT clusters could help us understand the behaviour of sT clusters. More generally, studying the acquisition of different clusters, for example word initial clusters alongside their word medial counterparts, can be a lot more insightful than studying the acquisition of a cluster type in isolation.

Following this reasoning, in order to examine the phonology of the clusters in question, I test the production of consonant clusters by children acquiring Greek as their first language.

The paper proceeds as follows: Section 2 contains a short discussion on the word initial clusters in question. Section 3 deals with the data collection and in section 4
general results are presented. In section 5 I proceed to the analysis; in section 5.1 some problems of the extrasyllabic theory are presented, and in section 5.2 I introduce an alternative proposal for the analysis of the data based on Lowenstamm’s initial ON hypothesis. A short conclusion follows.

2 Word initial clusters

2.1 Word initial extrasyllabicity

Word initial sT clusters do not respect the Sonority Sequencing Generalisation (SSG, Clements (1990)) according to which sonority increases towards the syllable peak and decreases towards the edges. Initial sT breaks this generalisation, since the second member of the cluster has a lower (in the case of stops) or an equal (in the case of fricatives) sonority value when compared to the first member (s). This is the opposite of what the SSG dictates for onsets, namely that the second member of the cluster should be of higher sonority.

Faced with this inconsistency, several researchers have opted for a syllabification algorithm that leaves the s outside the onset: the s is extrasyllabic (e.g. Halle & Vergnaud (1980), Levin (1985), Steriade (1982)). An example of such a structure is given in (1) below.

1) sT extrasyllabicity: Italian spērītō ‘spirit’

Later in derivation the s may be linked to a constituent via some kind of adjunction rule. The desired effect is thus attained: at the first stage, the SSG is not violated, since the s is not linked to the onset, while at the same time eventual integration to the syllabic structure is achieved.

The same extrasyllabic structure has been proposed for word initial TT clusters (e.g. Rubach & Booij (1990), Steriade (1982)), which also violate the SSG.

2) TT extrasyllabicity: Greek xτενί ‘comb’
2.2 Order of acquisition

In first language acquisition, sT extrasyllabicity shows unusual behaviour: sT can be acquired after, but also before TR. Several studies have shown that children start producing initial sT clusters after TR clusters (e.g. Chin (1996), Smith (1973)). However, other studies (e.g. Barlow (1997), Gierut (1999)) report that some children produce initial sT clusters first.

The variation in the order of initial sT-TR acquisition has long puzzled researchers and there have been a number of proposals developed in order to tackle this problem. For example, it has been suggested that the explanation for these data lies in the possibility that some children acquire branching onset structures (TR) before extrasyllabicity, while others acquire extrasyllabic structures first (Fikkert 1994). This assumes that extrasyllabicity and branching onsets (TR) are different, but equally marked structures, and the order of acquisition is therefore subject to variation. A different suggestion holds that, in acquisition, extrasyllabic clusters (and more generally consonantal sequences) may be structured like affricates (Barlow (1997), Lleó & Prinz (1997)). The relevant structure is shown below.

3) sT as an affricate: Italian *spirito* 'spirit'

\[
\begin{array}{cccc}
\sigma & \sigma & \sigma & \sigma \\
O & R & O & R \\
N & N & N \\
x & x & x & x & x \\
s & p & i & r & i & t & o
\end{array}
\]

As seen in (3), sT clusters are represented as complex segments with a single timing slot. According to this approach, if a child does not structure sT like an affricate, s/he will acquire it after TR (i.e. as extrasyllabic, and therefore more marked). If, on the other hand, in a developing grammar, sT is structured like an affricate, it will be acquired before TR (on the assumption that complex segments are less marked than complex onsets). This optionality of structure, it is argued, can account for the variation in initial sT versus initial TR acquisition.

The acquisition of word initial TT clusters has not received much attention. From a theoretical point of view, an analysis that assumes extrasyllabicity of initial clusters of non-rising sonority will predict the same variation in TT versus TR acquisition as in sT versus TR acquisition. If TT is extrasyllabic like sT, and sT is acquired before or after TR, then TT is expected to be acquired before or after TR. Both analyses of sT versus TR acquisition outlined above (that extrasyllabicity can be acquired before or after TR, or that extrasyllabic clusters can be structured as complex segments in acquisition) would make the same prediction in this case. Moreover, word initial sT and TT are expected to be acquired at roughly the same time, under the assumption that they share the same (extrasyllabic) structure. Furthermore, a comparison of these clusters to their word medial counterparts can further test the theory. Though it is not clear from the theory of extrasyllabicity whether we should expect to find a difference between word initial and word medial sT, and if so, in what direction, whatever the relationship between initial and medial sT (i.e. whichever is acquired first), the same relationship should hold between initial and medial TT. Word initial and word medial TR, on the other hand, are expected to show no difference, since both positions involve the same structure (namely complex onset).
3 Method

3.1 Subjects

Fifty-nine monolingual typically developing Greek children were tested (21 boys and 38 girls). The age range was from 2;03 to 5;00, mean age 3;08. The experiments took place in four different nurseries in Crete (three in Rethymno and one in Iraklio) and, in the case of one child only, in a relative’s house.

3.2 Materials and procedure

A non word repetition task was used. Novel, made-up words that had the desired structures were paired with pictures of novel animals. The child was asked to call the animals with their name.

The experiment consisted of six conditions: the first three conditions involved words with sT, TR and TT clusters in word initial position, and the remaining three conditions contained words with the same clusters in word medial position. Specifically, the following combinations of consonants were tested:

4) sT sp, st, sk, sf, sx  TR tr, kl, fl, xr, vr  TT ft, xt, vð, vΓ

The construction of the nonwords used in the experiment followed the phonotactics of Greek. The words were either feminine or neuter nouns, with inflectional endings -a (feminine), -i (feminine or neuter), or -o (neuter). All words were bisyllabic, with a voiceless stop (p, t or k) as an onset for the non target syllable.

The stimuli of the word initial conditions were the following:

5) sT sp voki, st vipo, sk vapi, sf vito, sx vika
   TR tr vika, kl vito, fl vapi, xr voki, vr vipo
   TT ft vipo, xt vika, vð vito, vΓ voki, vΓ vapi

The stimuli used in the word medial conditions were formed by reversing the syllable order. For uniformity, the target cluster always preceded the stressed vowel. This creates pairs such as sp voki – kisv o. Note that both members of these pairs are well-formed in Greek, which is characterised by a lexical accent system, restricted by the trisyllabic window (i.e. stress must fall in one of the last three syllables of the word).

The test items were arranged in three different pseudo-random orders so as to avoid sequence effects, and each of these orders was followed for a third of the children tested. There were four warm-up items without any clusters. Each of the selected children was tested individually in a separate room. Each session lasted about half an hour.

3.3 Transcription and coding

The responses were transcribed on-line by the experimenter. The sessions were also DAT recorded. The original transcriptions were then checked and amended off-line by the experimenter.

An independent transcription was made by a second transcriber, who is a Greek native speaker and is well-trained in doing transcriptions. Ten percent of the data were cross-checked. In particular, one-tenth of the responses of each child were
transcribed. The consistency rate between the two transcriptions, focusing on the cluster data, was 96 percent.

4 Results

Figure 1 below contains the percentage of correct responses for each of the clusters in word initial and word medial position. Percentages were calculated on the basis of conflated raw figures. This method of calculation was possible because of the structure of the data: there was an equal amount and type of data for each child.

Figure 1. Percentage of correct responses for word initial sT, TR and TT clusters in word initial and word medial position for all children combined

<table>
<thead>
<tr>
<th></th>
<th>percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>sT</td>
<td>initial</td>
<td>TT</td>
</tr>
<tr>
<td>TR</td>
<td>initial</td>
<td>TT</td>
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<tr>
<td>TT</td>
<td>initial</td>
<td>TT</td>
</tr>
</tbody>
</table>

A visual examination of the figure indicates that word initial TT is different from the other clusters. Detailed comparisons will be now presented for the cluster pairs that interest us, starting with word initial sT versus word initial TR.

The results for word initial sT and word initial TR are very similar, and no statistically significant difference was found ($\chi^2=0.034$, $p=0.859$, DF=1). In addition, the table showing the number of correct responses for each child for the two conditions (initial sT and initial TR) is shown below (table 1). This organisation of the data allows us to look at the overall results in conjunction with the results of each individual child.

In table 1 the vertical dimension represents the number of correct responses in the word initial sT condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the word initial TR condition (again from zero to five). One can therefore read out of the table the number of correct responses each child gave in the two conditions. For example, nine children (in the first row) gave no correct responses in the sT condition. Of these children, four (in the first cell starting from the left hand side) gave no correct responses in the TR position either, two (in the second cell) gave one correct response, two (third cell) two correct responses and so on. Children are divided into two groups, represented by the two sectors, divided by the diagonal: the top right sector contains children that performed better at TR, while the bottom left sector consists of children that performed better at sT. Children that fall on the diagonal performed the same in both conditions.
Table 1. Number of correct responses for word initial sT and TR for each child

<table>
<thead>
<tr>
<th>#sT</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>0</td>
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</tr>
</tbody>
</table>

A visual examination of the table shows that the top right and the bottom left sector are equally populated. No statistically significant difference was found between the two sectors ($\chi^2=0.095$, $p=0.758$, DF=1). Moreover, the tally marks representing the children are scattered all over the table, showing that there is wide variation in performance. This includes children that performed almost adult-like in sT but badly at TR, and vice-versa, as well as children that were equally advanced in the two cluster types.

In a word initial TT versus TR comparison, figure 1 shows a considerable difference in the percentage of correct responses. Children performed better at the TR condition, and the difference is statistically significant ($\chi^2=18.337$, $p<0.001$, DF=1). As before, the table containing the number of correct responses for each child for both conditions (initial TT versus initial TR) was drawn.

Table 2. Number of correct responses for word initial TT and TR for each child

<table>
<thead>
<tr>
<th>#TT</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</tbody>
</table>

130
A visual examination of the table shows that the top right sector, corresponding to children that performed better at TR, is much more populated than the bottom left sector, which includes children that performed better at TT. The difference is statistically significant ($\chi^2=14.400$, $p<0.001$, $DF=1$). Several children performed well at TR and badly at TT, while the reverse pattern was uncommon.

The results for initial sT and initial TT also differ significantly ($\chi^2=19.866$, $p<0.001$, $DF=1$), with children performing better in the sT condition.

Having examined the results in the word initial conditions, I now compare the results in the word initial position with those in the word medial position, starting with sT clusters. There was no difference between word initial and word medial sT ($\chi^2=1.225$, $p=0.268$, $DF=1$) or word initial and word medial TR ($\chi^2=0.007$, $p<0.933$, $DF=1$), while there was a statistically significant difference between word initial and word medial TT ($\chi^2=10.319$, $p<0.001$, $DF=1$). As seen in figure 1, children's performance was better at word medial TT.

To sum up, some children performed better at word initial sT than TR, while others performed better at TR than at sT, creating a balance in the overall results. Children's performance at word initial TT was systematically worse than at word initial sT and word initial TR. In a comparison with the word medial position, no difference was found in children's performance at sT (initial versus medial) and TR (initial versus medial), while there was a difference between word initial and word medial TT.

5 Discussion

5.1 Extrasyllabicity-problems

The results regarding initial sT versus initial TR were as expected. No overall difference was found between sT and TR clusters. These results were representative of the paradox that is found in the acquisition literature in other languages, with some of the children acquiring sT before TR and some following the opposite path.

These results, combined with the results for word initial TT and TR are particularly problematic for the extrasyllabic analysis of sT and TT. Extrasyllabicity would only be able to account for one set of data: either the TT versus TR, or sT versus TR. The TT versus TR results could be explained by an extrasyllabicity model according to which extrasyllabic structures are more marked than regular branching onsets and are therefore expected to be acquired later. This model would explain late acquisition of TT when compared to TR, but would fail to tackle the paradox of sT versus TR variation. On the other hand, the TT versus TR data would not be covered by the amended extrasyllabicity proposals discussed in section 2.2 – namely a) that extrasyllabicity can be acquired before or after branching onsets, and b) that in some children's grammar, extrasyllabic clusters are structured like affricates, and are therefore acquired before branching onsets. Any such proposal would cover the data it was designed to explain (sT-TR variation), but would have to answer the question of why the same variation is not found in TT versus TR acquisition. Either way, the results are problematic for the extrasyllabic approach. Evidence for the different nature of sT and TT was also found in the comparison with their word medial counterparts. Although word initial TT was acquired later than word medial TT, such imbalance was not found with sT clusters.

In order to account for the data, it would be possible to add an auxiliary hypothesis that assumes two different kinds of extrasyllabicity, one for initial sT and one for initial TT. However, this would not be enough: we would further have to stipulate the order of acquisition of these different structures. Specifically, we would have to stipulate that sT-type extrasyllabicity is acquired before TT-type extrasyllabicity. If TT was found to be acquired before sT, extrasyllabicity could
simply stipulate that it is TT that is acquired before sT, and thus be made consistent with the opposite reality.

To make matters even more complicated, in languages that have both, sT and TT show identical behaviour in some adult language phenomena. Specifically, there is evidence from languages that have both initial sT and initial TT that the two are syllabically the same (Seigneur-Froli 2006; Steriade 1982). A well-known example is Attic Greek reduplication: perfective forms of roots beginning with sT and TT follow the same pattern, in contrast to verbs that begin with TR. The perfective forms of roots commencing with a single consonant (including s) are formed by reduplication; an initial syllable consisting of the first consonant followed by e is added (6a). In the case of roots commencing with TR clusters, reduplication also takes place (the initial syllable consists of the obstruent plus e) (6b). In contrast, in the case of roots commencing with TT no reduplication takes place: the vowel e is added word initially (6c). As for the perfective forms of roots starting with sT, these are formed in the same way as TT initial roots (6d).

6) Reduplication patterns

a. CV
   - paideνυοο paideνυοο  ‘bring up’
   - lυοο lυοο  ‘loosen’
   - saleνυοο saleνυοο  ‘cause to rock’

b. TR
   - krνινοο krνινοο  ‘pick out’
   - klνινοο klνινοο  ‘make to bend’
   - plνεοο plνεοο  ‘sail’

c. TT
   - ptναιοο περταίκα  ‘make to stumble’
   - κτνεινοο κεκτααμαι  ‘kill’
   - p’θνανοο περθ’θακα  ‘come first’

d. sT
   - spναοο  ‘draw’ (a sword)
   - stνελοο  ‘arrange’
   - skiναζοο  ‘shade’

Such behaviour has led phonologists to conclude that sT and TT in (ancient) Greek have the same structure (Seigneur-Froli 2006; Steriade 1982). On the other hand, our experimental results demonstrate that sT and TT are different in some way crucial to first language acquisition. The question arises, if sT and TT have the same structure, why are they not acquired together?

5.2 Towards an analysis

If we try to categorise word initial clusters based on the acquisition data presented here, the division appears to be between TR and sT on one side and TT on the other side. The acquisition of TT clusters requires an extra step when compared to the rest of the word initial clusters.

Interestingly, this descriptive division corresponds to a theoretical division that has been suggested on entirely different grounds, based on adult language phenomena. Scheer (2004) divides (adult) languages into those that allow word initial
TT clusters and those that do not. The theoretical distinction he proposes is the absence versus presence of an onset nucleus pair at the left margin of the word. The theoretical proposal is part of a system that defines structure according to relationships segments establish along the syntagmatic dimension i.e. governing and licensing relations with what follows and what precedes, thus eliminating vertical-branching structure.

7) Syntagmatic representations: πέφτω '(I) fall', μετί 'nose', κτένι 'comb'

The examples in (7) show the representations of three Greek words. As may be seen, the skeleton is a sequence of onsets (consonantal positions) and nuclei (vocalic positions), which may or may not enjoy segmental instantiation. An empty nucleus Ø is allowed to exist if it is followed by a filled nucleus, which governs the empty position.

Based on Lowenstamm's (1999) proposal that the left margin of the word (traditionally noted as #), corresponds to an onset nucleus pair without any segmental content (ON), Scheer proposes a parameterisation of the initial ON. The existence of an initial ON pair in a language creates a ban on word initial TT clusters. This is because the empty nucleus of the initial ON would fail to be governed, since the following nucleus (within the TT cluster) is itself empty (8a). Absence of the initial ON in a language makes the existence of initial TT clusters possible (8b).

8) Parameterisation of initial ON and typology of initial TT clusters

On the other hand, the presence or absence of the initial ON pair does not affect the existence of word initial TR and sT clusters, which have alternative ways of governing the empty nucleus of the initial ON (for TR see Scheer (2004); for sT see Sanoudaki (2007). The proposal finds independent support in diachronic lenition and fortition phenomena (Seigneur-Froli 2003; 2006).

Extending this to first language acquisition, the presence of an initial ON pair in a developing grammar creates a ban on word initial TT clusters. Word initial TT clusters only appear when the initial ON pair has disappeared from the child's grammar. This can explain the later acquisition of initial TT when compared to other word initial clusters.

9) Acquisition stage n-1: ON present: No TT clusters
Acquisition stage n: ON absent: TT clusters

Moreover, once the initial ON pair has disappeared (in other words, when initial TT is acquired) initial sT and initial TT have the same structure, as that is defined by the governing and licensing relations in their environment.
10) Word initial TT (\textit{xt\textipa{eni} `comb`) and sT (\textit{st\textipa{roma} `mouth`) in Greek

\begin{center}
\begin{tabular}{c|c}
\textbf{a.} & \textbf{b.} \\
\hline
\begin{tabular}{c}
\textit{gov} \\
\vspace{0.2cm}
\textit{ONONON} \\
\vspace{0.2cm}
\textit{x\textipa{oteni}}
\end{tabular} & \begin{tabular}{c}
\textit{gov} \\
\vspace{0.2cm}
\textit{ONONON} \\
\vspace{0.2cm}
\textit{s\textipa{otoma}}
\end{tabular}
\end{tabular}
\end{center}

Thus, the discrepancy between adult language and first language acquisition whereby sT is acquired earlier, while in adult language sT and TT behave identically, is predicted.

The remaining findings are also consistent with this model. Word initial TT is acquired later than its word medial counterpart because initial TT, unlike medial TT, has the extra requirement that the ON pair be absent. There is no difference in the acquisition of sT in initial versus medial position, since no such extra requirement is involved. The same holds for initial versus medial TR. Finally, the optionality in the acquisition of sT versus TR can be attributed to optionality in the mastering of the relevant structures (government and licensing respectively, see Sanoudaki 2007).

6 Conclusion

Despite what most phonologists would think, sT and TT in word initial position are different. The existence of the difference would not have been discovered without the help of developmental data, which show that Greek children acquire TT later than sT. The nature of the difference was further examined by comparing children’s production of different clusters in different positions. While word initial sT is acquired before TR by some children and after TR by others, TT is systematically acquired later than TR. Moreover, initial TT was acquired later than its word medial counterpart, while no such difference was found for word initial versus word medial sT. These findings point against existing extrasyllabic analyses of these clusters and indicate a division between initial sT and TR on the one hand and initial TT on the other hand, which is best captured by Lowenstamm’s initial ON hypothesis.

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References


