BARBARA OSTAPIUK
Szczecin University

Asymmetry in Sound Production in Persons with Ankyloglossia

ABSTRACT

In this article I present the sound as a three-dimensional configuration of organs forming the peripheral articulatory apparatus (horizontally, to the front-to the back with reference to parallel frontal vertical planes in the segments of the voice channel, vertically up-down with reference to parallel horizontal planes, horizontally, to the right-to the left with reference to the horizontal, sagittal plane). First of all, I discuss the untypical articulatory positions and movements of the lips, tongue and the mandible (illustrated by photographs from videophone recordings) with reference to the vertical sagittal plane. I relate the articulatory asymmetry of the tongue directly to the limited mobility of the tongue in ankyloglossia. I relate the asymmetry of the lips (mandible) to the labiovelar complex and interpret it as an indirect effect of ankyloglossia, caused by compensation that levels the restricted tongue mobility in making sounds. I challenge the strategy of supporting the tongue by lips in speech therapy of persons with ankyloglossia.

Key words: ankyloglossia, articulatory asymmetry, dismediality, articulatory polymorphism, labio-velar complex, speech therapy

Man inhales and exhales successive portions of air several times a minute. With every inspiration he takes in oxygen, which is indispensable for life, and with each expiration he removes of carbon dioxide. Moreover, each exhalation can be used for speaking and the exhaled air is then changed into language sound material. During breathing at rest, the air goes out of the lungs to the larynx, then to the throat and finally to the nasal cavity, from where, almost silently, it flows out (through the front apertures). During breathing in speaking the stream of air is directed to the oral cavity (less frequently also to the nasal cavity), from where it

flows out as a sequence of complex segmental acoustic phenomena (sounds) and suprasegmental phenomena (accent, intonation, pause), in which the "languaged"[1] human minds can find the language value.

The movement of expired air (and the sound of the sound) is formed in every segment of the voice channel. In the larynx (the phonatory part of speech apparatus) one of a few features of each sound is produced (voicedness/voicelessness) and over the larynx (the articulatory part of speech apparatus) the remaining ones: connected with the path of air flow determined by the air-tightness of the hard palate and the position of the soft palate (orality/nasality/oral-nasality, with the degree of openness in oral, oral-nasal air flow (vocality/consonantness), with a kind of obstacle (labiality, labio-dentality etc.),its position antero-linguality, postero-linguality etc.), the way of overtaking the obstacle, as well as pace and force of air stream (explosiveness, fluctuation, friction, etc.).

It can be said that pronouncing sounds is de facto sculpting the air, and logopedic therapy of faulty pronunciation – correcting the shape of an amorphous sculpture[2].

One configuration of the speech apparatus (and sound) produced owing to the changes of the position and shape of the organs unnoticeably changes into another and yet another one – together they form an unbroken phonic series. The borders between one and the other sound in the phonic sequence are therefore not distinct: one sound still lasts when another arrangement is produced for another one (in accordance with the phonemic-phonetic intentions and possibilities of the speaker). In auditory terms, a sound seems to be a simultaneous system of features (respiratory-phonatory-articulatory). In fact, we can only talk about the relative simultaneity of the position and movements of organs forming each segment of a phonic sequence. A segment is – according to B. Rocławski [1986] – "such a minimal phonic element of the text as is received by a phonetically trained ear as something inseparable" [p. 20], and a sound is "A segment that can occur beside other different segments and segments that always occur jointly" [p. 20]. A sound is usually equal to a segment, some sounds are, however, multi- segmental (most frequently they are formed by two segments), but "an average language user does not distinguish segments in sounds" [p. 20].

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[1] We should return to accurate terms "interindividual **language communing**", "**human individuals**" or rather individual human heads with their other parts of organism **languaged (lingualized**) in one way or another. They were used about a hundred years ago by Jan Baudouin de Courtenay in his article "Charakterystyka psychologiczna języka polskiego" [1915 in: Baudouin de Courtenay 1984; my emphasis B. O.].

[2] W. Zawadowski, discussing the x-ray method in examining sounds refers to "the shape of air space laying between the edges of lips, teeth, tongue and palate, which changes when each sound is being pronounced" [Koneczna, Zawadowski 1951, 4].

Simultaneous visual and auditory observation of the sound structure (the features of spatial configuration) and the sounding that corresponds to it (the sounding features), and especially combining of one kind of features with the other is very difficult in living speech [see: Essen 1967, Rocławski 1986, 2001, Wierzchowska 1971, Koneczna, Zawadowski 1951]. Especially, when we need to subject the observed sounds (short-lasting, transitory and closely connected one with another in speech) to qualitative assessment in order to distinguish desirable and undesirable features in them, as well as to establish what mechanisms lead to their formation [Ostapiuk 1997].

A SOUND AS A THREE-DIMENSIONAL CONFIGURATION OF ARTICULATORY ORGANS

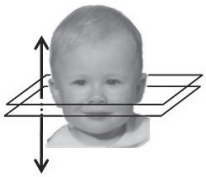
Each sound can be described as a relatively simultaneous configuration of positions and movements of organs forming the peripheral pronunciation apparatus. The positions and movements of organs can be assessed in three dimensions:

1. Horizontally (to the front – to the back) with reference to one of the few frontal vertical planes in subsequent segments of voice channel (anterior, middle, posterior[3]): in correct phoneme realizations – depending on the sound – the following are on one plane: either the lower and upper lip ([p, b, m]), or the lower lip and upper incisors ([f, w]), or the apical part of the front of the tongue and the palatal surface of upper incisors ([t, d, n, c, dz]), or the gums behind the upper incisors ([sz, ż, cz, dż, l, r]), or the dorsum of the palatal part of the tongue and palatal surface of the upper incisors ([s, z]), or the middle of the tongue and the hard palate ([ś, ź, ć, dź, ń, j]), or the dorsum of the posterior part of the tongue and the soft palate ([k, g, ch, ł])[4]. Besides the main, we can also speak about the additional, vertical plane of reference that runs either in the point of approximation/recession of both the dental arches in the first segment (dentalized /non-dentalized sounds), or in the point of approximation of both lips ([ł]), or where the anterior part of the tongue approaches the gingival folds ([ś, ź, ć, dź, ń, j, i]). And there is yet another one – along the posterior wall of the throat, which is approached (or moved away from) by the soft palate with the uvula (oral/ nasal/ oral-nasal sounds). The undesirable shifts (backwards, forwards) of the lower lip, tongue and maxilla lead to the formation of sounds with a different articulation structure (and tone).

[3] Or – as it is defined in phoniatrics – in the first, second and third articulation zone [e.g.. Pruszewicz 1992].

[4] The appropriate positional variants have to be considered as well, for instance: gingival positional variants of dental phonemes, etc.

Certain imperfections of the speech apparatus a priori exclude the correct articulatory position of the organs in anterior-posterior direction. The horizontal shifts of organs during sound formation are unavoidable in persons with malocclusion [Konopska 2006] or with the cleft palate [Pluta-Wojciechowska 2006]. For instance, the maxilla, which is shifted forward, excludes positioning the apical part of the tongue behind the upper incisors, which may lead to undesirable dorsality[5]. The backward position of the maxilla enlarges the dentalizing fissure, which may lead to forward movements of the maxilla. Some of the shifts result from the faulty structure of speech apparatus, while some others – from actions that compensate for unfavorable conditions.



2. Vertically (upwards – downwards) with reference to one of several horizontal planes. One is demarcated by the immovable hard palate, which, together with the movable soft palate, separates the oral cavity from the nasal cavity , determining the orality/nasality of sounds[6], the next ones: the j a w (the maxilla approaches it or moves away from it, differentiating between sounds: dentalized, for instance: [sz] and non-dentalized, e.g. [l][7]), the oral cavity floor (sounds with higher/lower position of the tongue), vocal ligaments (sounds requiring rising the larynx above the respiratory position), the tongue bone (sounds requiring rising/lowering the tongue bone). The translocation of movable organs in relation to the static ones takes place on the whole length of the vocal channel , and the organs cooperate with one another – a specific act of one organ in one place automatically affects the formation of space in another place, for instance, at "a" positioning of the tongue (low, posterior – less posterior than in "o") and the lowered position of the maxilla, the throat channel is narrow, and

[5] This is confirmed by study results: "Dorsality occurs significantly more often in persons with forward malocclusion (80%) than in those with open occlusion (50%), or with backward malocclusion (23%)" [Konopska 2006, 89–90].

[6] The tightness of this barrier is especially broken by the cleft palate that enforces a different strategy of differentiating phoneme features in speech, not only with regard to orality/nasality [see:. Pluta-Wojciechowska 2006].

[7] The maxilla moves in various directions, depending on the act. "While opening the mouth hinge, movements take place between the mandibular condyle and the mandibular disc, with simultaneous forward sliding movement of the mandibular disc and mandibular condyle under the articular tuberculum. Slight movements of the mandible, e.g. during speaking, are merely hinge movements between the mandibular condyle and mandibular disc. As there is a strong adhesion of the disc to the mandible, the hinge and sliding movements take place in separate intervals (floors) of the joint" [MacKinnon, Morris 1997, 62]. Transverse and anterior-posterior movements of the jaw are not justified by the needs of articulation, and lowering or rising of the maxilla towards the jaw is justified or not, depending on the phoneme and co-articulation vicinity.

at the ”i” position of the tongue (high, anterior) and the maxilla raised towards the jaw , the throat channel is broad [Fig. 1] (characterization of the “a” , “i” positions of the tongue, see: Rocławski 2001).

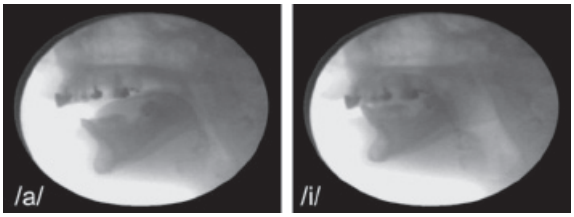


Fig. 1. Correlation of tongue and maxilla movements in the realization of phonemes /a/ and /i/ in isolation

Source: author’s own in cooperation with dr V. Posio (a video X-ray recording)

Certain anomalies of the pronunciation apparatus exclude a priori the correct articulatory position of the organs upwards-forwards. For example, it is impossible to bring the maxilla towards the jaw in the anterior segment in accomplishing dentalized phonemes in anterior open occlusion [see: Konopska 2006], or raise the anterior part of the tongue towards the gingival folds at the lowered maxilla in the realizations of alveolar, non-dentalized phonemes with significant ankyloglossia (tongue-tie) [Ostapiuk 2005].

3. Horizontally (right-left) with reference to the sagittal horizontal plane, dividing the tongue, oral cavity floor, the hard and soft palate, jaw and maxilla, nasal cavity and larynx into mutually symmetrical halves: right and left. In correct realizations of phonemes the contact (aperture or approximation) between the particular organs – the lower and upper lip (bilabial sounds), lower lip and upper incisors (labiodental sounds), tongue and teeth, gums or palate (dental, alveolar, i-sounds, posterolingual), jaw and mandible (dentalized/non-dentalized sounds), right and left vocal ligament (voiced/voiceless sounds) – takes place in the middle line. The gingivolingual sulcus (the sulcus on the tongue dorsum) , palatine raphe, lingual frenulum, the middle line between the upper and lower incisors, nasal septum, as well as the rima glottidis are then in one plane and the shape of particular organs is symmetrical towards it.

A SOUND WITH REFERENCE TO THE VERTICAL SAGITTAL PLANE (RIGHT-LEFT DIRECTION)

In this work I focus on assessing the realization of several Polish phonemes with reference to the sagittal vertical plane. In certain individual realizations of phonemes, the positions and movements of organs on the right and left of that

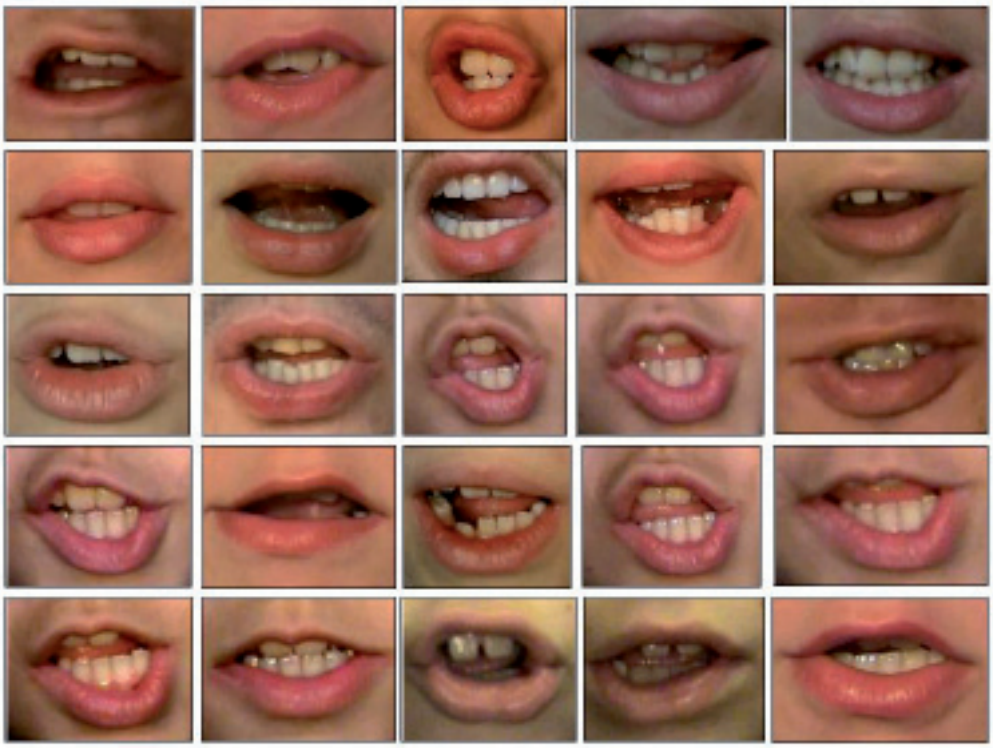


Fig. 2. Asymmetry of lips, tongue and mandible in speech

Source: author's own (a videophone recording)

plane are not symmetrical[8]. In direct examination it is easy to assess the symmetry of organs which are clearly visible during sound formation: the easiest – lips, then mandible, more difficult – anterior part of the tongue[9] [Fig.. 1], even more difficult

[8] There is a well-known result of the experiment in which two halves (left or right) were artificially combined, showing the natural symmetry of human faces and thereby demonstrating that we are under the illusion when we see full symmetry in somewhat asymmetrical shapes. The articulatory symmetry in question (that of lips, tongue and mandible) cannot be associated with the (hidden) asymmetrical structure of the organs: the lack of symmetry in organ movements while producing sounds attracts attention because it differs from the symmetry of the organs at rest position. The two asymmetries can co-occur (for example articulatory asymmetry in persons with transverse malocclusion).

[9] The assessment of tongue symmetry, position and movements requires at least minimum lowering of the mandible , that is why it is easier to assess the realizations of non-dentalized phonemes, e.g. /l/, /r/ (the mandible is away from the jaw) than of dentalized phonemes (the mandible approaches the jaw). Lacking teeth make the task easier, so the teeth replacement period in children is favorable for assessing tongue movements, as well as – contrary to appearances – to start speech therapy, because seeking the appropriate tongue position, e.g. for [sz, ż, cz, dż] sounds can be easier to control visually and correct.

– further parts of the tongue. The assessment of other organs, situated deeper, for instance the larynx, is not possible at all in direct logopedic observation[10].

Asymmetry of lips, tongue, and mandible is not a phonemically oppositional feature in relation to symmetry; thus, the very breaching of symmetry (even a significant one) does not lead to the sound accomplishment in a different phonemic class, which makes the asymmetry – especially when it occurs among other, more clearly visible imperfections – easy to overlook (or ignore). Noticing asymmetry makes us face the question: why does it happen?

TONGUE ASYMMETRY

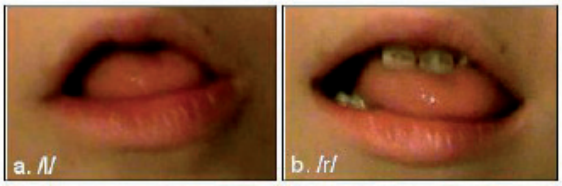


Fig. 3 Extra-phonetic realization of the /l/ phoneme in the word /lody/ and extra-phonemic realization of the /r/ phoneme /r/ in the word /rama/ in a 4-year-old girl

Source: author's own (a videophone recording)

In Figure 3 I present the realizations of phonemes /l/ and /r/ by a 4-year-old girl, where, besides tongue asymmetry, other undesirable features occur. The realization of phoneme /l/ [Fig. 3 a] in auditory assessment can even be easily considered as correct ("only" a slight difference in the tone), although in visual assessment it significantly diverges from the arrangement of [l] sound – the tongue is placed dismedially and protruding between the dental arches. Achieving the lateral air flow in this abnormal arrangement is possible owing to the dorsum of the tongue, which, when rising, effectively blocks the medial air flow.

The tone of lateral sound [l], produced by the correctly positioned tongue (broadly and symmetrically distributed, raised behind the upper teeth) [Fig. 3] is different than the tone of lateral sounds ([l_1], [l_2], [l_3] etc.) produced by the non-symmetrically positioned tongue, but the tone differences are subtle; consequently, they are easily omitted, especially because they do not play any role in the system of phonemes (/l/ is the only lateral phoneme) [Ostapiuk 1998, 2006]. The realization of phoneme /r/ [Fig. 3 b] also lacks many desirable features – lack of vibrations predominates in the auditory assessment (we hear a sound of radically different tone from the phonemic class of /l/), in the visual assessment – no apical tilting of the tongue (tongue positioned dismedially and protruding between the

[10] That is why assessing the function of certain speech organs exceeds the competence of a speech therapist. The insight into the position and movement of these organs during sound formation is possible owing to the application of special apparatus by a physician (inter alia by a phoniatrist).

dental arches). In the set of described symptoms the dismediality in the tongue position may seem of secondary importance. Is it really so?

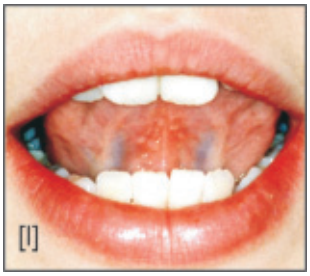


Fig. 4 Realization of the /l/ phoneme in /al/ sequence

Source: author's own (a videophone recording)

Figures 5 and 6 show vibrating realizations of phoneme /r/ by a 30-year-old man, one – in the word [rama] repeated at request (0.56 sec.[11]), and the other – intentionally performed in isolation with prolongation (0.96 sec.) and the slightly lowered maxilla.

In the auditory assessment, both the vibrating sound in the word [rama], and the prolonged vibrating sound in isolation, can be considered as "almost correct". In both of them the front of the left-shifted tongue is raised: the apex (in the figures marked with a circle) is near the edge of the left upper lateral incisor (it moves on its whole width), the mandible is slightly lowered (more in isolation)[12], and the right edge of the tongue vibrates (which is more visible in the realization intentionally prolonged for the needs of the study).

[11] The total duration of [rama] I established on auditory-visual basis from a videophone recording. B. Rocławski [1986] measured the duration of 66 words recorded on three times on a magnetic band, obtaining for the word *rama* the results ranging from 0,737 to 0,674 sec. [p. 207]. The measurement result depends both on the measured phenomena (speaking pace normal, fast), and on the measurement tool (in my measurements the restriction of segmenting the analyzed material is 0.08 sec. – program Windows Movie Maker), but also upon the decision of researcher determining the beginning and end of the measured phenomenon. This decision is more difficult at demarcating the border between one and the other sound in an articulation series, which is pointed out by B. Rocławski with reference to sound material: "Hearing sound duration is much more difficult than hearing the duration of words. Sometimes the borders of sounds are difficult to establish. We can observe the merging of sounds and transitory zones", (emphasis mine-B O.) [p. 210]. The simultaneous visual analysis makes the task complicated, for not only tones merge, but also images, and the borders between what we hear and what we see do not coincide, for instance the auditory impression, accompanying fragment 9. of the image in figure 13. contains both the ending of /r/, and the beginning of /ł/, which I record as /r…ł/). As B. Rocławski says, the acoustic duration "can be shorter or equal to the articulatory duration of the sound. The articulatory duration of the sound is established during observation of the articulators' work. We know that certain kinds of articulation behavior do not produce the voice wave. The duration of articulation is longer than acoustic duration in the case of voiceless plosive sounds (consonants) (…) and frictional sounds (…). The movements that prepare for articulation of other sounds also sometimes are not accompanied by an acoustic wave" [Rocławski, 209; see also: Wierzchowska 1971,. 210 and next].

[12] The measurements of distance between the secant plane of the lower and upper incisors allowed us to establish that lowering the mandible in the realization of phoneme /r/ in the word /rama/ constitutes 14%, and in isolation 19% of the same distance measured at performing a single (non-articulatory) movement of the tongue raising with the simultaneous maximal lowering of the mandible [Fig. 7.b].

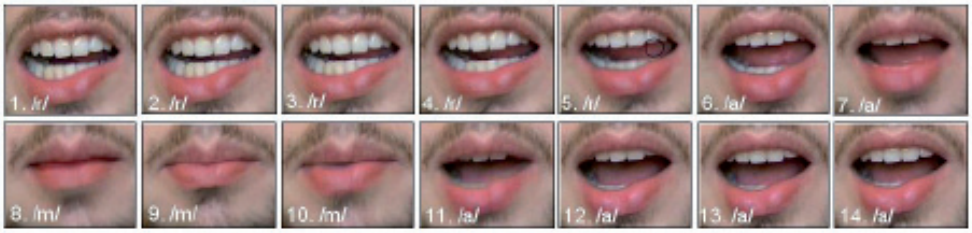


Fig. 5. Asymmetry of tongue, lips and maxilla in the realization of the phoneme sequence /rama/ by a 30-year-old man (frame after frame every 0.08 sec. in extended time from 0.56 to 1.12 sec.)

Source: author's own (a videophone recording)

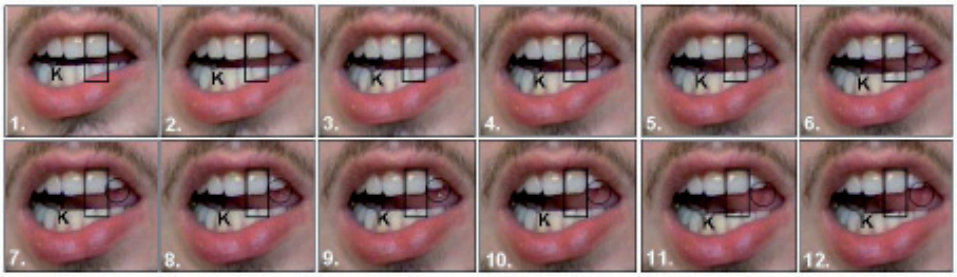


Fig. 6. Prolonged realization of the /r/ phoneme in isolation by a 30-year-old man (0.96 sec., frame after frame every 0.08 sec). The rectangle on the medial left incisor of the jaw allows us to observe changes in the position of mandible, lower lip and tongue (apex marked with a circle). Letter K denotes the right the right, lower cuspid tooth.

Source: author's own (a videophone recording)

Together with the tongue, the mandible shifts left (almost by the width of the lower incisor) [Fig. 6], and shifting of the tongue and mandible is accompanied by asymmetrical positioning of lips – the mouth slit is broader on the opposite (right) side. The examinee feels inconvenience in pronunciation (that is why he had seen a speech therapist). As can be seen, producing a vibrating sound (sounding – let us recall –only slightly different) at the dismedial position of the tongue is not impossible, yet troublesome for the speaker. Why does the examinee, when realizing the phoneme /r/ shift his tongue? Its m o b i li ty cannot be denied, if in this – as it seems - "acrobatic" way – he achieves the vibrations.

Below, for comparison, I present an incorrect realization of the phoneme sequence /rama/ performed by a 4-year-old girl (extra-phonemic realization of phoneme /r/ makes us hear [lama]) [Fig. 7]. We should observe that the times of both performances are completely different (0.56 sec. and 1.28 sec.), which also seems

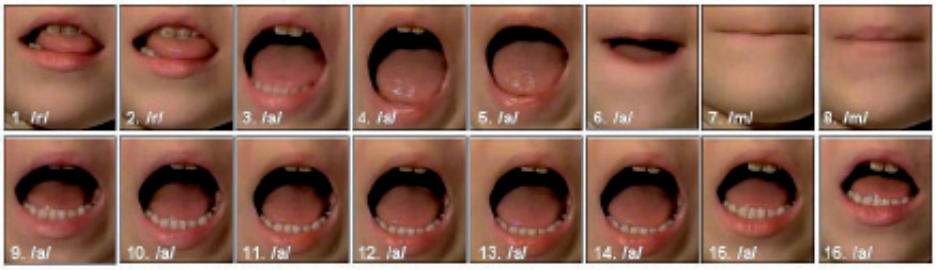


Fig. 7. Realization of phoneme sequence /rama/ by a 4-year-old girl (1.28 sec., frame after frame every 0.08 sec.).

Source: author's own (a videophone recording)

to be determined by different pronunciation styles (the man repeats the word neutrally, and the girl – with emphasis), and in each of them – different proportions of particular sounds' duration, e.g. the word-final /a/ takes 50% (girl) or 28,6% (man) of the whole and the word-initial /r/ –12.5% (girl) or 35.7% (man).

What connects the realizations of phoneme /r/ by a 4-year-old girl [Fig. 3.b] and by a 30year-old man [Fig. 5, 6]? Examining tongue mobility allows us to discover that both these persons are not fully free to raise their tongues vertically, which is caused by the lingual frenulum – in one case significantly [Fig. 8 b], in the other only slightly [Fig. 8 a] shortened [tongue mobility assessment in ankyloglossia according to Ostapiuk 2005]. During rising of the tongue behind the upper incisors, the f r e n u l u m becomes very tense and arrests the tongue before the goal is achieved. Persistence in overcoming the resistance of the tense frenulum does not bring the desirable effect, but it brings undesirable results: pain (sometimes even disruption of the frenulum can happen). We can say that the tongue is tilted, but because of a mechanical obstacle it cannot be fully tilted[13] [Ostapiuk 2005].

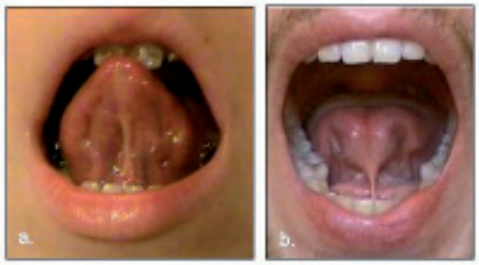


Fig. 8. Slightly (a) and significantly (b) shortened tongue frenulum in raising the tongue behind the upper teeth

Source: author's own (a videophone recording)

As we can see, language users, aiming at the realization of phoneme /r/ look for a shorter way to achieve their goal, by moving the tongue to the side. Another sound effect of this strategy in both the discussed cases – reverse, incidentally, in relation to

[13] The faulty mechanism described above obviously does not include other restrictions in tongue tilting, e.g. neurological ones, though – which is worth noticing – it can coexist with other ones .

the degree of frenulum shortening: an imperfect, but vibrating sound at a significantly shortened frenulum and the lateral consonant instead of the vibrating one at only a slightly shortened frenulum – can be explained by their different age of the two persons (and maybe other, unnoticed factors).

According to the interpretation, which is commonly applied in logopedics, the above-described realization of phoneme /r/ by a 4-year-old girl cannot be treated (substitution in the period of articulation development) [Kania 1975, Ostapiuk 2002]. If, however, we connect this substitution with the short frenulum, which disturbs the child with medial tongue tilting, we cannot expect that he/she will naturally "grow up" to the vibrating consonant. Quite contrary, we can expect that if – in spite of the obstacle – the child finds another, substitute way and, finally, a vibrating realization of phoneme /r/ is be obtained, it will be in a certain faulty form – for instance dismedial (like the 30-year-old man with the substantially shortened frenulum [Fig. 5, 6], or the 20-year- old woman with the slightly shortened frenulum [Fig. 9][14]). The way from non-vibrating (extra-phonemic) to vibrating (phonemic), but dismedial (extra-phonetic) realization of phoneme /r/cannot be regarded as correct. Should we then wait with the therapy of the 4-year-old girl until she achieves the abnormal vibration (deformation) or she does not achieve it until she is 6–7 years old (remaining at substitution) and will undergo therapy in accordance with the linguistic-register (age) criterion commonly applied in speech therapy , or – applying the etiological criterion – shall we undertake the corrective measures straight away, disregarding the form of realization and her age [Ostapiuk 2002]?

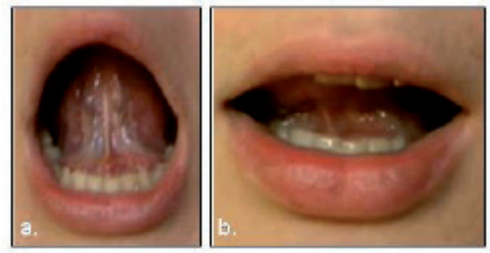


Fig. 9 Asymmetry of the tongue in the vibrating realization of he /r/ phoneme, in isolation (b) by a 20-year-old woman with the slightly shortened tongue frenulum (a)

Source: author's own (a videophone recording)

TONGUE AND LIP MOVEMENTS IN ANKYLOGLOSSIA AND THE ARTICULATORY POLYMORPHISM

In persons with a short lingual frenulum I also record a very significant differentiation of lipwork in the realizations, not only of consonant, but also of vowel phonemes.

[14] The most surprising, asymmetrically formed sound that I have encountered in my practice as a speech therapist, was the vibrating realization of phoneme /r/ produced by the lateral edge of the anterior part of the tongue with the apex at the upper sixth tooth (in an adult with a short lingual frenulum).

In Figure 10. I present completely different images of phoneme /o/ realizations (in various contexts) in three subjects. In the auditory assessment, the realizations of /o/ with lips moved forward (Subject 3.) or flat (Subject 1.), symmetrical (Subject 1.) or asymmetrical: distinctly (Subject 2.) or discretely (Subject 3.), with mandible moved away (Subject 2. and 3.), or close to the jaw (Subject 1.), with tongue moved forward: "bulging" (Subject 3.), or flat (Subject 2.), seem to be equally good, especially if we refer to the idea of polymorphism, the essence of which is the conviction that "t h e s a m e s o u n d , e s p e c i a l l y t h e s a m e v o w e l c a n b e p r o n o u n c e d i n m o r e t h a n o n e w a y" [Gołąb, Heinz, Polański 1970, 432, Dłuska 1983; emphasis mine-B.O.]. The observation of how the lips and tongue cooperate "when vowels are pronounced by different persons" [Styczek 1979, 113] convinced the researchers that "The oral cavity resonator can be extended by moving the lips forward **o r** m o v i n g t h e t o n g u e b a c k w a r d s – the acoustic effect remains the same". In the idea of polymorphism, without going into details about the cause of different arrangements, it is assumed that "In certain persons lips work strong during pronunciation of vowels, whereas in others the mobility of lips is small, and the tongue works more" [Styczek 1979, 113; (emphasis mine-B. O.), see also: Dłuska 1983]. Polymorphism was earlier observed in producing vowels (in two persons) in X-ray examinations by H. Koneczna [Koneczna, Zawadowski 1951]: "Subject One pronounces them with very insignificant changes in the arrangement of lips, whereas Subject Two demonstrates much greater mobility of the mouth. This "laziness" of the lips is compensated for by Subject One, by the increased work of the tongue" [p. 8].

Is the "acoustic effect "of various arrangements presented in figure 10 really the same? Can each of these sounds be included into the class of model a standard sounds (as a model sound [o] or its combination variant [o^1], [o^2], [o^3], [o^4], etc. [B. Rocławski2001, 212]), or should it be counted into the class of faulty sounds within this phoneme ([o_1], [o_2], [o_3], [o_4] etc.)[15]? What auditory satisfaction can provide, is only the assurance that at various arrangements of lips and tongue a sound can be produced with the features of phoneme /o/. The question that remains unanswered is: why does such a differentiation occur? In figure 11, I present the examination of non-articulatory tongue mobility, which reveals that

[15] B. Rocławski emphasizes that the abundance of phonetic phenomena creates needs for special phonetic signs, which are especially significant in logopedics. He himself suggests that sounds, well described in terms of articulation and acoustics, should be marked as follows: with a letter – basic sounds (e.g. [r]), with a letter and the subsequent number written next to the letter in superscript – non-basic sounds, accepted by the orthophonic standard (e.g. [r^1]), and with a letter and number in subscript – non-basic sounds, not accepted by the orthophonic standard (e.g. [r_1]) (or the other way round) [Rocławski 2001,166]. This is the way of recording that I use.

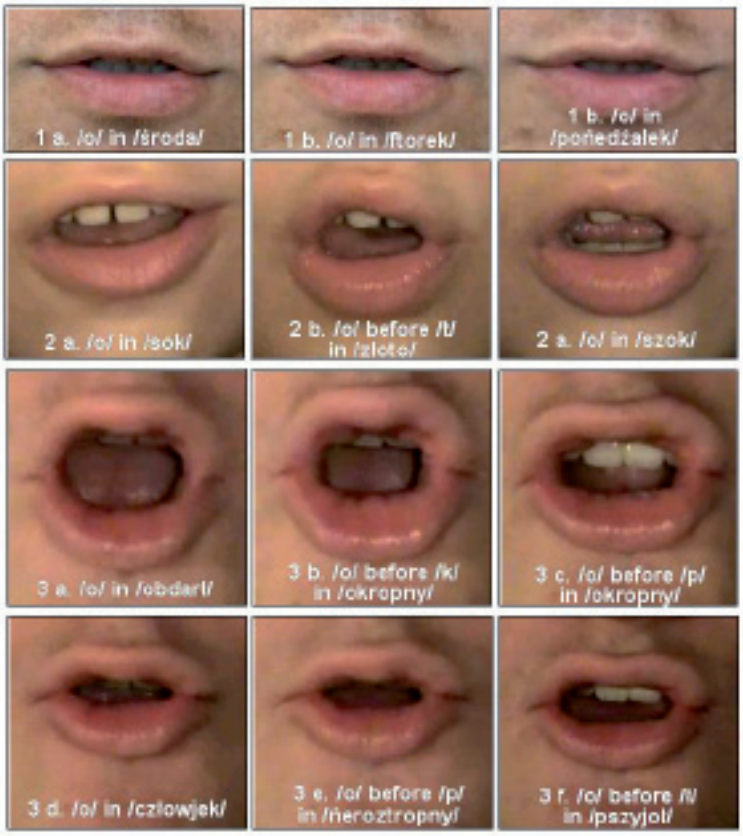


Fig. 10. Labiograms of the phoneme /o/ realizations in the speech of three people

Source: author's own (a videophone recording)

in each case we deal with the limited freedom of tongue movements: the restriction is significant (Subject 1.), average (medium) (Subject 3.), slight (Subject 2.) [assessment according to Ostapiuk 2005]. Is the "l a z y " or i n c r e a s e d , even a s y m m e t r i c a l w o r k o f t h e l i p s i n r e a l i z a t i o n s o f p h o n e m e /o/ presented in figure 10., the expression of polymorphous freedom, or the result of limited tongue mobility in ankyloglossia?

Faulty realizations of vowel phonemes are seldom distinguished in literature, because vowel defects are treated as "only" carelessness, sloppiness, and negligence of articulation not r e l a t e d to the s t r u c t u r e of the a r t i c u l a t i o n a p p a r a t u s [see: Ostapiuk, Konopska 2006], and even as m a s k i n g of the s p e e c h defect, which is suggested by B. Wierzchowska [1971], as she discussed the disorders in the pronunciation of oral vowels: "It sometimes happens that indistinct way of speaking is aimed at c o v e r i n g u p some speech defect, e.g.

lisping, which the speaker is ashamed of" [p. 131; emphasis mine - B. O.]. The realizations of vowel phonemes very rarely attract the attention of speech therapists, in fact only when they exceed the limits of a phoneme[16], probably also because the "damage" resulting from the defective structure or work of the organs in speech apparatus is smaller in vowels than in consonants. Are there any grounds for thinking that incorrect realizations of consonant phonemes can be accompanied by exemplary realizations of vowel phonemes, or the other way round, that faulty vowels can be accompanied by correct consonants. Or quite contrary – considering the fact that both these types of sounds are produced in the same speech apparatus, we can assume, even a priori, that the imperfection of speech apparatus adversely affects all the sounds produced in it, regardless of its different participation in forming a syllable. The "damage" is greater, indeed – and at the same time it is more perceptible – in the realizations of consonants than those of vowels. We can even perversely say that faulty consonants mask the occurrence of faulty vowels (in the eyes and ears of the observer).

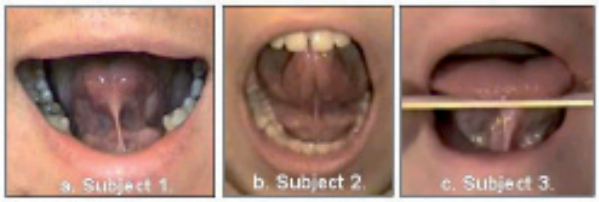


Fig. 11 Tongue mobility restriction in subjects from Fig. 10

Source: author's own (a videophone recording)

If two different articulation arrangements lead to the same sound, then the logopedist should recognize both arrangements as correct; if, however two different arrangements lead to two different sounds, then the speech therapist should know what is the difference between the arrangement leading to a sound with normal tone and the arrangement leading to a sound with almost normal tone. Then he should aim at establishing why the untypical arrangement is formed.

How to refer to a pronunciation, where sounds with definitely different tones (for instance: [r_1]) co-occur with "almost normal" sounds (for instance [l_1], [o_1])? Should only the first ones be regarded as faulty, and the second ones as

[16] "In Polish, the vowels are not very frequently incorrectly pronounced (…). However, in spite of this fact, sometimes incorrect vowel articulations occur, involving, first of all, substitution. (…) We also encounter articulations, which are **not definitely incorrect but** their pronunciation is **careless**, with minor application of the lips, the result of which are not very comprehensible utterances" [Sołtys-Chmielowicz 2008,. 127; emphasis mine – B. O.; see as well: Skorek 2000, 37–39].

"polymorphously" correct? Or the opposite – considering the economics of actions undertaken in speech therapy and its effectiveness – the sounds with "almost normal" tone, should also be diligently studied with reference to anatomical conditions?

Can therefore vowel imperfections be ignored, or quite contrary – although they are slight – should they also be carefully studied, also in consideration of consonants? My experience shows that undesirable features in vowels (a different arrangement of the tongue, lips, and mandible) accompany the undesirable features in consonants, and that imperfect vowels are not "ordinary" carelessness, and negligence of articulation, but – together with imperfect consonants – they produce a speech defect.

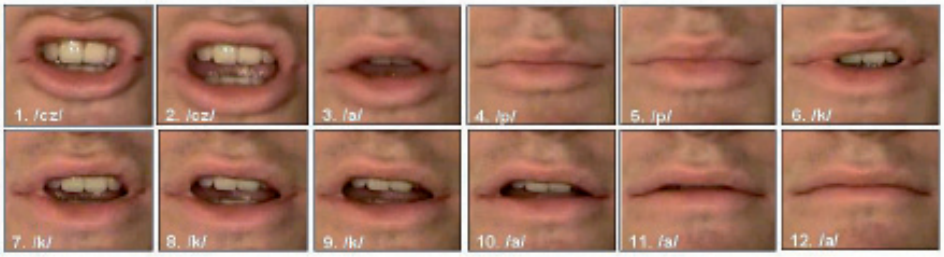


Fig. 12. Asymmetry of lips in the phoneme sequence /czapka/. Subject 3 (frame after frame every 0.08 sec., in extended time from 0.48 to 96 sec.)

Source: author's own (a videophone recording)

In figures 12.-15. I present the examples of accomplishing a few consonant and vowel phonemes in the speech of Subject 3. (a 19-year-old man with a moderately shortened lingual frenulum, who pays a lot of attention to pronunciation quality and, with visible diligence, aims at as good results as possible). The broadening of the mouth slit, (especially active in this case) is either left- or right-side for particular phonemes, and sometimes, as in the realization of /k/, variable: once to the left [Fig. 12.6-7], and after a while, in the same [Fig. 12.8-9] and in a different sound [Fig. 13.12-13] to the right.

No realization exceeds the appropriate phonemic field, consequently, speech is understandable, but in the tone of particular sounds (in the auditory assessment) we find features that prevent us from regarding them as exemplary. The difference in tone is greater (and can be heard more clearly) in realizing certain consonant phonemes, for instance /r/ (disvibrating sounds) than in others, for instance /l/ (lateral, but dental sounds). The auditory assessment of how the consonant phoneme realizations sound is practically impossible.

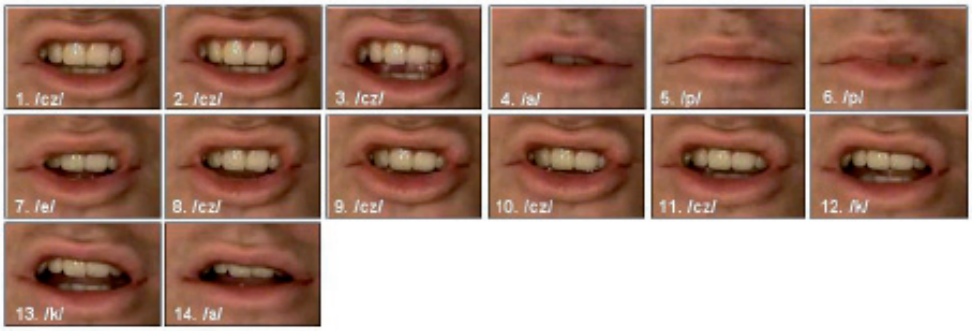


Fig. 13. Asymmetry of lips in the realization of the phoneme sequence /czapeczka/. Subject 3 (frame after frame every 0.08 sec., in extended time from 0.56 to 1.12 sec.).

Source: author's own (a videophone recording)

Also the phonetic vicinity is of importance, as well as the phonemic structure of the word, for example the undesirable palatality is discrete in word initial [cz_1] in /czapka/ [Fig. 12], slightly greater in [cz_2] and [cz_3] [Fig. 13] in /czapeczka/, and still greater in [cz_4], [cz_5] in utterances like: /tszy czerwone czapeczki/.

During every realization of phoneme /cz/ (from 0.16 to 0.32 sec.) the lips are in a more or less asymmetrical arrangement, protruding (the upper lip strongly turned up and raised), the lower dental arch not exactly close to the jaw, and the tongue - which is visible when the maxilla is slightly lowered - does not rise fully behind the upper teeth, but contacts the palatal surface of upper incisors by the edge of its anterior part, its lower surface is not broadly, freely distributed, but slightly bulging [Fig. 11, 12].

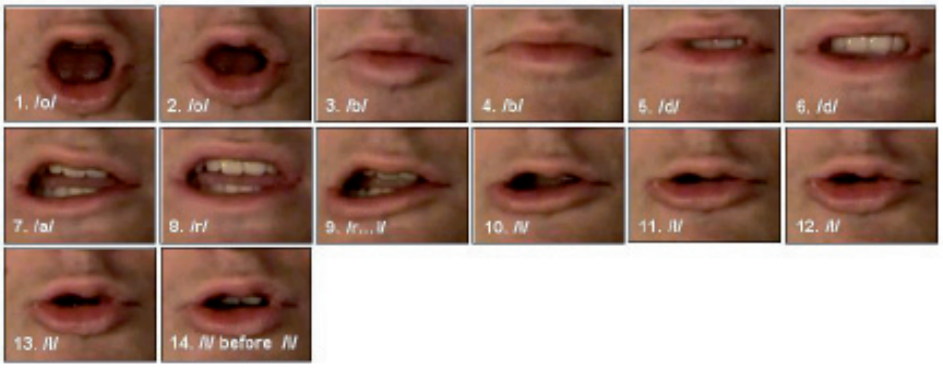


Fig. 14. Asymmetry of lips in the realization of the phoneme sequence /obdarł/ – Subject 3 (frame after frame every 0.08 sec. in extended time from 0.56 to 1.12 sec.)

Source: author's own (a videophone recording)

Let us look at the arrangement of lips in the realization of the difficult phoneme sequence /obdarł/ in figure 14. A discrete lack of symmetry is noticeable already at /b/, slightly greater at /d/, still greater at /a/ before /r/, and especially big at passing from /r/ to /ł/ and in the whole course of (the longest lasting) realization of /ł/ (before the word initial /l/ of the next word). The broadening of the mouth slit "moves" from left to right side during the subsequent segments of utterance.

In simpler phonemic sequences, e.g. /lef/ the lip asymmetry is smaller, but here it is also visible that it coexists with – also small – abnormalities of the tongue position: shifting left (at /l/, as well as at /e/), incomplete rising towards the gums behind the upper incisors and narrowing the anterior part (at /l/), moving the oral cavity forward (at /l/ and /e/).

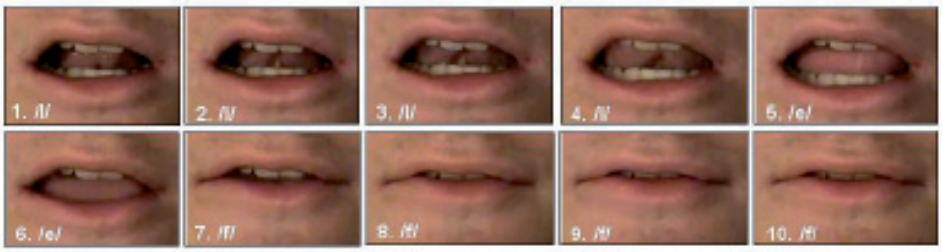


Fig. 15. Asymmetry of lips in the realization of the phoneme sequence /lef/ – Subject 3 (frame after frame every 0.08 sec in extended time from 0.40 to 0.80 sec.).

Source: author's own (a videophone recording)

It is similar in the realizations of simple sequences /ara/, /rak/, /al/, /ala/, /la/ and /r/ in isolation, presented in figure 16. The mass of the tongue is slightly shifted f o r w a r d – in /a/ the apex touches the tongue surfaces of the lower incisors (as in the description by B. Wierzchowska [1980, 54]). The edge line of the anterior part of the tongue is near the edges of lower incisors, or coincides with it, and sometimes it is even a little higher (for instance the first images of the word initial /a/ in /al/, /ala/).

In sequences /al/, /ala/, /ara/ the tongue, n a r r o w e d in the anterior part (which makes it longer at the same time), rises from this very position – without moving backwards – to /l/ or /r/, encountering, however, not the gums, but the teeth, and then it moves slightly backwards towards the gums (and also moves slightly left) and again moves to the teeth, its lower surface is slightly bulging, which prompts us to suppose that on the dorsum of the tongue a shallow hollow might be formed. In the reverse passage – from /l/, /r/ to /a/ – the arrangements are similar.

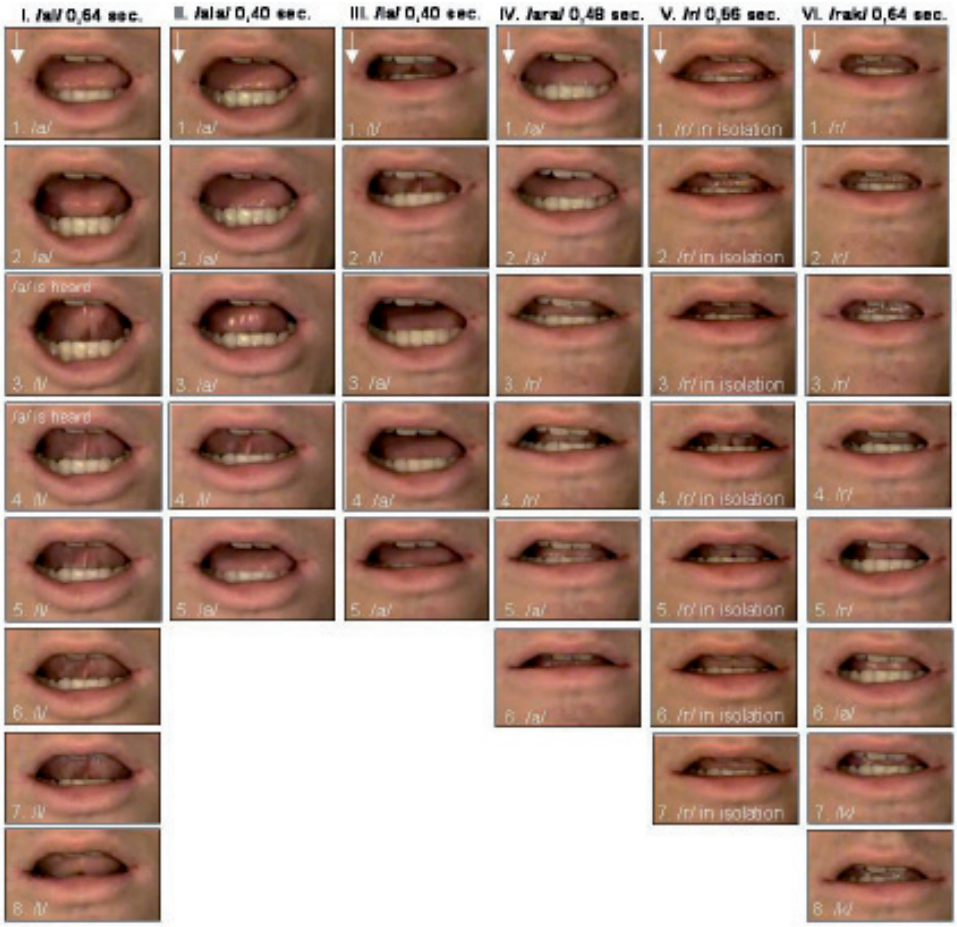


Fig. 16. Realization of simple phoneme sequences – Subject 3.

Source: author's own (a videophone recording)

Asymmetry of the lips is greater in the realization of phonemes that require raising the anterior part of the tongue behind the upper incisors (/r/, /l/, /cz/) or high positioning of the posterior part of the tongue[17] (/k/, /ł/), and the greatest – when some of them are in each other's neighborhood (for instance /rł/).

[17] Such an arrangement is what B. Rocławski [2001] briefly calls u-arrangement [p. 214, 230, et seq.].

MOVEMENTS OF THE TONGUE AND LIPS VERSUS THE LABIO-VELAR COMPLEX

The participation of lips in realizing labial consonant phonemes is obvious – the sounds [p, b] are produced owing to the explosion which happens "at the moment of abrupt dilation of the lips" [Rocławski 2001, 289], the sounds [f, w] – "owing to the slit formed by the upper teeth and lower lip" [p. 262]. In the literature lip movement descriptions are also found in the characterizations of non-labial sounds, but they are rare and scarce. It is emphasized that the arrangement of lips is different in isolation (at [sz, ż, cz, dż] "lips are protruded, rounded", at [ś, ź, ć, dź] the corners of the mouth are parted and the lips slightly protruding, at [s, z, c, dz] the mouth corners are parted), and it is different in context – the arrangement of lips in the above-mentioned sounds and other sounds: non-labial ([t, d, n, ń, k, g, ch, r, l] and labial [p, b, m, f, w]) "is affected by the neighboring sounds " and they determine whether "the lips move forward" or "assume the flat position" [Rocławski 2001: 203–294; see also: Wierzchowska 1980: 39].

The association the shape of lips with the tongue position is directly emphasized with of reference to vowels. Thus – in Polish – the "i", i.e. the high, anterior tongue position is connected with the flat position of lips (delabial-palatal complex) [Rocławski 2001, 207], and the "u", i.e. "the posterior and high arrangement of tongue mass is accompanied by strong forward movement and rounding of lips" (the labio-velar complex)[18] [Rocławski 2001, 214].

The relationship between the lip arrangement and tongue movements in consonants is seldom spoken of. B. Rocławski [2001], while characterizing the post-alveolar phonemes, states: "when uttering sounds constituting post-alveolar phonemes, lips tend to move forward. This results from the necessity of shaping the resonators appropriately for these consonants. Besides, this may be connected with the slight backward shifting of the tongue mass in relation to the hissing sounds" [p. 274–275; my emphasis - B. O.]. The author, referring to the connection of the tongue with lips in vowels, emphasizes: "This articulatory tendency is used while eliciting the consonant [sz]. We elicit [sz] by bringing our lips together. The arrangement of lips observed here resembles their arrangement in the labio-velar articulatory complex" [p. 275; my emphasis-B.O.]. The description of realization of the phoneme /ł/ reads: "The tongue, and especially the lips, change their position. Their movement takes place within the limits of the "u" arrangement" [p. 230]. "The dynamic 'u-ness'

[18] B. Wierzchowska [1980], while discussing labialization and delabialization with reference to the doming of the tongue at the front or at the back of oral cavity, uses the following words: "we speak about the so-called complex of articulation movements" [p. 46].

can be spoken of here"[19] [p. 227]. I also understand the remarks about the alveolar variant of phoneme /n/ as the expression of the connection between the tongue arrangement and the shape of lips, although the lips are not directly referred to here: "Most frequently the alveolar variant is said to occur before all the alveolar consonants. In my opinion, it also appears in the position before [u] and [o]" [p. 246].

For the logopedist the connection between the movement of lips and tongue in vowels is especially important. "For many years I have been telling logopedists/speech therapists that the k e y to c o n s o n a n t s a r e v o w e l s" – B. Rocławski says [2001: 275] and explains that "the f o r m a t i o n of a r t i c u l a t i o n c o m p l e x e s during v o w e l t r a i n i n g permits use of lips later t o c o n t r o l t h e t o n g u e w h i l e e l i c i t i n g c o n s o n a n t s" [Rocławski 2001, 275; emphasis mine-B.O.]. Therefore -as we read - "eliciting post alveolar consonants is well enhanced by the **labio-velar complex correctly formed** in vowels as well as in the vicinity of the vowel [u] [Rocławski 2001 p. 275].

STRATEGY FOR SUPPORTING THE TONGUE BY LIPS IN THERAPY VIS-À-VIS THE LABIO-VELAR COMPLEX

The presented material allows us to talk about the correct labio-velar complex, in which we observe f r e e **c o o p e r a t i o n** o f b o t h t h e o r g a n s : "the lips move forward **and** the tongue moves backwards": and about the incorrect one, where o n e o r g a n i s **supported** by the o t h e r: "the lips move forward **or** the tongue goes backwards". The concept of polymorphism, which allows us to regard sounds which are produced "in a slightly different way" as "the same" as the correct ones ("The oral cavity resonator can be extended by moving the lips forward, or moving the tongue backwards – the acoustic effect remains the same" [Styczek 1979, 113; my emphasis-B.O.]) distracts attention from the difference in both the arrangements.

In speech therapy the recommendation to support the work of the tongue with additional work of the lips (alluding to the labio-velar complex[20]) and the certainty

[19] The subsequent edition of B. Rocławski's "Podstawy wiedzy o języku polskim dla glottodydaktyków pedagogów psychologów i logopedów" (2005) contains a mistake, which is absent from previous editions, namely: on page 227, instead of the roentgenogram with the "u" arrangement, there is a roentgenogram with the "i" arrangement (repeated from the previous page). The above-quoted sentence: "Here we can speak about the dynamic "u"-ness is, in turn, absent from the 2001 edition, so I am quoting it after the later edition [2005: 227].

[20] A. Sołtys-Chmielowicz [2008] writes: "Each forward movement of the tongue causes the backward movement of the lip angles, i.e. their flattening, backward movement of the tongue during pronunciation of vowels means protruding and rounding of the lips at the same time" [p. 128], 'consciously working with our lips we try to activate the reverse mechanism – adjusting the arrangement of the tongue to the shape of lips", 'a child articulates (repeating after the speech therapist) all the vowels in different orders, overemphasizing the work of lips " [p. 128; emphasis mine-B. O.]

that "i n s uf f i c i e n t work of the t o n g u e **can be easily replaced** by more effective w o r k of the l i p s " [Sołtys-Chmielowicz 2008, 128; my emphasis-B.O.]) a r e n o t a c c o m p a n i e d by the c o n c e r n about the l a b i o – v e l a r c o m p l e x in v o w e l s, though it is difficult to assume that an imperfect vowel [u_1], [u_2], [u_3], [u_4] etc. is an equally good aid in eliciting post-alveolar consonants like the vowel [u] with the correct labio-velar complex. When a patient with a short frenulum is told to protrude the lips, simultaneously ignoring the restricted tongue mobility, then instead of the sound [sz] its apparent production is obtained (excessively protruding lips and underworked anteriolingual-alveolar fissure[21]), which, however, as it is still "better" than a hissing sound, is persistently retained in syllables, words with simple, and then more complicated phonemic structures, yet it cannot be… consolidated (then the patient hears: "too little exercising!") or it does become established, but in a faulty, (e.g. dorsal) form.

When we decide that the cooperation of lips and tongue in articulation is **correct** only when "the lips go forwards and the tongue goes backwards" (the labio-velar complex), and the cooperation of lips and tongue is **incorrect**, when "the lips protrude, but the tongue does not go backwards far enough" (polymorphism), then it is difficult to interpret the presented activity of lips as articulatory f r e e d o m (in specific anatomical conditions various configurations of positions and movements of organs are possible for a given sound). Considering the knowledge about the cooperation of tongue and lips, an untypical activity of lips can be perceived as the n e c e s s i t y resulting from restricted tongue movements (i n certain anatomical conditions the desirable configuration of organs producing a given sound cannot be obtained, therefore other configurations are produced and, in effect, slightly different sounds, similar, but not the same, e.g. [$o_{1, 2, 3...}$], [$a_{1, 2, 3...}$], [$l_{1, 2, 3...}$] etc.). The persons with ankyloglossia spontaneously and not consciously utilize o t h e r o r g a n s to c o m p e n s a t e for the i n s u f f i c i e n c i e s of the t o n g u e, among others, lips, but they only obtain as much as possible within the labio-velar assistance. More can be achieved through speech therapy. However, we should discard the naive hope that w i t h o u t r e m o v i n g the c a u s e of the l i m i t e d r a n g e of tongue m o v e m e n t s the r a n g e of i t s m o v e m e n t s c a n be i m p r o v e d [Ostapiuk 2005, 2006, 2008].

[21] A. Sołtys-Chmielowicz [2008] quotes the opinion of J. Liška, who related incorrect protrusion of lips to the compensation for inadequacies in tongue position (tongue too close to the teeth) [p. 103], but she still does not go into details about the reason for abnormal positioning of lips; she only warns the patients against it: "Next we train lip rounding, which, sometimes is not simple, because children make a "lip beak", whereas it should only be a slight forward movement of the lips and a slight rounding, like in the vowel "*o*" [p. 103; my emphasis – B. O.]. The principal question is: Why is sticking the lips out *not* simple on some occasions?"

ANKYLOGLOSSIA AND COMPENSATION STRATEGIES IN ANKYLOGLOSSIA VERSUS THE THREE-DIMENSIONAL CONFIGURATION OF ARTICULATORY ORGANS

Abnormal articulatory configurations of the articulatory organs that form in persons with ankyloglossia are directly or indirectly related to the restriction of vertical tongue movements. A short frenulum directly restricts the vertical tongue movements in its whole length , therefore it hinders not only raising the anterior part of the tongue towards the gingival folds (inter alia the phonemes /l/, /r/ /cz/), but also the medium part of the tongue towards the hard palate (inter alia phonemes: /ń/, /j/, /i/, /ś/) and the posterior part of the tongue towards the soft palate (inter alia /k/, /ł/, /u/). Different compensation strategies applied by persons with ankyloglossia allow them to eliminate the effects of restrictions in vertical tongue movements, but indirectly they lead to incorrect formation of the tongue mass in both horizontal directions (backward-forward, right-left), among others at the **expense of** symmetry. The strategy of tongue narrowing allows one to achieve its elongation, which minimizes the restrictions of vertical movement and offers a chance of reaching the goal with appropriate parts of the tongue (anterior, middle, posterior; and the goal could be: gingival folds, hard palate or soft palate), but at the **expense of** the tongue width or its medial position in the oral cavity, horizontally (right-left). The strategy of using some other part of the tongue (for instance the dorsum instead of its anterior part) or some other place in the oral cavity (for instance the teeth instead of the gingival folds) to produce explosion, friction, scraping, or vibration **thwarts** the correct contacts of the tongue in the horizontal anterior-posterior direction. The strategy of using another organ (for instance lips or mandible) to support the tongue also allow minimizing the effects of restricting vertical tongue movements, but at the same time it is the **source** of abnormal horizontal movements of the supporting organ (for instance asymmetry of lips) or its vertical movements (for instance moving the mandible towards the jaw). The strategy of the use of some other organ instead of the tongue (for example the uvula) leads to a completely different configuration of the organs.

In ankyloglossia, comprehensible speech can be produced, but it is not possible to achieve all the desirable effects in realizations of all phonemes. Depending on the phoneme, co-articulatory vicinity, the degree of frenulum shortening and the applied compensation strategies, various abnormal configurations of speech organs arise. The abnormalities concern one **or** more than one imperfection. A special abundance of possibilities and their

combinations can be observed in the realizations of phoneme /r/: the tongue is not raised sufficiently high (especially in the anterior, but also in its further parts), the anterior part of the tongue is excluded, and the further part of the dorsum rises towards the gums, or the tongue is absolutely excluded and its role in the formation of a vibration is taken over by another organ (e.g. the uvula), the tongue mass is not distributed broadly enough (the side edges of the tongue do not adhere to the molar teeth in the jaw), the tongue does not place itself medially in the oral cavity (the palatine raphe and the sulcus on the dorsum of the tongue, as well as the lingual frenulum are not in one plane, and the lower surface of the tongue on the right and left side of the lingual frenulum are not symmetrical), the maxilla assumes the dentalizing postion in relation to the jaw (this strategy is applied by Subject 1. in Figure 9) [Ostapiuk 2002a].

The significance of the problems in ankyloglossic dislalia is the insufficient work of the tongue and, strictly speaking, there is no other possibility, as the short frenulum (to a greater or smaller extent) blocks the movement [Ostapiuk 2005, 2006, 2008, 2011]. On the one hand, the use of lips (the mandible) in therapy, in the hope that this (unjustified) strategy will solve the tongue problem, causes astonishment, whereas on the other – because it yields effects to a certain extent – it is understandable why it is not accompanied by doubts. Especially, if we consider the phenomena that are still commonly present in logopedics: disregarding of the influence of a short lingual frenulum upon the quality of speech, the conviction about the effectiveness of treating ankyloglossic dislalia by a speech therapist without the surgical treatment of ankyloglossia, as well as unawareness of frequent occurrence of this anatomical defect [for more, see Ostapiuk 2005, 2006, 2008, 20011]. This is proven, among others, by the fact that a speech defect caused by a short lingual frenulum is not specified in the International Statistical Classification of Diseases and Health Problems (ICD-10). We should refer to the studies conducted by students the Postgraduate Logopedics and Language Didactics Course of the Szczecin University, where the subject of analysis is the connection between the quality of speech apparatus and (inter alia the lingual frenulum) and the quality of realization of the selected Polish consonant phonemes in different age groups. The results of these methodologically uniform, unpublished studies are to a significant extent similar[22] and confirm the adverse

[22] Divergences in the results of the quoted studies are small and result from different numbers of examinees (from 49 to 168 persons – a statistically less frequent phenomenon may not occur in a smaller group) and – first of all – from obvious doubts felt by the examiners, speech therapy junior research workers, who did use the same tool of lingual frenulum assessment, but it was only during the studies that they became skilful in using it. The same tool guarantees equal study results only when it is used in the same way – in examining simple tongue movements according to my suggestion [Ostapiuk 2005], the divergence in the tongue scope assessment can be determined by lack of

effect of ankyloglossia upon pronunciation. They also prove that ankyloglossia is a frequent phenomenon: it concerns ca. 70% of the population (more often it is in a mild form – ca. 38%, less frequently –medium – ca. 25%, and the least frequently -severe - ca. 5%) (I am giving the data on the basis of several studies covering a total of 708 examinees of 6-54 years old [Cytrynowicz, Krasuń 2004, Kozłowska, Warzoszczak 2004, Martyn 2004: Prządka, Kowalska 2004, Wizjan 2004, Wójcik 2004, Zakosztowicz 2004], which means that a speech therapist attempting to correct faulty pronunciation very often encounters ankyloglossic dislalia. If he disregards ankyloglossia and the meaning of its surgical treatment, he equally often condemns himself and, first of all, the patient, to failures in speech therapy. The results of these studies are also a contribution to establishing the effect of ankyloglossia upon the formation of occlusion.

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proficiency in achieving the maximum lowering of maxilla, then a slight restriction of movement can be qualified as lack of restriction, medium restriction –as slight, etc. The authors of the studies cited were aware of the signaled difficulties and *post factum* they emphasized that independent performance of the examinations was for them an important step on the way from theory to practice.

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