VARIATION AND SIMILARITY IN THE PHONOLOGICAL DEVELOPMENT OF FRENCH DIZYGOTIC TWINS: PHONOLOGICAL BOOTSTRAPPING TOWARDS SEGMENTAL LEARNING?

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Abstract

The few existing studies comparing the language acquisition of twins have shown contrasting findings with regard to phonological development (Bloch (1921), Leonard et al (1980)). Focussing on the implementation of templates – preferred output patterns implemented to facilitate production – this study compares the phonological acquisitions of a pair of twins, as systematisation of the output through templates appears to set the framework for an important shift in language development. Parallel templates are discussed alongside the observation of a coordinated shift towards segmental learning despite an initially dissimilar approach to language learning. Evidence from this data suggests that a form of phonological bootstrapping is taking place between these infants, which leads to further questions regarding the language acquisition of twins in the longer-term.

1. Introduction

Common universals can be found in the phonological acquisition of different children acquiring different languages; Smith (1975) identified four universal tendencies of phonological systematization: consonant harmony, cluster reduction, systematic simplification and grammatical simplification. Examples of these phenomena can be found in many longitudinal studies of individual children, such as Macken's study of Si, acquiring Spanish (1979), Smith's study of Amahl, acquiring English (1973), and Vihman's study of Raivo, acquiring Estonian (1981). In all of these studies, phonological patterns, or 'templates', are implemented to facilitate production in the output, generalizing common features found in the infants' early word forms and causing an infant to adapt words to fit a familiar output pattern (Vihman and Vihman (in press)). Words are either 'selected' or 'adapted' in line with an infant's preferred output patterns; words which already fit the structure of an infant's preferred pattern are 'selected' for production and are thus produced accurately, while target words which do not match an infant's preferred output pattern are 'adapted', changing the structure of the word to match a preferred output pattern. Adapted words highlight an overriding pattern force of a specific template, allowing an infant to produce more words, forfeiting output quality for output quantity (Smith (2010)) as systematic patterns are implemented throughout the lexicon. In later development, infants begin to shift towards a segment-based approach to word-adaptation, as individual segments rather than whole words are adapted to facilitate the production of adult word forms (Vihman (1996)). This highlights an important step in the course of phonological development, as this allows lexical development on a phoneme-by-phoneme basis, rather than word-by-word (Smith (2010)).

Templates such as consonant harmony have been found to occur universally (Vihman (1978)), yet individual infants have been found to differ substantially in their use of templates (Vihman et al. (1994)), due to factors such as biological constraints, ambient language effects

and motor and cognitive factors, as well as the variability in each infant's own input. According to Vihman:

> Each child, drawing on his or her *unique genetic inheritance* to develop vocal resources in the course of the first year of life, *influenced or shaped by the speech of the caretakers*, faces and solves a range of word production problems, resulting in an *idiosyncratic* first phonological organization.
>
> (Vihman 1993:62; emphases added)

But what does this mean for children who share a genetic inheritance and learning environment? With the above statement in mind, we could hypothesize that the phonological development of a set of twins would be similar, or at least show more resemblance than two unrelated children growing up in different learning environments. Though there are very few studies observing the phonological development of twins in the current literature, contrasting reports on this hypothesis can be found in studies by Bloch (1921) and Leonard et al (1980). Bloch discusses briefly the language development of his twin nephews, whose language is "identical: as soon as a modification or an acquisition appears in one infant, the other follows almost immediately" (p. 693, own translation). However, Leonard et al (1980) found that there is no similarity between twins in the acquisition of phonemes, despite the shared learning environment and genetic make-up of the infants. This study will consider this hypothesis further, by focussing on both the similarities and differences in a pair of dizygotic aɔɛtwins acquiring French in the same environment, where it is fair to assume that they are receiving an input of the same nature from their caregivers.

2. Methodology

The data used in this study is taken from the CHILDES database (Hunkeler (2005)); a longitudinal study of dizygotic twins, Camille and Pierre, between the ages of 1;3 and 2;2, acquiring French as their target language. The data was taken from a set of bi-weekly sessions, in which the output of each child was transcribed during interaction at home with the mother, who prompted speech using stimuli such as toys or picture books. Only one twin was present during each session, ensuring that the infant's output was not influenced by speech from his or her twin. The data was transcribed by the investigator, who was analysing the early lexical interactions between an infant and his or her mother for his doctoral thesis. As these twins are not genetically identical, any similarities in their language development must either reflect fundamental elements of the acquisition of French as a target language, or 'shared idiosyncrasies' resulting from a shared learning environment and input.

The majority of tokens produced by both children were nouns relating to everyday objects such as animals and items of clothing. Due to the nature of the French noun, which rarely appears without an article, often the children's tokens were preceded by an open vowel, either /a/, /ɔ/ or /ɛ/, creating what could be interpreted as different realizations for the same word type (e.g. in Pierre's data, 'papa' *daddy* had eight different realizations, all with the same stem, including /apapa/, /papa/, /ɔpapa/ and /ɛpapa/). This 'pre-utterance vowel' was also observed in Macken's (1979) study of Si acquiring Spanish, and following Macken's interpretation of Si's vocabulary, this study will count different instances of vowel + noun combinations as the same token, as long as the noun itself remains constant.

This data will be used in this study to observe any similarities in the phonological development of the twins. If an infant's first output is "shaped by the speech of the caretaker", as Vihman (1993, p.62) proposed, then it is possible to hypothesize that these twins will indeed share some similarities in their first word forms that go beyond the universal output patterns identified across all languages (Vihman (1978), Smith (1975)). A longitudinal study of each infant's lexical inventory will identify any recurrent templates in the output, which will be identified as patterns which are commonly used to adapt output forms. These will then be compared speculatively to observe whether there are any inherent similarities between the phonological development of these two infants. The infants' development will be compared with regard to both age and output. A comparison of the infants' development with regard to age will give a clear indication of any differences in the level of their output ability, while a comparison of the two outputs at the 15- and 25-word points (the points at which the infant produces 15 or 25 words in one recording session, respectively) will provide a fair comparison of the infants' lexicons over the course of their development.

3. *Analysis*

Each infant's output was observed longitudinally and recurrent patterns in both selected and adapted word forms were identified. Both infants were found to produce a large proportion of words with consonant harmony, and both omitted syllables in many forms to produce a simple CV structure. These patterns correspond with Smith's (1975) theory of universal tendencies in phonological development, reflecting universally common tendencies of simplifying word forms.

With regard to age, the twins' development shows no similarity; Camille produces many word forms even in her first session, some of which are realized accurately, while Pierre's output progresses more slowly, and retains a relatively low level of accuracy throughout the study. The twins' outputs in the first session at 1;3 can be seen in Table 1, below.

Camille		Pierre	
auto 'car'	[tu] [tɔ]	*balle* 'ball'	[bab]
ça c'est un poteau 'there's a post'	[sa sɛ œ̃ pɔtɔ]	*bateau* 'boat'	[ba]
c'est ça 'that's that'	[sɛ sa]	*maman* 'mummy'	[mama]
chat 'cat'	[ʃa]		
coucou 'darling'	[tutu]		
maman 'mummy'	[mama]		
ours 'bear'	[dɔ]		
sauterelle 'grasshopper'	[isøtø]		
tchou tchou [train noise]	[tɔʃ tɔʃ]		
tortue 'tortoise'	[tate], [tata], [toty]		

Table 1: Camille and Pierre's output forms at 1;3

From Table 1 it is clear that Camille and Pierre differ vastly in their approach to language production. An analysis of each child's individual phonological development will therefore provide a framework from which the results can be observed, in order to identify any similarities between the two twins.

3.1. Camille

In her first recording session at 1;3 Camille produces a small yet relatively accurate set of word forms, as shown in Table 1. Most of these first words are selected, as Camille produces words which already contain her preferred output patterns, exploiting existing patterns such as consonant harmony in *maman* 'mummy' – [mama] and *tortue* 'tortoise' – [tata]. Some of her output forms do not match the target word, however, and are 'adapted' to fit her capabilities; syllable deletion is seen in *auto* 'car', which is reduced to [tɔ], and velar fronting occurs in *coucou* 'darling' as the velar plosive is realized as an alveolar plosive [tutu]. A notable occurrence in this first set of words is seen when Camille produces a string of words, *ça c'est un poteau* 'there's a post', produced accurately as [sa sɛ œ̃ pɔtɔ]. Disyllables are the most common structure amongst the first words of infants acquiring French, and indeed they make up the majority of Camille's word forms throughout the recordings in this study. However, though polysyllables are not uncommon in French as they are in English (Vihman (1991)), this five-syllable word string does suggest that Camille is developing a good phonological memory and an ability to plan her output at a very early stage in her development.

Camille continues with a high level of accuracy in her output, and variability in her word forms is rare, with only 8% of her accumulative word forms produced with any variation by the 25-word point at 1;8. One of these variable forms marks an important development in Camille's phonological progress: in her third session, at 1;4, Camille produces an almost accurate realization of the target *attention* 'watch out', as [sayːtɑ̃sjɔ]. However, at 1;6 this form undergoes syllable deletion to become [tɑ̃sjɔ], outlining an instance of regression in the quality of Camille's output. From this point in her development, Camille's word forms become much more systematic, as she develops a set of preferred output patterns and begins adapting words throughout her inventory to match a set of templates. For example, 'palatal patterns' (replacement of certain segments, such as liquids, with the palatal [j], found to be common in the acquisition of French (Wauquier-Gravelines & Suet-Bouret (2004)), become much more prevalent, as 31% of Camille's output forms contain [j] between 1;6 and 2;0. These forms are either selected due to an existing [j] in the target word, or adapted using [j] in place of segments such as /l/ and /ʀ/, as in the examples in Table 2 below:

Replacement of /l/			Replacement of /{/		
langue 'tongue*'* [jɑ̃g]	(1;8)		*souris* 'mouse'	[sɔji]	(1;4)
de l'eau 'water' [djo]	(1;8)		*au revoir* 'good bye' [aja]		(1;5)
lampe 'lamp'	[ja]	(1;8)	*roue* 'wheel'	[ju]	(1;9)

Table 2: use of /j/ in Camille's adapted word forms

In addition to this palatal pattern, over one third of word forms contain a consonant harmony template in this period; Camille is certainly implementing systematic templates to her word forms at this point, facilitating her word learning and maximising her output, which is growing at every recording session.

Just before Camille reaches two years of age, a further development can be seen in her output forms. At 1;11 she finally produces *attention* accurately, as [atɑ̃sjɔ̃], and the appearance of palatal patterns diminishes as the target consonant [l] appears more regularly in her inventory, both in the correct context – *il pleut pas* 'it's not raining' [iplœpæ] (2;0), and incorrectly in *citron* 'lemon' [sitlɔ̃] (2;2) – as she starts to over-generalize this newly stable addition in her phoneme inventory, now replacing target /ʀ/ with [l] instead of [j]. At the age of 2;0 it appears that Camille's word forms start to shift towards a more accurate production, as she begins to adapt individual phonological segments rather than whole words. This change to a segmental approach to production occurs as her output becomes less systematic and moves closer to the adult target.

3.2. Pierre

With regard to his output forms and his approach to word learning Pierre's phonological development differs substantially from that of his twin sister; he produces only four words in

his first recording session compared to eleven words in Camille's first session (shown in Table 1). While Camille expands her output very gradually, increasing her production and reaching the 15-word point at 1;7, Pierre produces an average of only four words per session for the first six sessions, and then suddenly increases his output three-fold, reaching his 15-word point a month earlier than Camille, at 1;6. His learning continues in this fashion, increasing his output suddenly and substantially, until he reaches his 25-word point, almost 3 months later than Camille, at 1;11. He displays a large amount of variability in specific word forms, especially in sessions where his vocabulary has shown a large increase since the previous session, as in the following examples in Table 3, taken from the session where he reaches his 15-word point:

balle 'ball'	*chausson* 'slipper'
[ba]	[ʃøʃɔ̃]
[baj]	[ʃəla]
[bɔ]	[ʃø]
[bajaj]	

Table 3: variation in the realization of the target words *balle* and *chausson* in one recording session.

This variability could reflect instability in Pierre's word form representations, showing that he could be struggling with motor and planning capabilities in his production.

Disregarding the use of the pre-utterance filler, Pierre's word forms are all mono- and disyllabic throughout the recordings, with one exception [apapabrumbrum] – *papa brum brum* 'daddy brum brum' in his final session at 2;2. Alongside a preference for consonant harmony before the 25-word point, which appears in 25% of word forms, both selected and adapted, a small number of output constraints are also applied to Pierre's output forms. He selects words with a shared place of articulation, as in [pɔm] *pomme* 'apple' (1;7.27) and [dɔn] *donne* 'to give' (1;8), or a front-back melody, as in [bato] *bâteau* 'boat' (1;10) and [abɛt] *bêtes* 'creatures' (1;11), both which contain a bilabial-alveolar melody. When target forms do not fit either of these preferred patterns, he adapts them using typical processes such as consonant harmony and syllable deletion, shown in the examples below:

(1)   [kaka] *canard* 'duck' – consonant harmony (1;6)

(2)   [bibɔ̃] *biberon* 'bib' – syllable deletion (1;11).

Though Pierre's output could be interpreted as less advanced than that of his twin sister in terms of both quantity and quality, his capabilities in terms of his articulatory output are not as restricted as Camille's. Whereas Camille systematically implements a palatal template to deal with the difficult phonemes /l/ and /ʀ/, Pierre is able to produce both of these in some instances, seen in Table 4:

/l/	/ʀ/
[vwala] *voilà* 'there we go' (1;8) [adlo] *de l'eau* 'some water' (1;7)	[ʀɛzɛ̃] *raisin* 'grape' (2;0) [ʀɔ̃] *rond* 'round' (2;1)

Table 4: instances of /l/ and /ʀ/ in Pierre's word inventory

Pierre's use of these difficult segments is by no means across-the-board, and he does use some processes to adapt words which are too challenging, for example:

(3)   [baj] *balle*, 'ball'   (1;6)

(4)   [labɑ] *là-bas,* 'over there'   (1;8)

(5)   [pɑja] *voilà*, 'there'   (1;10)

The lack of a consistent palatal template like Camille's for dealing with these segments reflects an important difference in the twins' development, showing that, though the twins share many of the same phonological challenges in their acquisition of French, they do not share the same methods for dealing with these. However, the example of *voilà* at 1;10, above, shows an occurrence of regression in Pierre's word forms when compared with the accurate realization of *voilà* in Table 4, [vwala], at 1;8. The use of both cluster reduction and palatal gliding in [pɑja] two months later shows evidence towards the use of a systematic output pattern in Pierre's vocabulary, though this may not occur across-the-board. This indicates that Pierre could also be moving towards a segmental approach to word learning, coinciding with Camille to reach a turning point at 2 years.

4. *Identifying Templates in the Infants' Outputs*

Both twins show signs of reaching a 'turning point' in their phonological development at around 2 years. Accuracy in the output increases as the twins begin to produce challenging segments correctly, and previously incorrect or regressive forms move towards a more accurate realization of the target word. This turning point is best observed through the example of templates, as they develop, regress and move towards the target production over time. The templates identified in these infants' output do not reflect a restriction in the production of individual consonants; rather they show restrictions in the production of word forms. Both twins are able to produce a large variety of phonemes, and no specific phonemes are completely omitted from either twin's inventory. This highlights the existence of a whole-word approach to production, not on a phonetic level, but on a phonetic level.

4.1. *Consonant Harmony Template*

The twins each implement two templates which are striking in their resemblance. The first template to appear in both infants' output forms is based on consonant harmony, which is

prevalent in both selected and adapted word forms for both twins. The production of the fricative /ʃ/ is a challenge for both Camille and Pierre, and the twins use the same consonant harmony adaptations to overcome the difficulties encountered in production of this phoneme.

Though Camille does not consistently produce /ʃ/ as [s], the use of this phoneme certainly limited in her output forms, as can be seen in Table 5.

Correct Realizations of /ʃ/				Incorrect Realizations of /ʃ/			
du chocolat	'some chocolate'	[dyʃojaja]	(1;10)	*chapeau*	'hat'	[po]	(1;9)
cacher	'to hide'	[taʃe]	(1;7)			[azø, apo]	(1;10)
chercher	'to look for'	[ʃeʃe]	(1;8)	*château*	'castle'	[to]	(1;8)

Table 5: realization of target /ʃ/ in Camille's inventory

Table 5 shows Camille's attempts at producing this phoneme as well as word forms which are adapted to avoid it, and it is clear that it is in some way limited in her output. Upon closer observation of the distribution of /ʃ/ in Camille's output forms, it is found that she does produce this consonant regularly, but only in instances of consonant harmony. There are only two exceptions to this rule, *du chocolat* and *cacher*, seen in Table 5. More examples of this restriction can be seen in the following word forms, which are very similar in structure, and Camille is able to take advantage of this by implementing a consonant harmony template which enables her to adapt all three targets for production:

(6)   a.   *chaussures*   'shoes' - [ʃoʃy]   (1;7 – 1;9)

       b.   *chaussons*   'slippers' - [ʃoʃɔ̃]   (1;7)

       c.   *chaussettes*   'socks' - [ʃoʃɔ̃] [ʃoʃɛt] [ʃoʃɛʃ]   (1;6 – 1 ;9)

There is an interesting use of consonant harmony at work in this case, as the consonant on the unstressed syllable is harmonized, rather than the /s/ on the stressed syllable. However, at 2;0, *chaussures*, which was produced consistently as [ʃoʃy] for three months, is realized as [sosy]. The shift from harmony of the unstressed syllable to harmony of the stressed syllable indicates that Camille is paying attention to the segmental building blocks of words, even though the output form remains incorrect. Little by little, this phoneme starts to appear correctly in some output forms, as she acquires new forms with /ʃ/ such as [aʃjɛ̃] *chien*, 'dog' (2;0) and [ʃənij] *chenille*, 'caterpillar' (2;2), as well as updating previously inaccurate forms with this new phoneme: [to] (1;8) → [ʃato] (2;1) *château*, 'castle'.

Pierre also appears to struggle with the phoneme /ʃ/ in his output, as well as its alveolar counterpart, /s/. Before 2;0 there are only three realizations of /s/ in his recordings which do not appear in the context of consonant harmony, while /ʃ/ is realized only in situations of

consonant harmony. Though Pierre's template is not identical to Camille's, he adapts the same word forms with the same process, to overcome the same phonological restrictions:

(7)   a.   *chaussures* 'shoes' - [aføfø] (1;8)

        b.   *chaussons* 'slipper' - [ʃøʃø] (1;4 – 1;10)

        c.   *chaussettes* 'socks' - [sosɛt] (1;9 – 2;1)

Like his twin sister, Pierre begins to adapt the template as he moves towards a segmental understanding of word forms; [ʃøʃø] becomes [sosɔ̃] at 1;10, and [aføfø] is realized as [ʃoʃɔ̃] at 2;1. Though the output forms are not the same for both twins in all cases, these examples suggest that one twin could be copying the other's output. Due to the limited appearance of /ʃ/ and the subsequent adaptations of words containing this phoneme, it is evident that both infants are struggling with the same output limitations. As one twin begins implementing a consonant harmony template in order to deal with this phoneme, it could be that the other twin takes advantage of this to overcome his or her own difficulties. The template first appears in Pierre's word inventory at 1;4, and two months later it is recorded in Camille's output forms, becoming a rather influential template over her whole lexicon in the following months, as it causes forms to regress through overgeneralization: *abeille* 'bee', first realized accurately as [abej] at 1;7, is realized as [ʃabeʃ] at 1;8.

Like Camille, Pierre's representation of /ʃ/ stabilizes at around 2;0, and both /ʃ/ and /s/ are produced accurately more often:

(8)   a.   *chaud*   'hot'   [ʃo]   (2;0)

        b.   *chaise* 'chair' [ʃɛz] (2;1)

        c.   *soleil*   'sun'   [sɔjɛj] (2;1)

        d.   *sous*   'under' [su]   (2;1)

Once again, this suggests that the twins are paying attention to individual segments as their phonological inventories grow, and they are both reaching this important landmark in their phonological development at around the same time, though it is clear that their development is not intrinsically similar in any significant way.

4.2. /m/-Replacement Template

Another limitation which appears in the phonology of both twins involves the phoneme /m/, and a template is used to adapt some target forms to facilitate production, hereon referred to as the '/m/-replacement template'. Though /m/ is produced accurately from the first recording session (in [mama] *maman* 'mummy' for both twins), this phoneme does not appear often in either twin's initial output, and Pierre's realizations of /m/ are especially limited, only appearing correctly in word-initial position in four target words before 2;0:

Camille's Realization of /m/	Pierre's Realization of /m/
maman 'mummy' [mama] (1;3)	*maman* 'mummy' [mama] (1;3)

main	'hand'		[mɛ̃]	(1;7)	*miaou*	cat noise	[mjau]	(1;8)
miaou (cat noise)		[mja]	(1;7)		*main*	'hand'	[mɛ̃]	(1;10)
Mini		[mini]	(1;7)		*moi*	'me'	[ma]	(1;11)

Table 6: realizations of /m/ in each twin's lexicon

Pierre continues to implement the /m/-replacement template until the end of the recordings at 2;2. Camille's realization of /m/ is also limited, as she only produces four target words with /m/ before 1;10. However, after this point her use of target /m/ increases rapidly, and she builds on her existing lexicon with words containing this new stable phoneme. As seen in Table 6, both infants are able to produce /m/-initial words when the second consonant in the word is either a nasal or a glide; otherwise, /m/ is replaced with a bilabial consonant with oral stricture. This suggests that both infants have trouble changing from nasal to oral stricture across a word, showing evidence towards a whole-word approach to word learning. The /m/-replacement template adapts words with changing stricture in the target form to facilitate word production, and is found in both twins' output forms. As with the consonant harmony template, the twins' adapted forms are not all identical, but both the phonological challenge and the process used to overcome this are exactly the same. This template first appears in Camille's lexicon at 1;4.21, when she realizes *mouton* 'sheep' as [bɔtɔ]:

Camille					**Pierre**			
mouton	'sheep'	[bɔtɔ]	(1;4)		*morceau*	'piece'	[bøzo]	(2;1)
					monsieur	'Mr.'	[bəsjø]	(2;2)
maison	'house'	[abɛzɔ̃]	(1;11)		*maison*	'house'	[abɛzɔ̃]	(2;0)
manteau	'coat'	[pɔto]	(2;0)		*manteau*	'coat'	[əpoto]	(2;2)
merci	'thank you'	[besi]	(1;7)		*merci*	'thank you'	[besi]	(2;1)

Table 7: use of the /m/-replacement template in each twin's lexicon

Table 7 shows all instances of the /m/-replacement template in the recordings. Pierre's use of this template is more consistent, as it appears more densely in his word inventory; more forms are produced in a shorter space of time. However, the template first appears in Camille's output forms, and as can be seen from the table, identical forms are produced by both twins, Pierre's appearing no more than two recording sessions after Camille first uses the forms. This could be another example of one twin 'borrowing' templates from the other; once again, the twins are meeting the same phonological challenges, and using the same methods to overcome these challenges.

The use of this template provides another good example of the shift from whole-word learning to segmental learning at the two-year stage. This is demonstrated in Table 8, below, where Camille's realization of *maison* 'house' is shown longitudinally:

1;9	1;10	1;11	2;1	2;2
[bɛzɔ̃]	[amɛzɔ̃]	[bazɔ̃]	[mɛso]	[mɛzɔ̃]
[mɛzɔ̃]		[abɛzɔ̃]		

Table 8: development and regression in Camille's realizations of *maison* 'house'

As can be seen in Table 8, Camille is able to produce *maison* accurately at 1;9, with /m/ in word-initial position. However, the representation is still unstable, and in the same month her existing /m/-replacement template is used to adapt this form. In the following month it seems that *maison* has resisted adaptation, but by 1;11, two different realizations of *maison* using this template prove otherwise. The stressed second syllable of the target word continues to be produced correctly, however, as the first syllable is adapted to retain oral stricture throughout the word; Camille is therefore working on words as whole units at this stage. By 2;1, she has started to move from the whole-word stage to learning individual segments of words, and this is reflected in her production of *maison*; the word is no longer adapted with the template, and the word-initial /m/ is realized correctly, showing that Camille is able to shift from nasal to oral stricture within a word. However, the stressed syllable is no longer accurate: the fricative is unvoiced and the vowel is not nasalized, and so as one element of her phonology develops, another regresses. However, this regression does not last long, as by 2;2 Camille is able to realize *maison* as the target form, and by this stage 71% of Camille's /m/-initial targets are produced correctly.

4.3. From Whole Words to Segments

Systematization of the lexicon through the implementation of templates provides a way for the developing infant to practice using words, despite lacking some of the necessary tools to do so. As Thelen and Smith (1994) explained in their theory of cognitive development, dynamic systems theory, action is a necessary part of development, and in the case of linguistic development, 'action' is manifested in word production. Infants select templates based on their own abilities and phonological preferences, and adapt whole word forms to meet their output constraints, as seen in this study, as the production of fricative consonants or oral stricture across whole word forms constrain the output of both Camille and Pierre. As an infant's phonemic lexicon grows, his constraints upon the whole word diminish, and he begins attending to the individual segments which make up the word. As seen in Table 8, this often causes previously accurate segments to regress as attention shifts to different units in the word, but as this example also shows, a regression in accuracy signals development, and accuracy will follow as a result of this.

At 2 years, both Camille and Pierre appear to reach a turning point in their development which marks the shift from whole word learning to segmental learning. Their routes to language in the preceding months show no similarities in terms of ability; the infants approach language learning in different ways throughout the recordings, and their strengths and weaknesses differed as a result of this; Camille's lexicon grew steadily over the recording sessions, while Pierre's remained constant before the occurrence of an apparent vocabulary

'spurt', for example. While Camille approached word use carefully, paying attention to detail and accuracy without producing any variability in her forms, Pierre's approach was comparatively haphazard, with many variable word forms and no real systematic approach to the more difficult phonemes. With this in mind, their joint arrival at segmental learning at around 2 years is surprising, though this is by no means an absolute in their production, as development is still very much on-going at this point. However, this raises questions about the relationship between the language development of a pair of twins: at first so different in nature, how can two infants reach segmental learning at the same time, gathering along the way the same set of templates and even some identical output forms? Further investigation into the development of twins is needed if this question is to be answered, both to identify any similarities in output forms, and to pinpoint any parallels in the landmark developments that infants make on their route into language.

5. Discussion

The findings from this study support the contrasting observations of both Bloch (1921) and Leonard et al (1980). In line with Leonard et al's findings, the twins do not acquire the same phonological units in the same order; in fact they do not even show signs of using the same approaches to phonological development. However, Bloch's observation of one twin following the other's phonological acquisitions is found in the data, as the twins implement the same template which causes them to produce some identical output forms, and no doubt a larger set of recordings would back up this observation even further.

It is unsurprising that the twins are encountering the same phonological difficulties in their outputs. Indeed, the four universal tendencies of phonological systematization (Smith (1975)) arise from a selection of common output constraints encountered during language development, which result in the same universal output patterns. Thus the appearance of consonant harmony in order to deal with a change in manner of articulation, or even the use of oral harmony to avoid changing vocal stricture within a word cannot be considered as unusual, for twins as well as for unrelated infants. However, questions remain regarding the identical forms found in both twins' outputs; are these identical due to both twins implementing their shared templates on the same words, or is one twin imitating the other's output forms? As different output forms for the same target words occur in each infant's lexicon as a result of these templates, it can be deduced that both templates are active in each infant's phonological development. However, the influence that the twins have on each other's input and output with regard to these templates cannot be judged from this data, and more recordings would be needed to track the full extent of these findings. It seems that a form of phonological 'bootstrapping' is at work here, as one twin uses the other twin's phonology to overcome his or her parallel phonological challenges. Even with a complete set of data it would not necessarily be possible to answer the question of which came first: the template or the output form – did the infant borrow a template, producing the same output forms as a result of this, or did the infant borrow an output form, which went on to become a template as a phonological hurdle became easier to overcome?

As for similarities in the phonological development of these twins, while these identical templates do not suggest any genetic influence on the twins' language developments, they do highlight the influence of the learning environment and the interactions within that environment on an infant's unfolding phonological system. Furthermore, the underlying phonological challenges reflect similarities in the twins' overall production capabilities,

which is backed up further by evidence of a coordinated shift from whole word learning to segmental learning despite a vast difference in the initial approach to language acquisition.

All in all, these findings raise some important questions regarding the language development of twins, especially those concerning the nature versus nurture dichotomy, which remains a contended issue in the world of language acquisition. Similarities found in this study could be down to inherent similarities in the infants' development due to genetic inheritance, though the findings lean towards the influence from a shared learning environment. After all, the learning environment of a pair of twins differs significantly from that of non-twin infants, both in terms of attention from the caregiver as well as input, which will consist largely of the other twin's output forms. All of these criteria must be considered when observing any form of twins' development, and without a large sample of both twin and non-twin infants, hypotheses regarding similarities are unlikely to be proven. However, the similarities found in this longitudinal observation of twins' output forms provides a basis for further investigation, as the implementation of templates sets up an infant for his continuing phonological development, and so the use of identical templates in the output could have some important effects on further language production.

6. References

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