LEXICAL PRIMING IN CHILDREN WHO STUTTER AND CHILDREN WHO DO NOT STUTTER IN THE EXAMPLE OF THE EXPLAN DEVELOPMENT MODEL OF STUTTERING

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**ABSTRACT**

The EXPLAN theory explains the occurrence of speech disfluencies as being caused by incongruity of language planning and speech performance, but also by the characteristics of language structures themselves. According to the EXPLAN theory, the crucial feature of language structures is the distinction between word types, especially between function and content words, and the transition from the disfluent articulation of function words to the disfluent articulation of content words.

The aims of this study were to be determined within the framework of the EXPLAN model, the impact of two lexical priming conditions on language planning, measured by two priming effects: the priming effect on the articulation of content words (effect A) in the conditions of function- and content-word priming, and the priming effect on the articulation of function words (the effect B) in the conditions of function- and content-word priming. This study aims to answer the questions: Is there a difference between (a) the duration of articulation, and (b) the number of disfluencies on content and function words (effects A and B) in the condition of content-word priming (CW), compared to the condition of function-word priming (FW)? Is the intensity of effects A and B higher in children who stutter compared to children who do not stutter? The question of this study was also: Is there a difference in the duration of silent pauses preceding the articulation of content words (effect B) in the condition of content-word priming (CW), compared to the condition of function-word priming (FW)?

In this study, two more questions came up: Does the *Speech initiation time* (SIT) for the first word in the target sentence in both conditions (the conditions of content- and function-word priming) last longer in children who stutter than in children who do not stutter, and is there a difference in the intensity of the two lexical priming effects (effects A and B) between younger and older groups of children who stutter, as well as a difference between younger and older children who do not stutter. The experimental group in this study was comprised of 40 children who stutter, and the control group of 40 children who do not stutter. All children were aged 3 to 9. Each group of participants was divided into two subgroups: younger and older children.

The obtained data suggests the following: Hypotheses H1.1, H1.2, H2.1, H2.2 and H2.3 have been completely confirmed because the dependent variable *duration of articulation of content*.
words, and variable duration of function words indicates a shorter duration of content and function words after content-word priming than after function-word priming. Also, the dependent variable number of disfluencies on content and function words indicates that the number of disfluencies is lower in the condition of content-word priming than in the condition of function-word priming. The variable duration of silent pauses preceding the articulation of content words, indicates a shorter duration of silent pauses after content word priming than after function word priming.

This study did not confirm that children who stutter demonstrate a stronger priming effect in the variable duration of content words in the effect A and duration of function word in the effect B than children who do not stutter. But, children who stutter demonstrated a stronger priming effect in the variables number of content and function words disfluencies. Therefore Hypotheses H1.3 and H2.4 has been partially confirmed. The difference in speech initiation time (SIT) of the first word in the target sentence in both of the above-mentioned priming conditions, between children who stutter and children who do not stutter, is not statistically significant, therefore, hypothesis H 3 has not been confirmed. Also, the hypothesis H4, that the difference in the intensity of the lexical priming effects (effect A and effect B) between the groups of younger and older children who stutter will be higher, than the difference between effects A and B between the groups of younger and older children who do not stutter, has been partially confirmed.

This study verified that content-word priming, but not function-word priming, can lead to a shorter speech initiation time, shorter word duration, shorter pause duration, and less disfluencies on content- and function-words in an utterance in the Croatian language as well. In other words, this study confirmed, within the framework of the EXPLAN theory of stuttering, that the effect of language planning on motor performance can be determined from and based on the occurrence of disfluencies. The occurrences of disfluencies taking places because of time discrepancy between language planning and speech performance which indicates universal nature of stuttering, regardless of language features and the language a child speaks.

Furthermore, this study was confirmed also that the transition from the symptom of stalling (i.e., the repetition of function words) to the symptom of advancing (i.e., repetitions or prolongations of content-word segments) may occur in Croatian earlier than in English. In this study younger children who stutter demonstrate a different distribution of disfluencies than older children who stutter, which is made contribution for understanding of stuttering in the Croatian language.
Key words: EXPLAN theory of stuttering, content and function words, language planning, speech performance, lexical priming, symptom of stalling, symptom of advancing.
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1. **INTRODUCTION**

“There is ample evidence to indicate that the defect is not simply one of motor control or coordination, but that involves more central functions of the language production.”

(Wingate, 1988, p. 238)

Stuttering is a specific type of verbal behavior which should be distinguished from the disorder in its background. The behavior itself is variable, relatively quick to “come and go”, its symptoms take place in milliseconds in speech, and all the emotional-communication features of an individual showing this type of variable verbal behavior can appear relatively slowly, after days, weeks, months, or even years of experiencing symptoms of verbal disfluency (Conture et. al., 2004). The occurrence of stuttering is a result of complex interrelations between cognitive, lingual, motor, and emotional constituents involved in forming the specific features of speech production of any individual who stutters throughout a significant period of his, or her life.

Despite the scientific consensus that stuttering is a complex phenomenon of speech production, over the last thirty years the theoretical concepts related to stuttering have focused either on the motor control of speech movements as the dominant factor in the disruption of fluent speech (Abbs and Gracco, 1984; Smith, 1992; van Lieshout, 2004; Van Lieshout et al., 2004; Max, 2004), or on the influence of linguistic – particularly phonological and syntactic – variables (Postma and Kolk, 1993; Perkins et al., 1991; Wingate, 1988; Ratner and Sih, 1987; Anderson and Conture, 2004; Howell et al., 2003; Savage and Lieven, 2004; Bloodstein, 2006). The standpoints of different authors have often been mutually exclusive and, based on their claims about stuttering, contradictory. In such motoric or linguistic interpretations of difficulties with speech fluency, the authors of theories of stuttering have followed either advances in psycholinguistic models or theories of speech motor control.

One of the most influential psycholinguistic models in the field of stuttering is certainly Levelt’s model of speech production in adults (1989, 1993), which places the multiple levels of linguistic hierarchy – such as grammatical encoding or metric and segment planning – in a position preceding speech performance, and which includes all the linguistic levels as input units for motor speech planning. Levelt’s hierarchical model begins with a subsystem called the *conceptualizer*; the conceptualizer forms an idea from declarative knowledge, and the
form of that idea is then processed in the *formulator*, where it is grammatically and phonologically encoded. The code then also includes the retrieval of lemmas from the mental lexicon, after which the encoded forms enter the *comprehension* subsystem. In Levelt's model, the information carried by the lemma of a lexical unit contains the meaning or sense of that lexical unit – i.e., the concept that goes along with the word. The lemma of a word also includes its syntactic properties, such as its status as a noun or a transitive verb. These syntactic properties are used in the planning of sentences and determine the grammatical encoding.

After retrieval of the lemmas, the coded forms enter the subsystem of *understanding*. Subsequently, lemmas are associated with the last and the least elaborated subsystem, the *articulator*, which in Levelt's model remains outside the focus of interest (Smith and Goffman, 2004). In the literature on stuttering, an important role is also played by Dell’s *Interactive Activation model* (Dell, 1986), the first computer model of speech production. This model deals with one of the two most important areas in the study of speech production: the statistical distribution of the types of errors occurring in speech (the other area being the distribution of picture- and word-naming latencies). The difference between Dell’s interactive model and Levelt’s model is the degree of interaction between the levels of lexical processing. The question which arises is whether the lexical processing takes place in separated (time) phases (Levelt), or simultaneously (Dell).

Models of stuttering that explicitly include motor control commonly rely on models of the control and coordination of speech movements and include neither questions nor presumptions about potential linguistic levels (Smith, 1992). These models apply the discourse of motor control theories, so researchers seek to explain stuttering using terms such as *reflexes*, *central motor commands*, and *impediments to limb control*. The concepts behind these terms can account only for the production of speech movements. Common explanations are that individuals who stutter have “less efficient”, variable, and undeveloped speech motor control, rendering them unable to carry out complex motor coordination during articulation (van Lieshout et al., 2004).

“Stuttering is a complex communication problem whose core consists of idiosyncratic limitations in speech motor skill as evidenced in more variable, less effective and more basic movement patterns in dealing with high demands for movement accuracy and speed required for speech.” (van Lieshout et al., 2004, p. 341)
Authors supporting motor theories of stuttering also associate the onset of stuttering with difficulties in consolidating internal models that coordinate motor and sensory commands for speech movements (Max, 2004). Models of motor speech control often completely omit in their final analyses the potential influence of language processes, and their results are usually not interpreted in relation to linguistic elements and units (Abbs and Gracco, 1984). Nevertheless, there are theories in every subfield that attempt to bridge the gap between motor and linguistic interpretations of speech production by individuals who stutter.

Anne Smith is one of several researchers who interpret speech production based on the interaction between motor control and language planning; she is interested in how the linguistic level is conveyed into motor commands. What is it that the brain needs to generate commands for (Is it sentences, phrases, words, or syllables?) in order to control the activation of a motor neuron area (a group of neurons in the brainstem or spinal cord that innervates individual muscles)? In other words, she poses the question as to which linguistic units the brain needs to convey into muscular contraction and the movements of the articulator, larynx, and thorax (Smith and Goffman, 2004; Smith, 2006).

Edward Conture et al. (2006) also try to bridge the gap between the linguistic and motor aspects in the occurrence of stuttering. In his model, Conture et al. try to combine both components, language planning and speech (performance), into a single factor, referring to them as proximal contributors to the occurrence of stuttering, while they refer to genetics and environment as distal contributors to the occurrence of stuttering. The model is referred to as the Communication–Emotional model, and it includes emotional sensibility and ability to regulate emotions as factors in the exacerbation of stuttering (figure 1). In their concept of stuttering, Conture et al. (2006) point out cognition as the first mental category meeting the requirement of variability and speed-rate in speech production. Thoughts which form verbal intention alternate quickly, causing quick changes in the linguistic plan; the linguistic plan is developed during the stages of selecting meaning and syntactic word-frame, then during the stage of appropriate phoneme selection, and ends with the formation of the final stage of speech performance – articulated speech. All of these stages take place alongside respiratory, phonatory, and articulatory movements, which are all part of the motor segment of verbal production. Motor behavior is only the final stage, following cognitive intention and language planning.
Conture et al., (2004) raise the question of the disrupted or atypical course of language planning being able to cause impediments to fluency in the same way that atypical motor planning of a speech performance act can.

“If these rapidly changing events, that precede motoric planning, control, and/or execution are themselves less efficient, not well integrated, or even slower than typical, is it not possible that they contribute to a person’s relative lack of fluent speech? Do we know if they do? No, of course not, but we never will until we look outside the motoric lamplight into the linguistic darkness for the keys to stuttering”. (Conture et al., 2004, p. 255)

Although this research will not focus on general linguistic theories, questions concerning the stage in the language or motor segment of speech production that can be atypical or less effective are interesting to consider in the light of linguistic and cognitive models of language processing, be they structuralist, such as Universal Grammar and the modular model (Chomsky, 1986; Fodor, 1983) or functionalist, such as the interactive connectionist model (McClelland and Rumelhart, 1981); the model of language performance in Cognitive grammar (Langacker, 2000; Lieven et al., 2003) or the competition model (Bates and MacWhinney, 1982).
The modularity of linguistic theories that accepts a series of researchers presupposes the existence of language modules separated from other cognitive systems that are non-modular (Fodor, 1983), but the strict separation between language and motor speech functions commonly represent a type of (theoretical) simplification (Aboitz and Garcia, 1997). Bates and Dick (2002) radically point out their belief that both knowledge of language and language performance are distributed throughout the neural network.

When it comes to the separation of language and motor systems, and their successive or parallel processing, the results of neurocognitive research can also be analyzed. An example of this type of research is an fMRI study of unificatory language processes during the disruption of grammatical elements (Hagoort, 2005). In the domain of language processing, but also of language production, it enables a reassessment of the understanding of Broca’s area as an area of the left inferior frontal gyrus (LIFG), the area of the unification of phonology, semantics, and morphology. In previous decades, Broca's area has been associated mainly with motor aspects of speech (Falk, 2007).

When it comes to language acquisition and the development of speech in children, two questions can be raised:

- **How does language acquisition affect speech motor development?**
- **How do fundamental motor speech processes affect language acquisition?**

The relation between early acoustic perception and chattering in children (an indicator of early speech motor patterns) and phonological development was an important segment of Marilyn Vihman’s research. Her research from 1986 to 2014 included data on the phonemes and syllables of children chattering and acoustic analyses of the first words of children acquiring British English, Welsh, Finnish, French, Estonian, and Japanese (Vihman, 2014). All the patterns a child acquires and forms reflect the perceptual experience of the language a child hears, but also everything added by the child’s own motor experience, that is, the experience of the child’s own speech performance beginning with chattering (Vihman, 2009). Vihman’s research showed that, in many languages, children’s chattering is connected to the development of phonological competence and the development of the child’s vocabulary. Likewise, the expansion of the productive lexicon offers the child an opportunity to hear and shape different phonotactic patterns which, assuming distributed learning, result in the multiplication of the child’s productive routines (Vihman et al. 2004). An overview of this
stady makes it seem justified to accept the idea of parallel language acquisition and the associated motor speech processes connected with the articulation of phonemes, syllables, words, or sentence phrases, and their permanent interaction.

It can be concluded that, in observing both, the occurrence and development of stuttering, an increasing number of researchers combine language planning and speech performance.

Some authors point out additional etiological factors in stuttering, especially the alignment of the time needed for language planning with the time needed for word pronunciation. The most important of these are the authors of the Covert Repair model, Postma and Kolk (1993), and the EXPLAN theory’s authors, Howell and Au-Yeung (2002).

The main assumptions of the Covert Repair hypothesis are (1) that, in persons who stutter slowly, phonological processing is considered to be a supporting factor for the occurrence of stuttering, and (2) the symptoms of speech disfluency occur during attempts to correct detected errors in phonological encoding before articulation begins.

The EXPLAN theory (Howell and Au-Yeung, 2002) explains the occurrence of speech disfluencies as being caused by incongruity of language planning and speech performance, but also by the characteristics of language structures themselves. This theory attempts to clarify the development of the disorder and the changes in symptoms over the years, during which time those symptoms either last or disappear in the form of recovery.

The postulates of the EXPLAN theory about the differences in language planning and speech performance between children who stutter and children who do not stutter have been investigated by the method of lexical priming or by, so-called, the method of using interfering stimuli. This method attempts to gain insight into stuttering as a linguisticspeech act, and not merely into the details of the disfluency symptoms of uttered words. It also aims at observing, in terms of language planning, what preceded the final act of speaking, i.e., what occurred prior to its motor performance (Conture, 2004; Brocklehurst, 2008).

The method of lexical priming involving two types of words was used in an experimental design that observed the relationship between language planning and speech performance in children-speakers of English, those- who stutter and those who do not stutter (Savage and Howell, 2008). The results of this study should have an impact on the further understanding of the phenomenon of disfluency and provide the first experimental evidence that speech disfluencies occur due to a time discrepancy between language planning and speech.
performance. According to these two authors, the presumptions of the Covert Repair hypothesis cannot account for the fact that shorter planning, enabled by content-word priming, also reduces the performance time of a function word, so the content-word priming leads to fewer speech disfluencies in both function and content words. This research has prompted the following new questions regarding the EXPLAN theory:

*Would the influence of lexical priming on language planning in a pro-drop language such as Croatian differ depending on which of the two types of words are used, function words or content words?*

*Would the results of selective priming in the Croatian language confirm the presumption of the EXPLAN theory that speech disfluencies occur due to a time discrepancy between language planning and speech performance, or due to slow phonological processing, as stated by the Covert Repair hypothesis?*

*Is it possible to confirm the different results of selective lexical priming in children-speakers of Croatian, those who stutter and those who do not stutter, as well as the different results in the two age groups?*
2. DEVELOPMENTAL STUTTERING

2.1 Definitions and specific features

Developmental stuttering is a type of verbal behavior characterized by sudden and frequent repetitions, disruptions, or prolongations of phonemes, syllables, and words occurring after a child has already begun to speak fluently, connecting words into binominal and trinominal sentences. Sometime at the onset of stuttering, along with the already-mentioned milder symptoms, symptoms such as abrupt disruptions of speech, tics, and grimaces, or avoidance of certain words may also occur (Yairi and Ambrose, 1992). Such verbal behavior usually takes place between the ages of two and five years. Their frequency and duration are very clearly perceived as atypical of the prior speech-language development of the child by his parents and environment.

The occurrence of this speech disorder is most frequently related to the repetition of monosyllabic words, mostly pronouns, auxiliary verbs, prepositions, and conjunctions, leading over time to disfluencies which also include content or lexical words (main verbs, nouns, adjectives, and adverbs) (Brown, 1937, according to Howell, 2011). In content words, the most frequent symptoms are repetitions or prolongations of the first consonant or syllable of the word. Yairi and Ambrose (1992) refer to such repetitions of words and word segments, as well as prolongations, as stuttering-like disfluencies.

Sometimes the initial symptoms can have features characteristic of a developed phase of stuttering, with numerous repetitions and prolongations of initial phonemes of a word (Howell et al., 1999). Around 80% of children spontaneously stop stuttering during the preschool period. Until puberty, the rate of spontaneous recovery falls to 50% (Howell, 2011). Permanent stuttering is characterized by dysrhythmic phonation, abrupt disruptions, and a number of associated or secondary symptoms, such as the avoidance of certain words, interlocutors, or situations (Bloodstein, 1995; Guitar, 2006). The lifetime prevalence (an epidemiological measure of all individuals experiencing stuttering symptoms at any period of life) is 1%, while the incidence (the number of new individuals experiencing stuttering symptoms at a certain period of time in their life) is around 5% (Bloodstein, 1995).
Ambrose (2006) believes that stuttering is equally distributed in all cultures and points out that in the U.S. 2.5% of preschool children from Afro-American families and 2.5% of children from families of European-American origin stutter.

Ambrose (2006) states that, at the onset of this speech disorder, boys who stutter outnumber girls who stutter by a ratio of 2:1. Among adults, men who stutter outnumber women who stutter four or five to one. This ratio is accounted for by the fact that women more frequently experience spontaneous recovery. According to Dworzynsky et al. (2007), out of 135 children who continue to stutter, 100 (74%) are boys and 35 (26%) are girls – a ratio of 2.9 to 1. Howell et al. (2008) confirm these results, stating that, in a group of older children (aged 8 to 12 and above), the ratio is 5.33 boys to 1 girl. All of this data suggests that gender is an important risk factor in the development of stuttering.

When observing the symptoms, it is important to highlight the significance of the most frequent type of symptoms in individuals who stutter. It has been shown, according to a study by Yaruss et al. (1998) on a clinical sample of one hundred children, as well as by a study by Pellowsky and Conture (2002) on a random controlled sample of 36 children who stutter and 36 children of the same age and gender who do not experience speech disfluencies, that there is a certain non-random number of disfluencies occurring in the highest percentage of children. For 47 - 50% of children who stutter, it is phoneme or syllable repetition; for 25 - 26% of children who stutter, it is phoneme prolongation. The repetition of monosyllabic words is the most common symptom in 13 - 25% of children, and 10 - 12% of children experience sentence alternations and insertions of words or word segments as the most common types of disfluency.
2.1.1 Classification of stuttering symptoms

The classical approach to the characterization of stuttering symptoms consists of the following eight symptoms listed by Wendell Johnson in 1959:

1. Insertions – e.g., an inserted syllable *au, au Africa is ...*, or pauses filled with *hm*;
2. The repetition of words – e.g., *I, I, I am going*;
3. The repetition of sentence segments – e.g., *when I go to school, when I go to school*;
4. The repetition of word segments – e.g., *sh-sh-sh-shop*;
5. The prolongation of phonemes – e.g., *sssun, noooow*;
6. The disruption of words – e.g., *pa-rent*;
7. Incomplete sentence segments – e.g., *that animal was...*;
8. Corrections – e.g., *that is my aunt, my mom*;

Howell (2011) states that roughly two approaches can be taken in relation to the symptoms from Johnson’s list:

1. **Distinguish those symptoms crucial to the development of stuttering from those which are not.**
2. **Include all the symptoms from the list, or almost all of them, but make a clear distinction between their roles in the occurrence and development of stuttering.**

Considering Johnson’s list, it is important to bear in mind the overlapping symptoms of fluent speakers and speakers who stutter, and determine those symptoms that occur at the onset of stuttering, those that occur when stuttering fades, and those occurring in cases when stuttering lasts for many years.

Another question concerning the onset of stuttering is the following: Can stuttering be instantly associated with a higher intensity and frequency of the symptoms, or can the intensity of symptoms change gradually, shifting towards more severe and complex forms (Howell, 2011; Ambrose, 2006; Conture, 2004)?

Opinions on the grouping of symptoms and their role in the further development of this speech disorder within various theoretical models differ. Conture (1990) highlights the category of stuttering within words, which includes phoneme and syllable repetitions, phoneme prolongations, word disruptions, and monosyllabic word repetitions, marking this category as crucial for the further development of stuttering. The category of symptoms occurring between words, such as repetitions of polysyllabic words (part of Johnson’s second
symptom), sentence repetitions (Johnson’s third symptom), insertions (Johnson’s first symptom), and corrections (Johnson’s eighth symptom) are considered less important for the continuation of stuttering.

Yairi and Ambrose (2005) introduced a category of stuttering-like disfluencies which include repetitions of word segments (Conture’s phoneme and syllable repetitions), repetitions of monosyllabic words, and dysrhythmic phonation including phoneme prolongations and stops (audible and inaudible phoneme prolongations in a word). They believe that these disfluencies make up for the majority of disfluencies in children’s speech. Yairi and Ambrose categorize incomplete sentence segments, corrections, and insertions under the rubric of “other” disfluencies, corresponding to Johnson’s first, seventh, and eighth symptoms (Yairi and Ambrose, 2005; Ambrose, 2006). According to Ambrose (2006), most children with “normal” speech-language development can occasionally produce disfluencies, but this is usually a smaller number of disfluencies, while the frequency and type of disfluencies that affect children who are beginning to stutter are significantly different. Ambrose believes that there are only a few overlaps in verbal behavior between these two groups of children. Ambrose’s view is supported by data obtained in a study by Throneburg et al. (1994) in which the acoustic analysis of speech by children who stutter and children who do not stutter proved that the former group’s repetitions of word syllables occur at a much faster rate.

When it comes to the question of when disfluencies should be considered symptoms of stuttering and when they should not be, Ward (2006) believes that the frequency and severity of the articulation of all the symptoms mentioned are crucial. More specifically, if an individual repeats a monosyllabic word individually ten times in five minutes, this will not be perceived as a symptom of stuttering. However, if an individual repeats the same word eight times in a row, it will be perceived as stuttering, even if this occurs only twice in five minutes. Therefore, the most significant classifications of symptoms are created for the purpose of marking (and distinguishing between) the more typical symptoms (MT) of stuttering and the less typical symptoms (LT) of stuttering (Ward, 2006; Howell, 2010a).

There is a consensus among researchers that the symptoms from Johnson’s list under numbers 4, 5, and 6 are among the more typical symptoms of stuttering, while the symptoms under numbers 1, 3, 7, and 8 are less typical symptoms (Yairi and Ambrose, 2005; Ambrose, 2006; Wingate, 2002; Conture, 2004; Ward, 2006). The only disputable part of Johnson’s list is the meaning of the symptom described under number 2 (which includes repetitions of monosyllabic and polysyllabic words). Wingate (2001) does not include this symptom among
the more typical symptoms, while Yairi and Ambrose (2005), Conture et al. (2004), and Howell (2010a) consider it to be one of the more typical symptoms if it refers to repetitions of monosyllabic words.

Howell breaks down repetitions of whole words based not only on the number of syllables of the word in question, but also on its word class. He clearly distinguishes between repetitions of whole function and whole content words. However he also believes that the repetition of both content words and function words, can be functions of stalling the linguistic plan of the following word (most frequently, the following content word), or advancing, when repetition occurs as a symptom of progressed stuttering, where no recovery from stuttering occurs.

The symptoms described under numbers 7 and 8 are, according to Howell, not symptoms of stuttering, since they do not imply difficulties in language planning and speech, but imply that an individual at the moment of experiencing them cannot think straight (Howell et al., 2010a).

Howell et al. (2010a) point out four underlying schemas built on Johnson’s list of symptoms and divide all the symptoms between those that are more typical and those that are less typical. Moreover, all four schemas are put into the perspective of predicting recovery from stuttering.

Figure 2 presents the more and less typical symptoms of stuttering, beginning with the more typical ones and ending with less typical ones. The four columns illustrate a division into:

1. Stuttering-like disfluencies /stuttering within words; other disfluencies / stuttering between words by Yairi and Ambrose (2005) and Conture et al. (2004) or SLD/WW; OD/SBW.
2. The more and less typical symptoms; (Wingate, 2001).
3. Howell’s division into stalling and advancing; (Howell, 2010a).

The symbol * signifies that, in Howell’s division into stalling and advancing, there is a possibility in every group of repetitions of monosyllabic and polysyllabic words, depending on whether it is a symptom of temporary or permanent stuttering (according to Howell et al., 2010a).
Howell concludes that all four schemas clearly distinguish between recovery and permanent stuttering, and that, in children who recover from stuttering, the less typical symptoms increase, while the more typical ones decrease (Howell et al., 2010a).

<table>
<thead>
<tr>
<th></th>
<th>WW/SLD</th>
<th>BW/OD</th>
<th>Wingate typical</th>
<th>Wingate not-typical</th>
<th>Advancing</th>
<th>Stalling</th>
<th>J Cha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>More typical of stuttering class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound/syllable repetitions</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Sound prolongations</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Broken word</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<td>6</td>
</tr>
<tr>
<td>Monosyllabic whole-word repetitions</td>
<td>x</td>
<td></td>
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<td>*</td>
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<td>2</td>
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<tr>
<td>Multisyllabic whole-word repetitions</td>
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<td></td>
<td></td>
<td>*</td>
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<td>2</td>
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<tr>
<td><strong>Less typical of stuttering class</strong></td>
<td></td>
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</tr>
<tr>
<td>Phrase repetitions</td>
<td>x</td>
<td></td>
<td>x</td>
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<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Interjections</td>
<td>x</td>
<td></td>
<td></td>
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<td>1</td>
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<tr>
<td>Monosyllabic whole-word repetitions</td>
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<tr>
<td>Multisyllabic whole-word repetitions</td>
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<td>2</td>
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</tbody>
</table>

x indicates inclusion in the corresponding scheme; * under monosyllabic and multisyllabic whole-word repetitions indicates further explanation is given in the text.

**Figure 2.** Four schemas of stuttering symptoms classification based on their typicality, according to Howell et al., (2010a).
2.2 Stuttering in research applying brain imaging methods

Brain imaging methods have also been used in the last few decades in research on stuttering. They are classified into those dealing with neuromorphological features of the brain in individuals who stutter and those dealing with observations on function changes in their neural structures. According to Neumann and Euler (2010), neuromorphological researches on people who stutter have shown underlying structural anomalies in the left hemisphere. These are the following:

a) deficiencies in the development of white matter in the orofacial motor part of the brain;

b) reduced development of gray matter in a part of the frontal lobe, in the lower frontal region including Broca’s area – these anomalies affect the basis of language planning, articulatory movements production, and auditory feedback, and lead to fundamental impairments connected to stuttering;

c) white matter volume increase found under the structures of the left frontal and parietal lobe, as well as in the right temporal and frontal lobe in cortex regions in charge of language planning, speech motor control, and listening;

d) gray matter volume increase in the temporal, frontal, and parietal lobes;

e) compensatory increases in the density and integrity of white and gray matter in the frontal, parietal, and temporal parts of the brain – these changes emerge as a replacement for the above-mentioned structural damages;

All changes in the density and integrity of “gray cortex”, overlaps of gyri, and the integrity of white matter can be of pathological nature or adaptive nature. According to Neumann and Euler (2010), adaptive changes also include gray matter increase in individuals who stutter, as opposed to individuals who do not stutter, in the subcortical area in both sides of the basal ganglia region. They suggest that the increase in gray matter is an indicator of structural adaptations to the dysfunctions in the structure of the basal ganglia (Giraud et al., 2008).
2.2.1 Neuromorphological research on children who stutter

A group of British scholars from University College London, or, so called, London group, (Watkins, Smith, Davis, and Howell, 2008) conducted a study on 12 children who stuttered and 12 children who did not stutter using the method of functional magnetic resonance imaging (fMRI) and the method of diffusion tensor imaging (DTI). The DTI method is used for the valuation of white and gray maturation in the brain.

This study, as well as studies on adults who stutter, indicated increased activity in the midbrain, in an area called the anterior insula, as well as in the area of the cerebellum, and a decrease in activity in the left premotor area, as well as the central sulcus (the Rolandic fissure). There was a decrease in activity in both sides of the sensomotoric areas of the cortex, as well as on the left side of the auditory cortex.

The study introduced two additional discoveries:

Firstly, there is increased activity in the area of midbrain called the substantia nigra, part of the neural circuit of the basal ganglia. This increased activity is consistent with some of the earlier evidence on the hyper-activation of this area in people who stutter and its relation to an increased level of dopamine. Parts of the basal ganglia and their increased activity are connected to stereotypical movements and disfluencies also occurring in Parkinson’s disease.

Secondly, there is decreased activity in neural circuits connecting the cortex and motor neurons triggering articulators. The analysis using diffusion tensor imaging showed that children who stutter also have reduced white-matter density below the less active regions in the frontal premotor cortex.

In their study, Chang et al. (2008) analyzed 8 children experiencing permanent stuttering aged 9 to 12, 7 children who had recovered from stuttering, and a control group of children of the same age. They discovered that the risk for the occurrence of stuttering is linked to the density of gray matter in the left frontal gyrus, while permanent stuttering is linked to reduced white matter density in the left hemisphere.

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1 Functional magnetic resonance imaging, or fMRI, indicates changes in the oxygen supply in the bloodstream of brain regions evoked in some of the tasks dealing with word, sentence, and picture recognition. After neurons have been active in their neural circuits, their need for oxygen increases, or the so-called blood oxygen level dependent reaction occurs. The local change of the BOLD level implies the activity of certain neural circuits appearing precisely in those parts of the brain which in the repetitive series overlap with particular types of cognitive tasks.
The authors of the study believe that all anatomical changes in the right hemisphere, usually accounted for in adults who stutter, are compensatory and appear after many years of stuttering.

2.2.2. Research during speech activities on functional magnetic brain imaging

Brown et al. (2005) conducted a data analysis of eight studies on adults who stutter which used PET analysis and the fMRI method. PET analysis, or positron emission topography, is a method using radiopharmaceuticals to display the functional state of tissue and organs. Functional magnetic resonance imaging, as mentioned above, displays changes in the oxygen supply in the bloodstream in brain regions evoked in certain tasks dealing with word, sentence, and picture recognition.

Brown et al. (2005) concluded that people who stutter during speech have the same activated regions as people who do not stutter, but that they have higher activation in the motor cortex (the right opercular frontal cortex, Brodmann’s region 47/12). This hyper-activation may be a result of compensatory processes in the right hemisphere of the brain (Preibish et al., 2003). This right-side region is analogous to Broca’s region in the left hemisphere, which would correspond to the compensatory activity of the right side of the brain, compensating for the deficient transmission of Broca’s area to the representations of motor neurons of the articulator from the left hemisphere.

Neumann and Euler (2010) believe that, in people who stutter, additional motor and non-motor areas are activated – areas which are not activated during speech tasks in people who do not stutter. The less active part of the cortex is the auditory region, while the activity in the left frontal region and the cerebellum is increased. Neumann and Euler state that lower activation in the auditory region and higher activation in the right frontal region and cerebellum may indicate that there are discrepancies between language planning and commands for executive speech motor performance, as implied by Howell (2002). Neumann noted that scholars should be careful when interpreting these results. A higher level of activation does not always mean more efficient neural action in the observed region. For this reason, the region with higher activation can also be an inhibitory region in which higher activation actually means the opposite, or less efficient action.
In an fMRI study, Giraud et al. (2008) tested the role of the basal ganglia\(^2\) structure in stuttering. The study recorded brain regions activated during reading tasks in 16 men aged 18 to 48. The aim was to determine the correlation between those results and the intensity of stuttering before the recording. The study also included the participants’ results after undergoing two years of fluency therapy.

Figures 3, 4, 5, and 6 present a functional model of stuttering based on brain imaging results from the study by Giraud et al (2008). The model presents the cortico-striato-cortical loop.

Figure 3 illustrates the speech of a fluent speaker. For this individual, the cortico-striato-cortical loop indicates positive feedback between Broca’s region and speech motor regions. In figure 3, the arrow connecting Broca’s region and the speech motor cortex is not in bold, indicating an unobstructed connection to the correct activation sequence. Such a sequence implies that Broca’s region is activated first, and then the speech motor cortex. The activation also reaches nuclei of the basal ganglia striatum, the pallidum, and the substantia nigra. The rows of the loop also include the thalamus in the activation feedback, as well as the auditory acortex.

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\(^2\)The basal ganglia include the subcortical area involved in motor and cognitive functions. The biggest nucleus of basal ganglia is the striatum, which is also their main “entrance area”. The striatum receives input projections from the cortex, thalamus, and brainstem. It is anatomically divided into the nucleus caudatus and the putamen and also includes the nucleus accumbens. The basal ganglia also include the pallidum and the substantia nigra as their output structures.
For individuals who stutter, the model includes a structural disruption of the connection between Broca’s region and the motor cortex. In Figure 4 this disruption is presented by a dotted line connecting Broca’s region and the speech motor cortex. Also, in the case illustrating stuttering (Figure 4), the order of activation sequences is modified. This is illustrated by the shading of the speech motor cortex, emphasizing that this part is activated before Broca’s region. This sequencing order is incorrect. The incorrect ordering or sequencing between language planning (Broca’s region) and the speech motor cortex is shown in results by Salmelin et al. (2002), who used the MEG technique to record speech (Magnetoencephalography).

In Figure 4, Giraud et al. highlight that, in individuals who stutter, the left inferior part of the frontal cortex, responsible for phonological and articulatory encoding, is activated before the left speech motor cortex, responsible for motor articulatory performance. However, in people who stutter, those sequences have an inverted order. Giraud et al. account for this finding by

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Figure 3. Diagram of neural activation during the speech of fluent speakers, according to Giraud et al. (2008).

Magnetoencephalography (MEG) is a non-invasive method for the direct measurement of the extra-cranial magnetic field generated by neuronal ion channels with a millisecond time resolution and space resolution of a few millimeters.
the deficiency of the left hemisphere fibers connecting the two regions (Giraud et al., 2008, according to Sommer et al., 2002).

The entrance to the striatum coming from the motor cortex is therefore, in individuals who stutter, less precise in the time sequencing and its phonological processing. This is highlighted by the use of the arrow in bold connecting the speech cortex and the striatum. Imprecise activation of the striatum results in the reduced suppression of competitive phonological patterns (Mink, 2003, according to Giraud et al., 2008). It also leads to an imbalance of feedback between the striatum and the cortex, and to the excitation of the motor cortex leading to the enhancement of the imbalance (in figure 4 this is illustrated by an arrow in bold between the thalamus and the speech motor cortex). Symptoms of stuttering such as repetitions and stops can be interpreted as a closing of the repetitive and abnormal cortico-striatal loop (Giraud et al., 2008).

Figure 4. Diagram of the neural activation of a person who stutters at the time when it initiates pronunciation, according to Giraud et al. (2008).
Figure 5. Display of neural activation during speech in a person who stutters and who is undergoing spontaneous recovery with compensation in the right hemisphere, according to Giraud et al. (2008).

Figure 5 shows compensatory changes in which, over years of stuttering, an homologous active area has developed on the right. This area is represented in the diagram as the shaded area labelled “right homologue”.

These right-sided hyper-activations are located in the area of the right prefrontal and motor regions, and the right frontal operculum (RFO); their activation has been noted in brain imaging research using magnetic resonance in fMRI studies by De Nil et al. (2000), Fox et al. (1996), Ingham (2001), and Neumann et al. (2003, 2005). The right frontal operculum region, or the RFO area, is consistently hyper-activated in verbal tasks in individuals who stutter, unlike those who do not stutter (Giraud et al., 2008).

Figure 6 shows the activation of these regions after a two-year fluency therapy. The arrow in bold signifies the (again) normal activation of Broca’s region, preceding the activation of the speech motor cortex. Figure 6 illustrates how fluency therapy changes the activation of those regions and signifies a development in the speech technique.
The symptoms, frequency, and severity of stuttering were the focus of a study by Jiang et al. (2012). These authors observed neural activity connected to the processing of the less and the most typical symptoms of stuttering using functional magnetic resonance imaging. They were also interested in the classification of whole-word repetitions. The language research was conducted on the Mandarin language. The results of this study showed a difference in the activation of neural circuits for the less and the most typical symptoms in this non-European language. Moreover, the study showed that whole-word repetitions are among the less typical stuttering symptoms. Despite this, the authors still believe that whole-word repetitions are a very important aspect of stuttering, both clinically and theoretically, and that the frequency of whole-word repetitions can give us insight into the prediction of outcomes, but also into the nature of stuttering itself (Jiang et al., 2012).

**Figure 6.** Display of neural activation during speech in a person who stutters and has undergone treatment, according to Giraud et al. (2008).
2.3 Lexical factors and severity of stuttering

As already mentioned in the chapter on the EXPLAN model, when it comes to stuttering symptoms, the questions that interest us are whether word type has an effect on children who stutter, whether the word type in which symptoms occur is susceptible to change, and whether the symptoms themselves change in those words over the course of years of having the disorder. As previously mentioned, Brown (1937, according to Howell, 2011) was the first to make a connection in adults who stutter between stuttering symptoms and word types. His lists included words from both function and content classes of words. Words on Brown’s scale are ranked according to the frequency of the occurring stuttering symptoms on a sample of 32 adult speakers. The scale of words with the associated frequency in stuttering is presented in Table 3. The scale begins with the simplest words marked as easy (minimum stuttering), and ends with the hardest words marked hard (maximum stuttering). Function words are at the top of the scale and are the “easiest”, while content or lexical words are at the bottom of the scale, since they present the most difficulties in articulation for an individual who stutters. According to the scale, the category of pronouns includes only personal and reflexive pronouns (Howell, 2011).

Table 1. Scale of symptom severity of nine word types in adults who stutter (Brown 1937, according to Howell, 2011).

<table>
<thead>
<tr>
<th>Article</th>
<th>Easy (minimum stuttering)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary verb</td>
<td>function word</td>
</tr>
<tr>
<td>Preposition</td>
<td>function word</td>
</tr>
<tr>
<td>Conjunction</td>
<td>function word</td>
</tr>
<tr>
<td>Pronoun</td>
<td>function word</td>
</tr>
<tr>
<td>Verb</td>
<td>content word</td>
</tr>
<tr>
<td>Adverb</td>
<td>content word</td>
</tr>
<tr>
<td>Noun</td>
<td>content word</td>
</tr>
<tr>
<td>Adjective</td>
<td>content word Hard (maximum stuttering)</td>
</tr>
</tbody>
</table>
Unlike Brown, who based his data on observing speech in adults, Bloodstein and Gantwerk (1967) were the first to report on the occurrence of a higher frequency in stuttering on function words rather than content words in children who stutter. In their description of five children who stutter aged 3;10 to 5;7, Bloodstein and Grossman (1981) stated that, in most children, stuttering symptoms were more reflected on function words than on content words.

### 2.3.1 Effect of phonological and/or phonetic complexity on occurrence of stuttering

In research on the effects of language on the occurrence of stuttering, the last two of Brown’s linguistic factors, the type of phoneme that words begin with and the number of syllables in a word, were considered to be the basis of the concept of phonological and/or phonetic complexity in words. During the last few decades, the verification of the phonological and/or phonetic complexity of words in which stuttering occurs has motivated dozens of studies (Throneburg et al., 1994; Howell and Au-Yeung, 1995; Howell et al., 2000; Weiss and Jakielsky, 2001; Dworzynski and Howell, 2004; Howell et al., 2006; Eldrige, 2006; Howell and Au-Yeung, 2007). Most of the studies showed that the number of all non-fluently articulated words has all the same conditions for phonological complexity as the entire speech pattern, negating the clear connection between phonological complexity and the occurrence of disfluencies similar to stuttering.

In a study by Throneburg et al. (1994) on a group of 24 preschool children, three factors of phonological difficulties can be pointed out:

1. late emerging consonants (LEC);
2. consonant strings (CS);
3. multisyllabic words (MSW).

By combining these three factors, the authors highlighted three groups of words:

1. words without phonological difficulties;
2. words with one element of phonological difficulty;
3. words with multiple phonological difficulties;
Throneburg et al. concluded that phonological difficulties in words in which disfluencies similar to stuttering occur and non-fluent words following them do not contribute to the occurrence of stuttering, and that phonological difficulties, as defined in their study, have no clear connection with the occurrence of disfluencies (Throneburg et al., 1994).

In their speech analysis of 31 children who stutter and 41 children with fluent speech, aged from 2;7 to 12;7, Howell and Au-Yeung (1995) tested the validity of the measurement of phonological difficulties presented in the study by Throneburg et al. (1994). They concluded that there was a difference between age groups in terms of the word “proportion” within each phonological category. Those differences occur equally in both the children who stutter and the children with fluent speech. The authors concluded that the results of their study confirmed Throneburg’s conclusion that phonological difficulties within words are not a crucial factor which could affect stuttering in younger children (Howell, 1995).

In the following study, Howell et al. (2000a) tested the conclusion from previous research (Throneburg et al., 1994; Howell and Au-Yeung, 1995) that phonological complexity is not an essential prerequisite for the occurrence of stuttering in younger children. In a group of 51 people who stutter divided into three age groups (younger children aged 3 to 11, teenagers aged 11 to 18, and adults aged 18 and above), a sample of spontaneous speech was analyzed. In this study, Howell et al. (2000a) measured the differences between phonological complexities within words and divided the sample into function and content words. They observed the initial and non-initial position of the factors late-emerging consonants (LEC) and consonant strings (CS) and all their possible combinations. For example, the word school includes both factors of phonological complexity –LEC and CS in the initial position (much like the Croatian word škola ‘school’). This word can potentially have a higher level of phonological complexity than the word quiz, where the CS factor appears before the vowel, and the LEC factor appears after the vowel (a similar example in Croatian is the word zrak ‘air’). In this study, the phonological complexity of function words was not found to have any effect.

The results of Howell et al. (2000a) substantially alter the conclusions of all the previous studies that found phonological complexity not to have an affect on the occurrence of disfluencies in younger children. The participants of this study stuttered significantly more on content words beginning in a consonant string than on those which did not. Likewise, the
youngest participants stuttered significantly more on words beginning with late-emerging consonants.

The conclusion of the study was that none of the factors of phonological complexity affected the occurrence of disfluencies in function words. The results of disfluencies in content words indicated consonant strings and late-emerging consonants in word-initial position as the crucial pathogenic factors for the occurrence of disfluencies. Howell et al. also concluded that the fluency of function words is not determined by their phonological complexity but by the external factors leading to the function words in language planning. The factors making content words susceptible to the occurrence of disfluencies are of an internal nature and are derived from the phonological complexity of their initial syllables. According to the EXPLAN theory, about which more will be said in section 3.1, the differences between the two word types form the basis of disfluency symptoms.

Research on the phonological and/or fonetic complexity of words, along with the analysis of syntactic complexity, is the most investigated area in linguistic research on stuttering.

Research teams have introduced new methods for testing the details of phonological and/or fonetic complexity which may affect the occurrence of disfluency. Weiss and Jakielski (2001), for example, used the Index of Phonetic Complexity (IPC) on a group of children aged 6 to 11. IPC reflects the relative motoric complexity of segment variations within words and transitions from one phoneme to another. They observe eight IPC factors in twenty-minute periods of structured and non-structured speech. The authors hypothesized that phonetic complexity might cause a higher occurrence of disfluencies only in the subgroup of children who stutter. The study did not confirm the occurrence of statistically significant differences in the group of children in terms of the IPC between fluent and non-fluent words and sentences and the age of the children (Weiss and Jakielski, 2001).

A study by Howell et al. (2006) repeated the concept of IPC measurement from the study by Weiss and Jakielski (2001) and introduced the rank of disfluencies for all content words and all function words in three age groups (6-11, 11-18, and 18 and above). The study showed that the stuttering measurement on content words in teenagers and adults was in correlation with IPC scores (Weiss and Jakielski, 2001). No correlation was confirmed in the youngest age group. The authors therefore concluded that the effect of phonetic complexity was distinct in the groups of teenagers and adults. They interpreted this later situation in the development of
stuttering as something affected by different factors than those affecting governing the onset of stuttering, and thus confirming their earlier findings (Howell et al., 2006).

Studies on phonetic complexity were also conducted on speakers of German (Dworzynski and Howell, 2004) and Spanish (Au-Yeung and Howell, 2007). Despite the significant differences between the three languages, important similarities were found in terms of common factors in the occurrence of stuttering.

The studies showed that, as chronological age rises, the effect of linguistic complexity of content words also rises. The length and phonological complexity of a word become suitable predictors for the occurrence of severe disfluency in all three languages. The German studies indicated that content words have a higher proximal sum of IPC scores than words in English. Therefore, the difference between the IPC scores of fluently and non-fluently articulated words in German is greater than in English (Dworzynski and Howell, 2004).

The Spanish study (Howell and Au-Yeung, 2007) was similar to the German and English studies. Stuttering on function words did not correlate with the IPC score for either of the groups, and it was confirmed that those words were not affected by phonetic complexity. There was a positive correlation between the IPC score for content words the stuttering rate in children aged 6 to 11, as well as in adult participants.

**The conclusions of the authors of research on phonological and/or phonetic complexity are:**

a) the connection between phonological and/or phonetic complexity and stuttering can be found in both, older children and adults;

b) if the symptoms occurring at the beginning of words are observed (late-emerging consonants and consonant strings), their connection to stuttering is significant in all age groups;

c) the phonological and/or phonetic complexity of function words does not correlate with the occurrence of disfluencies;

d) stuttering occurs during the years of the disorder’s duration as a result of the transition of disfluency symptoms to content words and the absence of the “protective” role of function-word repetitions (Howell, 2011).
In the EXPLAN theory, which will be discussed, as already mentioned, in chapter 3.1 on page 71, the cause for the occurrence of disfluency and the development of stuttering is associated with the production of content words. This finding of the EXPLAN theory, as can be seen from the above-mentioned results of interlanguage research, is of universal nature. A study in Jordanian Arabic also confirmed that phonological complexity is positively correlated with the occurrence of disfluency, mostly on content words (Tamimi et al., 2013).
2.3.2 Interconnection between stuttering and locus of syntactic, cognitive and emotional complexity

The results of observing syntactic complexity and stuttering are less consistent than those in research on phonological complexity and the occurrence of stuttering. Whether they focus on the length of utterances (Bernstein-Ratner and Sih, 1987; Karniol, 1995; Bernstein-Ratner, 1997; Silverman and Bernstein-Ratner, 1997), sentence constituents (Logan and Conture, 1997), the number of sentences in an utterance (Yaruss, 1999), or the age at which passive and negation are first used, in relation to the more simple grammatical categories (Silverman and Bernstein-Ratner, 1997), the results of research in the field of syntax are quite uneven and do not show a clear connection between the occurrence of stuttering and the above-mentioned loci of syntactic complexity.

A significant novelty in the field of syntax research is brought forward by research methods used in the linguistic model based on Savage and Lieven’s (2004) usage. In the model, “early” syntax is determined as a schema and a word-frame filler. Savage and Lieven (2004) state that the reason for the uneven results in research on the locus of syntactic complexity and the occurrence of stuttering is the fact that the early studies treated all syntactic categories as equally significant. Savage and Lieven believe that it is precisely the grammatical creativity in filling up the new patterns within the given frames of child’s utterances that makes the syntactic development from the third year on complex. The two authors note that a child can use a series of new meanings in the same frame within the schema:

For example, the utterance My little boat sailed and (was) sunk in comparison to the utterance My boat is tiny, and my tiny boat sails, and my tiny boat is sinking contains significant differences.

The two utterances differ not only according to the mean length of utterance (MLU) measured in the average number of morphemes or words in a sentence, but also according to the level of abstractness and creativity in the child’s use of grammatical forms (using attributives to describe a noun, using the preterite, and using the past participle).

Therefore, according to Savage and Lieven (2004), the syntax itself is not responsible for the occurrence of speech disfluencies in 5% of children. If that were so, stuttering would have appeared at the onset of syntax, and disfluencies would have appeared from the second year when a child begins to use binominal utterances. However, stuttering usually occurs at the age
of three, when a child has to use abstract filling for the categories of verbs and nouns, and when he begins to combine schemas with concrete and abstract forms (for example, the verb form *sailed* instead of *sails*, or *(was) sunk* instead of *is sinking*).

Savage and Lieven (2004) believe that using concrete forms corresponds to function words, while abstract forms correspond to content words. The very occurrence of abstract forms makes grammatical complexity, from the third year on, a challenging segment of language development. In this new constellation with many abstract words, the repetition of function words has the role of providing time for the planning of abstract words of expression through the use of concrete words and their repetitions. It is this abstract word that the child of that age relies upon for creative language use.

Savage and Howell (2008) stated in the conclusion of their study on selective lexical priming that disfluencies occur in many children aged 3 and above, and that they are a result of increasing abstractness and creativity of utterances after the age of three. According to these authors, these are the very reasons affecting the incidence of stuttering in around 5% of children in early childhood (Savage and Howell, 2008). Such a high percentage of children who stutter in early childhood led the authors of the EXPLAN theory to the conclusion that disfluencies in children who stutter at an early age are actually similar to disfluencies occurring in speech in all children at that age. Stuttering, which at an early age is mostly represented in function-word repetitions, would in that case be a good compensation for the additional time needed to plan more complex content words, and that way would be a sort of “protection” from a more developed type of stuttering.

One of the possible answers to the question why only 1% of children continue to stutter (equal to the stuttering prevalence in adulthood) is the possible incapacity of some other segment of cognitive processing, such as, for example, the incapacity of the central executor of the working memory (Bosshardt, 2002, 2006).

Research on the connection between the capacity of the central executive of the working memory and the occurrence of stuttering has been a central topic of studies dealing with stuttering for several years now. As part of the research on the working memory, the most investigated phenomenon was the effect of dual tasks as the most important index of the capacity of cognitive resources affecting the occurrence of speech disfluency in individuals who stutter and those who do not (Bosshardt, 1999, 2000; De Nil and Bosshardt, 2000; Bosshardt, 2002). All the studies analyzed the effect of a secondary task on speech fluency.
Their basis is Fodor’s concept of modularity (1983), which presupposes that the brain is organized as a modular and automatic system divided into separated automatic subsystems or modules, which can more or less successfully withstand the impact of competitive mental activities.

As mentioned earlier, in studies on syntactic complexity loci, the probability of stuttering increases at those points in language processing which bring about more complex “demands”, such as the number of words, length, and number of sentences in an utterance. Studies by Berstein, Ratner and Sih (1987), Logan and Conture (1995, 1997), Melnick and Conture (2000), and Yaruss (1999) have shown that, in children who stutter, it is precisely the length of a sentence that brings on such an increased stuttering locus. Similar studies have shown the same results in adults (Bosshardt, 1995; Jayaram, 1984; Silverman and Bernstein Ratner, 1997).

Bosshardt (2006) believes that neither studies on phonological complexity (Howell et al., 2000a; Wingate, 1988), nor the above-mentioned studies on syntactic complexity locus have enabled a complete insight into all elements of cognitive processing and their influence on the occurrence of disfluencies. Howell, therefore, developed a number of research paradigms to examine the effect of additional cognitive load on the process of language planning and speech performance in individuals who stutter and who do not stutter in dual tasks.

Bosshardt (2002) highlighted the hypothesis that stuttering is a result of difficulties in language planning and speech performance, due to which the attention resources are less effectively divided into different cognitive activities in people who stutter. In his studies, dual tasks are most commonly combinations of different language tasks and competitive tasks of other cognitive activities (memory or mathematical operations).

In a review on research on the cognitive load and the occurrence of stuttering, Bosshardt (2006) pointed out his study from 2002 as the crucial study for the paradigm of dual tasks performance. In the 2002 study, Bosshardt used three experimental tasks with the same material for every experimental condition. The material was first used in the condition of word repetition as a single task, and for the second and third time in a dual task (or the secondary condition) of the silent reading and memorization of a list of words.

In the task on repeating words, the participant had to repeat as quickly as possible three words after having read them on a screen, after which the screen would show similar or
phonologically different words, which the participants then had to read silently, memorize, and repeat.

The participant sample from the 2002 study included groups of 14 adults who stutter and 16 adults who do not stutter.

The results of the study showed that disfluencies in the people who stutter were significantly higher during repetitions of words phonologically similar to those they were reading and memorizing silently. Specifically, the secondary task with repetitions of phonologically similar words negatively affected fluency in the people who stutter. The individuals who do not stutter were not significantly affected by the secondary task.

The results of Bosshardt’s studies (2002) indicated that the speech of individuals who stutter was more susceptible to the effect of the dual task than the speech of individuals who do not stutter. The explanation behind this phenomenon, according to Bosshardt (2002, 2006), is that the phonological and articulatory modules in individuals who stutter are not “protected” enough from the effects of the cognitive modules. He believes that the distribution of attention resources within the central executor during the performance of language and cognitive tasks in individuals who stutter is ineffective.

The author concluded that individuals who stutter are more susceptible to the mutual effects of parallel cognitive and language tasks because their articulatory and phonological system is less modular, meaning that it is less independent from the effects of other cognitive modules in joint activities, which leads to the language system in individuals who stutter being more susceptible to errors in language planning and articulation.

Bosshardt’s studies using dual tasks provided a basis for the explanation of reasons behind the decreased percentage of individuals who stutter from an initial incidence of 5% to a life-long prevalence of only 1%.

Does the different percentage of individuals who stutter in childhood and adulthood mean that, besides the demands in the language development and alignment of language and speech development, in a number of individuals who continue to stutter there is something else that could be causing development of disfluency symptoms?

In other words, despite the fact that it is known that the language basis of the mother tongue is acquired during the third year (Kuvač Kraljević and Kolagranić Belić, 2015), intensive speech-language development takes later on and is not even roughly completed for a few
more years. The growth of vocabulary and everyday practice of their mother tongue lead to children reaching a position of higher language and speech competence (Vihman, 2009; Vihman and Keren-Portnoy, 2011). Therefore, it is not surprising that, from the third year on, around 5% of children may experience disfluency symptoms, and that the percentage slowly decreases during further speech-language development.

However, does anything else take place in the 1% of children who at the preschool age and even later continue to experience stuttering symptoms that would, at the level of the general cognitive processing, aggravate their language planning and speech, making them less effective?

The answer to this question should be viewed in the light of emotional processing, which may figure as a dual task with the tasks of language planning and performance. More specifically, if the *Communication-emotional model* of stuttering (Conture, et al. 2006) from the introduction of this dissertation is recalled, in which emotional sensitivity and the ability to regulate emotions aggravate stuttering, it is possible that the very factors of emotional reactivity and regulation are competitors of the language modules in the distribution of the limited attention resources within the central executor of the working memory.

Emotional reactivity (Eisenberg and Fabes, 1992; Eisenberg and Spinard, 2004) is a term denoting the intensity and range of positive and negative emotions. When it comes to children, the term signifies all the possible types of emotional reactions they preserve or bring about in conflicts with their peers. Vigorously emotionally reactive children will encounter on many occasions during their early social development a fierce emotional reaction to refusals, denials, or limitations presented by the environment they live in.

Emotional regulation is the process of tracking and evaluating, as well as adjusting one’s own emotional processes used to regulate inner emotional reactivity. Both processes can increase the frequency, type, and intensity of stuttering symptoms (Conture, et al. 2004). There are indicators that neural structures responsible for emotional reactions also take place in emotional regulation, and that those processes are mutually related (Conture and Walden, 2010). A study by Anderson et al. (2003) including 34 children aged 3 to 5;4 years, based on the interview results of their parents, showed that children who stutter are more susceptible to having a particular temperament type. Children who stutter experience more sleeping disorders due to a lower ability to relocate their focus of attention to something calming, they are less willing to accept changes in their environment and new situations, and they have less
orderly biological processes. Such results indicate a difference in temperament features in children who stutter and children who do not stutter. Anderson et al. (2003) concluded that the temperament features of children who stutter may contribute to the aggravation of stuttering.

Arnold et al. (2012) tested 19 preschool children who stutter and the same number of children who do not stutter to confirm whether or not physiological and behavioral indicators of emotional reactivity and regulation are connected to developmental stuttering. The children in the study faced a situation of listening to recordings of different types of conversation (neutral, happy, and angry ones), after which they spoke to the interviewer. They also commented on pictures from picture-books representing different situations.

The study’s results showed that, when the children showed less regulatory strategies during the conversation with the researcher, increased disfluency occurred in their speech. During the interview, there were no significant differences in EEG measurement in the children who stutter and those who do not. The authors of the study concluded that using regulatory strategies in children who stutter affected the occurrence of disfluencies – when they used fewer strategies for emotional regulation, they showed more disfluencies.

Arnold et al. (2012) concluded that it is possible that reduced usage of emotional reactivity results in the sabotaging of attention resources, which disrupts the possibility for stable and effective implementation of language planning and speech performance processes. Likewise, Arnold et al. concluded that control over emotional reactions during language planning and speech production is what Bosshardt (2006) described as the “concurrent attention-demanding cognitive processing” (Arnold et al., 2012, p.15).

Bosshardt (2002, 2006), as already mentioned, noted that adults who stutter experience an increased number of speech difficulties during different types of dual tasks (reading, memorizing and repeating words, articulating sentences, and calculating). Thus, when adults who stutter are faced with the need to incorporate different cognitive tasks into their speech activity, when they spread their attention to all of them, the number of disfluencies in their speech may increase.

In their study, Walden et al. (2012) introduced a Dual diathesis-stressor model of emotional and linguistic contributions to developmental stuttering. The authors tried to prove that language and emotional stress are factors which may increase the number of speech disfluencies. In their study they noted that, in language development, discrepancies in the development of expressive language constituents (e.g., a more developed vocabulary
compared to syntax or morphology) are the reason behind the increased probability of the occurrence of stuttering. They also noted that some children’s coping strategies for communication demands directed at adults, such as aggressive reactions, venting anger, seeking support, or distancing, are connected to stuttering.

Seeking support and distancing are considered to be the variables in children’s coping strategies that correlate the most with an increased number of disfluencies. The study showed that even weaker emotional regulation in children who stutter also contributes to an increased number of their disfluencies.

2.4 Lexical research on stuttering in cross-section of age groups

The transition of stuttering symptoms from function words in children’s stuttering to content words in adults who stutter was observed in English (Howell et al., 1999a), and also in German (Dworzynski and Howell, 2004; Dworzynski et al., 2004) and Spanish (Au-Yeung et al., 2003; Howell, 2004). Despite the specific features of each language, all of these studies indicated a transition in stuttering from function words in children who stutter to content words in adult speakers. The study by Howell et al. (1999a) in English was conducted on a sample of 51 participants who stutter and 68 participants in the control group, aged from 2;7 to 40 years. The children in both groups were divided into three age groups: children from 2 to 6 years (the younger group), from 7 to 9 years (the middle group), and from 10-12 (the older group). The study measured the percentage of disfluencies in children, teenagers, and adults during an interview with a therapist. Disfluencies included repetitions of monosyllabic and disyllabic words (e.g., she she she), and word segments (e.g., susususun or ssسسsun) and phoneme prolongations (e.g., su---n). The results indicated that fluent speakers have a higher percentage of disfluencies on function words preceding content words in all age groups. As they grow older, children who stutter exhibit changes in their disfluencies in terms of word type. In younger children who stutter, the percentage of disfluencies occurring in initial function words is higher than on content words; in older children who stutter, the ratio changes, leading to the older children stuttering more on content words. In teenagers and adults who stutter, disfluencies on content words also significantly prevail. Figure 7 illustrates a change in stuttering symptoms – there is an increase in the percentage of stuttering.
symptoms on content words and a decrease in the percentage of function words articulated non-fluently. The age groups are presented along the horizontal axis, while the percentages of disfluencies out of all articulated words during the conversation are indicated along the vertical axis. It is evident that in teenagers and adults who stutter, in comparison with the three age groups of children who stutter (younger, middle, and older), the percentage of stuttering on content words increases, while the percentage of stuttering on function words decreases. People who do not stutter experience disfluent articulation predominantly on function words that precede content words. Over the years, the number of disfluencies on content words in this group approaches zero.

Figure 7. Disfluency rate on function and content words in individuals who stutter (PWS) and individuals who do not stutter (PWDNS), according to Howell, 2011.
2.4.1 Longitudinal lexical research on stuttering

Although Howell et al. (1999a) showed a transition in their data from stuttering symptoms on function to content words, even more significant data for insight into the contribution of lexical factors for the development of stuttering symptoms was provided by Howell in his study from 2007 (Howell, 2007). This study observed 76 children between their eighth and twelfth year. All of the children had already been diagnosed as children who stutter before their participation in the study. All children were tested by Stuttering Severity Instrument 3 (SSI-3) (Riley, 1994). Children up to the age of 12 were divided according to SSI-3 criteria into two groups, those experiencing recovery and those experiencing persistent stuttering. A total of 41 children had experienced recovery, while 35 continued to stutter.

Most children aged 12 and above who stutter undergo a change in the relation between the types of disfluency, depending on whether they are recovering from stuttering or not. The data on children who have recovered showed that the average number of function-word, sentence, and phrase repetitions, in a speech sample lasting 2 minutes, decreases from 3.08 to 1.43, and that the number of word-segment repetitions and prolongations on content words decreases from 1.17 to 0.44. Children recovering from stuttering “approach” fluent speakers. The data on children who continue to stutter showed that the average of whole-word, sentence, and phrase repetitions in the two-minute period decreased from 2.89 to 1.58, but that the word-segment repetitions and word prolongations and disruptions increased from 1.38 to 1.68. The increase in words in which disruptions, repetitions, and prolongations occurred showed that these speakers differ from those who are recovering from stuttering.
2.4.2 Review of inter language EXPLAN theory research based on stuttering symptom exchange relation in function and content words

The exchange relation of symptoms during the disorder’s development, as mentioned in the section on lexical factors and stuttering (2.3), was determined in the English language in a study by Howell (1999a). The relation is based on the co-occurrence of a decreased number of disfluencies on function words experiencing symptoms of stalling and an increased number of advancing symptoms on content words over the years of the disorder’s development. Besides English, the exchange relation of symptoms and word types was confirmed in Spanish (Au-Yeung et al., 2003) and German (Dworzynski et al., 2003; Dworzynski and Howell, 2004).

Au-Yeung et al. (2003) found, in a sample of 46 monolingual Spanish speakers in five age groups (3 to 5, 6 to 9, 10 to 11, 12 to 16, and 20 to 68 years), an increased number of disfluencies on function words preceding content words, compared to the number of disfluencies on function words themselves. Likewise, they noted that in younger age groups a higher number of disfluencies occur in function words and that this number decreases with age, with an increase in the number of disfluencies on content words. This study is very significant due to the similarities between Spanish and Croatian. Both Croatian and Spanish are pro-drop languages, meaning that there is a possibility of omitting pronouns referring to the subject. This language feature leads to a decrease in the number of situations in which a function word precedes a content word in a phonological word, since only that position of a content word is significant for the occurrence of stalling symptoms (Howell, 2011). The English phonological phrase -I go to the house- is translated in to Spanish as voy a casa (I go) or vas a casa (You go). It is evident that in Spanish there is a possibility of leaving out the personal pronoun, since the grammatical agreement between the personal pronoun and the verb can be marked on the verb itself (voi, vas, va – I go, you go, he/she/it goes). The personal pronoun in the subject position can also be left out in Croatian. The English sentence- I go to the house- in Croatian can be produced without the personal pronoun, and can be translated as Idem kući’ (I go home’, where the suffixes –em and –eš determine the person agreement. In Croatian it is also possible to determine verb’s gender agreement, so the English sentence- I split the group- can be translated as Podijelio sam grupu (I = male) and Podijelila sam grupu (I = female). The suffixes –o and –la indicate the gender of the omitted subject. Due to a similar situation in Spanish (its pro-drop feature), the possibility of repeating a function word, in this case the personal pronoun I in the example- I I I split the group- is less plausible. This also minimizes the role of function word repetitions as a “protection” from disfluencies on the
content word, in this case the verb split. Au-Yeung et al. (2003) hypothesized that in Spanish the balance in the number of situations in which a pronoun precedes a content word can be achieved by observing sentence types in which pronouns fill the object position, such as the one as the phonological word I have it. The disfluency occurring as the repetition of the function word I I I have it is replaced by the phonological word lo lo lo tengo in Spanish. In this example, the pronoun lo, which is the object, comes before the verb and can, as a proclitic, be repeated in the stalling pattern.

Within the EXPLAN theory, it is important to mention the study by Howell (2004) on the Spanish language in which the exchange relation of symptoms was observed not only in relation to the transition of disfluency from function to content words, but also in the transition of disfluency from an unstressed to a stressed word when the stressed word is a function word. In Spanish, the nucleus of a phonological word can be a stressed content word, but also a function word, when it comes to a stressed function word. Howell’s study (2004) determined that both ways of word segmentation showed the relation of disfluency transition. According to those results, in the Spanish language, aging leads to the transition of disfluencies both from function to content words and from unstressed to stressed words. These results suggest that both lexical status and stress can be the focus of stuttering in a phonological word (Howell, 2004). Unlike English, in which such a scenario is not possible, in Croatian the transition of stress to a proclitic may occur in some cases (the function word within the phonological word; for, example, on se boji (he is scared) (Jelaska, 2004). It would certainly be significant to analyze this phenomenon further in an interlanguage study dealing with the hypotheses of the EXPLAN theory.
2.5 Motor research into stuttering

A critical review of theories that incorporate motor explanations for the occurrence of stuttering raise the same key question as the theories including purely linguistic/language explanations:

*How is it possible that individuals experiencing some of the more severe motor difficulties do not stutter?* Or, in other words:

*How can the fact that individuals with significant deviations within the processing of certain language constituents do not stutter be accounted for?*

These questions are not adequately answered either by purely linguistic, or by purely motor explanations of stuttering.

Motoric explanations of the occurrence and development of stuttering most commonly list causes from the domain of speech motorics and its neural innervation. In such explanations of the occurrence of stuttering, all segments of language planning are to a greater or lesser extent placed in the position of passively preceding a disrupted motor speech performance. The idea of a passive observance of the motor effect is equally present in language theories of stuttering. Therefore, the potential disruption of motor performance in stuttering is accounted for by the authors of language theories as a passive motor response to a certain deficiency in the stages of language processing preceding motor speech performance (Howell, et al., 2010b).

However, the absence of stuttering in individuals experiencing language difficulties clearly suggests that even some non-linguistic factors have a role in the occurrence and development of stuttering. Of these, motor factors are certainly the most significant. This kind of research would benefit greatly from the analysis of their influence on the very onset of stuttering. Howell (2011) believes that this is unfortunately not the case, and that there are only a few examples of such motoric research into stuttering. When it comes to motoric factors in stuttering, as well as research on language and stuttering, it is important to distinguish whether one is dealing with a primary motoric cause of stuttering, or with one of the compensatory changes in the functioning of motor innervations of the articulators happening as an adaptation to occurrences in the speech-language production of a child or an adult with a long-term history of stuttering.
Howell (2011) believes that observing language factors is a less demanding task for researchers, since children produce all of their speech-language activities spontaneously, which is not the case when it comes to non-speech motor activities. Non-speech activities placed in the focus of motor research commonly consist of the kinematics of orofacial non-speech and finger movements (Max, 2004), but these cannot be observed in the spontaneous behavior of children.

Only laterality or handedness can be observed in purely spontaneous behavior. This led to the effect of motor factors, especially in non-speech activities, to be observed mainly in later stages of stuttering development. However, the lack of discussion and research on the observance of spontaneous, non-speech motor activities in children only beginning to stutter does not mean that motor factors are not among those which can affect the occurrence of stuttering (Howell, 2011).

Howell, observing precisely the symptoms of stuttering in a number of his works, highlights another constraint of motor accounts of stuttering. It is the effect of changes in speech rate. Specifically, several studies aiming to observe motor control on speech performance systematically left out the effect of changes in speech rate on the type of stuttering symptoms. Motor studies (Hulstijn and van Lieshout, 1998; Vanryckegehem et al., 1999; Onslow et al., 1996; Natke et al., 2001) mainly used the classification of symptoms to distinguish between those participants who stutter and those participants who do not stutter. These studies inconsistently used classification into typical and less typical symptoms of stuttering. The manipulation of one of the most significant variables in observing motor factors – speech (speed) rate – was not used to observe whether or not changes in speed (and in what way) affect the occurrence of a higher number of whole-word or phrase repetitions, or the occurrence of insertions. Or, in other words, does the manipulation of the speech rate cause the occurrence of a higher number of or absence of typical stuttering symptoms, such as phoneme or syllable repetitions, phoneme prolongations, or abrupt disruptions of speech?

Motor accounts of stuttering are used in two techniques for the improvement of speech fluency in individuals who stutter – device for Delayed auditory feedback (DAF), and voluntary change in speech rate. The section on motor research into stuttering (2.5) will concentrate predominately on these two areas.

The DAF device has the effect of reducing stuttering symptoms in speakers who stutter. It was initially believed that this effect in adults who stutter differs completely from the effect
the DAF device has on a fluent speaker, and that an individual who does not stutter would begin to stutter when using the DAF device. However, this description of the effect of the DAF device is no longer used (Howell et al., 1988; Howell, et al. 2010b). The disruptions of fluency while using the DAF device take place as prolongations of middle vowels, and these prolongations occur in any individual using the device, regardless of the occurrence or absence of stuttering. However, something else is relevant. Under the influence of the DAF device, in individuals who stutter the prolongations of consonants at the beginning of a word are lost. These prolongations “make up” the typical symptoms of stuttering. This was how the DAF device was initially thought to help individuals who stutter, while individuals who do not stutter were thought to begin to stutter when using it. Howell et al. (1988) demonstrated that individuals who stutter “lose” the typical symptom of prolonging initial consonants, but that in the same way individuals who do not stutter begin to prolong the middle vocal in words.

In their *Disrupted Rhythm hypothesis*, Howell et al. (1983) (discussed in more detail in section 3.1.1), compared Lee’s effect \(^4\) of listening to one’s own speech through the device for delayed auditory feedback to speaking while listening to non-speech rhythms (metronome, some types of noise, speaking simultaneously with another person). Both occurrences are accounted for independently of the linguistic/language segment of the feedback. In the *Disrupted Rhythm hypothesis*, Howell et al. imply that speech is disrupted when what the speaker hears while speaking is simultaneous with the motor performance or word articulation. When an asynchronous interaction between auditory feedback and motor speech performance takes place, disfluencies occur. Thus, in the *Disrupted Rhythm hypothesis*, the interpretation of the effect of altered auditory feedback is an alternative to the language interpretation of Lee’s effect (the motor interpretation).

Alongside the already-mentioned auditory feedback, a significant effect on the fluency of individuals who stutter is also achieved by speech rate alternation. The explanations behind this phenomenon are also strictly motor-related. Observing auditory feedback, as well as other types of feedback, such as visual (Kalinowski et al., 2000), kinesthetic, and proprioceptive (De Nill and Abbs, 1991; Loucks and De Nill, 2001) feedback, motor research into stuttering focuses on measuring speech rate and analyzing its influence on fluency.

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4 Lee’s effect is the phenomenon in which a fluent speaker, when hearing his or her own speech with a certain interval of delay, begins to speak non-fluently)
Research measuring speech rate and the occurrence of stuttering differ based on whether or not they include in the measurement of speech rate the stuttering moments themselves. The traditional measuring of speech rate included pauses as well as all disfluencies, and speech rate in such measuring was expressed by the number of words or syllables divided by the overall duration of speech. More recent research used another measure – articulation rate (Kalinowski et al., 1993, 1995; Logan and Conture, 1995; Yaruss and Conture, 1995). This measure excludes all non-fluent words, syllables, and pauses during the utterance from measuring overall duration of speech.

These two measures are referred to as the global measure of speech rate, or measure of global speech rate, and the measure of global articulation rate (Howell et al., 1999b).

Besides the measure of global speech rate, there is also a local speech rate, obtained from the measure of articulation rate of a prosodically connected speech utterance. It is measured by calculating articulatory rate within one prosodic unit commonly extending over several words. The reason behind using the measure of local speech rate is that it can be used to examine the relation between language factors and the speech rate itself, believed by many researchers of stuttering to be of crucial importance.

The underlying idea behind the manipulation of speech rate is that a faster speech rate produces difficulty with maintaining the stability of motor control and therefore increases the chance of the occurrence of disfluencies. A higher speech rate in individuals with more severe stuttering usually “means” more disfluencies (Vanryckeghem et al., 1999) and greater variability in the alignment of movements needed for fluent speech performance (Ward, 1997). However, individuals who stutter under the circumstances of somewhat faster speech may demonstrate the same symmetry and speed of movement as individuals who do not stutter. Namasivayam and van Lieshout (2001) interpret this by the aligning the dynamics according to Kelso’s model of 1995. According to that model, the strength of interrelated movements reduces with faster movements, and therefore the entire motor system returns to more stable and more fundamental patterns of movement alignment, which may “assist” the maintenance of fluency (van Lieshout et al., 2004).

Therefore, a mere increase in speech rate does not have to result in a higher number of disfluencies. This was confirmed in studies by Kalinowski et al. from 1993 and 1995. These authors obtained different results in two separate studies. Their results imply that the speakers increased their speech rate either because of an accidental increase in speech rate during the
entire utterance (Kalinowski et al., 1993), or because of an increased rate in the slower, prolonged segments of the utterance, which would commonly “protect” speakers from disfluencies, and would be symptoms of disfluency themselves (Kalinowski et al., 1995). Since a higher speech rate can be achieved in different ways, the crucial information is in what way a higher speech rate may “provide” an individual with precise speech movements and usage of pauses between lexical units (van Lieshout et al., 2004). Also important is the question of how an individual who stutters can maintain stability of movement control with faster speech performance.

Speech motor skill very likely relates to the capability to postpone the occurrence of instability as induced by increases in rate. (van Lieshout et al., 2004, p. 321)

Since speech rate also refers to language planning preceding speech performance, in the 1999b study by Howell et al., speech rate was also observed. The hypothesis of this study conducted on eight children who stutter aged 9 to 11 concerned the verification of a higher possibility for the occurrence of stuttering in a more quickly articulated prosodic unit of an utterance, compared to one articulated at a moderate speed, or one articulated even more slowly. The study showed that longer prosodic units of utterances present a higher possibility for the occurrence of stuttering than the shorter ones. Likewise, the study demonstrated that the length of prosodic units without the occurrence of stuttering correlates with the speech rate (Howell et al., 1999b). It can therefore be claimed that an increase in the overall or global speech rate does not increase the occurrence of stuttering, but that, for the fluency of individuals who stutter, it is the local variations in the speech rate that are influential (van Lieshout et al., 2004).

It is certainly important to point out that motor models of stuttering also deal with two areas of study not dealt with by linguistic theories of stuttering. These are the variability of particular movements of the articulator and the alignment of the movements of the articulator (Howell, 2011).

The most significant theoretical motor models of stuttering dealing with these motor variables are:

1. *Dynamical Systems Theory* (DST) (van Lieshout, 2004);
2. *General Model of Motor Control and Application to Stuttering* (Max et al., 2004).
Van Lieshout’s (2004) dynamical systems theory is based on observing fluent speech and has made significant contributions to the understanding of stuttering. DST as a concept, according to the author of the theory himself, is a powerful tool in the research of speech motor control and its influence on the stability, plasticity, and variability of speech movements. Van Lieshout tries to strictly distinguish between adaptation to potential motor restrictions of speech capabilities and their direct manifestations. DST also provides a significant contribution to the research on the relationship between neural activities and verbal behavior (van Lieshout, 2004).

Motor behavior of individuals who stutter, according to van Lieshout et al., strives to be less effective, more variable and simpler, sometimes even “immature” in dealing with the demands of the complex alignment of specific articulators. Speech motor abilities are not a dichotomy but a continuum, and individuals are “placed” in different areas on this continuum. Therefore, it would not be justified to refer to stuttering as a disorder, since disorders imply a complete understanding of what is normal/usual and what is not normal/usual in speech production (van Lieshout, 2004).

*In this sense, we hesitate to call stuttering (yet) a disorder, since the label “disorder” implies we have a good and complete understanding of what is normal in speech production. We do not.* (van Lieshout et al., 2004, p. 340)

Authors of motor theories of stuttering commonly deal with and refer to speech production. Keeping in mind that every speech production is preceded by language planning (discussed in more detail in Chapter 3), language production and speech performance, or speech-language production, should inevitably be mentioned here as well.

The General Model of Motor Control and Application to Stuttering by Ludo Max et al. included a feedback and a feedforward control of speech movements during a performance. The advantage of this model is that it introduced computational implementations of its predictions. In this theoretical model of stuttering, it is predicted that stuttering is a result of incorrect and unstable inner models of sensomotoric control of movements.

*In essence I have suggested the possibility that the onset of stuttering may be related to difficulties with the formation, consolidation and/or updating of internal models that correspond to neural mappings between central motor commands and sensory consequences resulting from those movements.* (Max, 2004, p. 379)
2.6 Research into stuttering in Croatian

The first paper on stuttering in the Croatian language was published in *Liječnički vjesnik* (*Medical Journal*) by Dr. Hinko Lehner, a physician who stuttered himself. The paper was actually a lecture, titled *O mucanju* [On stuttering], given at the Assembly of Physicians in August of 1895 (Vučak, 2010).

In treating individuals who stutter, Lehner used hypnotic techniques, since he linked the cause of stuttering mostly to the psychological and volitional areas of speech.

In an issue of *Liječnički vjesnik* published in 1939, stuttering was referred to as a neurosis by Dr. Hinko Freund, MD, one of the first authors to deal with speech-language pathology in Croatia:

> *Today the prevailing thought is that the combination of abnormal speech constitution ("easy" disruptions of speech due to affects, "light" inclination towards paraphrases, tachylalia, etc.) with a neuropathic or psychopathic disposition is what influences the development of stuttering.* (Freund, 1939, p. 131)

It can be noted that in the first decades of the twentieth century hypotheses on the causes of stuttering resulted from psychological interpretations. In these presumptions a strong influence of psychoanalysis is apparent, since its concepts at that time were included in almost all interpretations of human behavior, particularly in those dealing with verbal behavior.

In the next few decades of the twentieth century the science of stuttering was mostly marked by combinations of psycho-motor and functional interpretations of its occurrence and development (Sulejmanpašić, 1969; Vladisavljević, 1983; Brajović i Brajović, 1981).

Since 1972 in Croatia the most prolific researcher on stuttering has been Behlul Brestovci. Brestovci has written about stuttering from different points of view. Among his various approaches are analyzing the effect of listening to one’s own speech in individuals who stutter (Brestovci, 1972), predicting the intensity of stuttering (Brestovci, 1975; 1976), classifying stuttering symptoms (Brestovci, 1977), connecting stuttering, motorics, and anxiety (Brestovci, 1978), differentiating between anxiety in individuals who stutter and individuals who do not stutter (Brestovci, 1979), and connecting intellectual status to stuttering (Ljubešić and Brestovci, 1979). In 1986 Brestovci also published a book titled *Mucanje* [Stuttering], a detailed overview of etiological factors, occurrences of symptoms, and research into stuttering.
One of Brestovci’s crucial studies on stuttering was conducted in 1977, on the classification of errors in stuttering. This study was conducted on 107 pupils aged 15 and was based on the analysis of reading recordings. The results are significant because this was the first study on the Croatian language which confirmed that errors can be divided into more crucial and less crucial ones for the occurrence of stuttering. The obtained vectors, interpreted as the underlying factor of disfluency, comprised the following variables: syllable repetition, pauses, word repetition, phoneme prolongation, and insertion. The nonspecific factor of disfluency included the following variables: phrase repetition, alternation in speech rate, and omission. Despite the fact that the analysis and interpretation of results could neither confirm nor deny the hypothesis of a two-factor classification of disfluencies in individuals who stutter, this research provided first significant indicators that different disfluency symptoms have different linguistic origins. The study also significantly affected the further development of diagnostics and stuttering therapy in Croatia.

Another study by Brestovci from the early 1980s is very important: his study on the canonical relations between certain motor factors and anxiety in individuals who stutter (Brestovci, 1980). The study included 107 boys aged 14;5 to 15;5, and relations between the factors of motor coordination and anxiety were analyzed. The canonical correlation analysis demonstrated that there is a significant segment of common variability (30%) between the factors of anxiety and motor function. In the interpretation of the results, the author pointed out that anxiety “acts” differentially as noise affecting the performance of particular coordination movements in individuals who stutter. The obtained results, i.e. their interpretation, were in accordance with Brestovci’s hypothesis (1975) that some general motor coordination movements are pathologically affected by conative factors, and not stuttering itself.

The significance of this research lies in the elimination of the “pathogenic” effect of stuttering on the disruption of general motor functioning. The same was achieved by another important study on speakers of Croatian, which focussed on intellectual status and stuttering (Ljubešić and Brestovci, 1979). The two authors conducted 11 cognitive tests on a sample of 106 pupils aged 14;5 to 15;5 who stutter and on the control group of their peers. Their research demonstrated that there is no significant difference on the tests between the groups of pupils who stutter and the control group. The only statistically significant difference was obtained on the test of verbal naming of synonyms. This difference was interpreted using the presumption of the effect of neurotic symptoms on the test result. The authors concluded that cognitive
factors are not the reason behind the occurrence of stuttering, although they may occur in the development of accompanying symptoms (Ljubešić and Brestovci, 1979).

In the 1990s, research on stuttering in Croatian was mostly directed towards the study of electromyographic biological feedback. Novosel (1990) measured the difference in the level of tension in the muscles of the larynx in the prephonatory stage of speaking, during the maximal voluntary contraction of the larynx, in the prephonatory stage of reading, and while actually reading (out loud) in 90 participants of both genders, aged 15 to 24. The participants were divided into two groups: a group who stutter and a group who do not-stutter. This study demonstrated that the prephonatory stage of speaking has the highest coefficient of correlation with stuttering, and that the highest level of significance is in the relation between the level of muscle contraction in the larynx and the intensity of stuttering in the prephonatory stage of reading. Furthermore, significant differences were found in the prephonatory stage of speaking and reading between individuals who stutter and individuals who do not stutter (Novosel, 1990).

Studies using electromyographic feedback had far-reaching impact on the science – theoretical as well as therapeutic – of stuttering.

The success achieved using this method was demonstrated by Prizl (1997). This research was aimed at analyzing the manifestations of stuttering during the application of electromyographic biological feedback, and dealt with the effects of the method on 68 participants aged 10 to 43 (21 females and 47 males). In the study, the manifest area of stuttering was measured by 9 variables for which basic statistical indicators were measured and factor analysis and t-test were applied. The results demonstrated significant differences in the structure of the manifestations of stuttering at the beginning and at the end of therapy. Alongside the decreased tension in the muscles of the larynx, qualitative and quantitative changes in the frequency of stuttering in speaking and reading were noted, as well as changes in the duration of disruptions (Prizl, 1997).

Research into stuttering from the end of the twentieth century were also aimed at analyzing attitudes towards stuttering (Popović-Sardelić, 1981; Mitrović, 1979), analyzing accompanying occurrences and undesirable patterns of behavior in children who stutter (Sardelić and Heđever, 1988), as well as looking into social sensitivity and stuttering (Jelčić Jakšić, 1996). Prpić (2011) compared self-reporting, reporting by parents and by teachers on
emotional, behavioral problems and competences between children and adolescents who stutter and a control group.

Research into stuttering in the Croatian language in the twenty-first century has been mostly conducted on groups of children who stutter. Recent studies have focussed on laryngeal dynamics in children who stutter (Heđever et al., 2003), distinguishing between neurogenic and developmental stuttering (Sardelić and Šikić, 2008), speech motor abilities in children who stutter (Pavičić Dokoza and Heđever, 2010), the duration and variability of segments in fluent speech in children who stutter and children who do not stutter (Pavičić Dokoza et al., 2011), and the orofacial skills of children who stutter (Sardelić et al., 2014).

Other research has focussed on the analysis of the attitudes of children who stutter towards verbal communication (Jelčić Jakšić, 2012) and on the phonological consciousness of children who stutter, with the aim of analyzing linguistic variables (Sardelić et al., 2007).

Synthesizing the conclusions of the above-mentioned studies on stuttering in the Croatian language in the last fifteen years we can point out the following conclusions:

a) Children who stutter are less successful in controlling respiratory-laryngeal dynamics (Heđever et al., 2003).

b) Slower duration of certain time segments in children who stutter is either an unconscious compensatory mechanism, or a result of a disrupted articulatory program which is not able to reach the norms of the population without speech difficulties (Heđever et al., 2003).

c) In early childhood, around 5% of children stutter, and around 3% of children spontaneously stop stuttering. In the remaining 2% there are a lot of children for whom stuttering is only a symptom of another pathology (Sardelić and Šikić, 2008).

d) Children who stutter demonstrate lower results on diadochokinetic tasks than children in the control group (Pavičić Dokoza and Heđever, 2010).

e) Children who stutter cannot achieve the same duration of syllables as children in the control sample when the verbal task is conditioned by fast and rhythmic repetitions. The detected slowness is not the underlying behavior but a compensatory mechanism.
for avoiding “breaks” in speech production. Slower movements of the articulator provide more time for other systems to meet the demands crucial for the performance of the required task (Pavičić Dokoza and Heđever, 2010).

f) The length of an utterance in combination with the phonetic characteristics of articulated phonemes at the beginning of a sentence may result in a more complex fluent articulation for children who stutter compared to children who do not stutter (Pavičić Dokoza et al., 2011).

g) Orofacial abilities in children who stutter (abilities including movements of the mandible, tongue, lips, palate, cheeks, and throat) are of lower quality than orofacial abilities in children who do not stutter. In children who stutter, difficulties in the articulation of certain phonemes are more frequent, and they have a mandibular and sensor consciousness of lower quality, which can be concluded on the basis of a higher number of difficulties in recognizing objects by the touch of the tongue or by recognizing the point of contact on the tongue. Stuttering is therefore a motor disorder (Sardelić et al., 2014).

h) In children who stutter the severity of stuttering is in a statistically significant positive correlation with the attitudes on verbal communication. The attitudes on verbal communication are negatively altered with age in children who stutter, and are more negative in families with a history of stuttering. Likewise, the attitudes of children who began to stutter earlier are more positive than the attitudes of children who begin to stutter later on, and there is a statistically significant positive correlation between stuttering and emotions (Jelčić Jakšić, 2012).

i) Results of parental estimates indicate that subjects who stutter are worse on the scale of capabilities in the variables of school success and overall capability. Parents attach more problems to children who stutter on most of the variables of the problem scale (withdrawal, anxiety/depression, social problems, cognitive problems, internalizing disorder, and total problems). According to the assessment of teachers (and/or speech therapists) and the self-assessment of young people, the group of children and adolescents who stutter are not distinguished from the control sample in terms of their capabilities, while in the problem-solving scale more social problems are observed.
The duration of stuttering positively correlates with the problem of attention (Prpić, 2011).

j) In the analysis of four phonological variables (the extraction of the initial phoneme in a word, the extraction of the final phoneme in a word, the analysis of a sound sequence, the synthesis of a sound sequence) the control group of children was significantly more successful than children who stutter only when it came to the variable *analysis of a sound sequence*. The research did not show whether or not children who stutter have less successful phonological abilities than children who do not stutter, as opposed to some studies of stuttering in English. The authors concluded that, due to the interlanguage differences between English (the language with the highest number of conducted studies) and Croatian, language research on stuttering should be conducted on speakers of Croatian as well (Sardelić et al., 2007).
A few psycholinguistic models suggest the existence of a connection between speech disfluency and language planning – the models of Wingate (1988), Perkins et al. (1991), the sentence plan alignment model (SPA) (Karniol, 1995), the covert repair model (Postma and Kolk, 1993), and the EXPLAN model (Howell and Au-Yeung, 2002). According to Wingate, disfluencies occur due to errors in the phonological encoding of a syllable in a word, since the retrieval of the syllable onset and the retrieval of syllable ending, or the syllable rhyme, do not happen at the same rate. (A rhyme consists of a nucleus and a coda [Jelaska, 2004]). According to Wingate, an individual who stutters, after having articulated the syllable onset of a word, cannot fluently move on to the articulation of the final segment of a syllable.

In their model, Perkins et al. observe disfluencies as the result of a time discrepancy between the linguistic and paralinguistic systems. Their model is based on Shattuck-Hufnagel’s (1979) phonological concept of slots and fillers, and it assumes that disfluencies occur due to a discrepancy between the time needed to process a syllable slot carrying suprasegmental or paralinguistic information and the processing time or the time required for the phonological filler retrieval of a syllable carrying segment information.

Karniol, in his Sentence Plan Alignment Model (SPA), brings forth the assumption that disfluencies occur when a speaker realigns the core suprasegmental plan with a revised sentence plan formed while speaking.

All three models suggest that, stuttering occurs when there is a disturbance in the time alignment of the language planning and the articulation act of that plan. Such alignment is a necessary precondition for speech fluency.

Two more relevant models address the effect of language planning on the occurrence of disfluency– Postma and Kolk’s Covert repair hypothesis (1993) and Howell and Yeung’s EXPLAN theory (2002).
The covert repair hypothesis is essentially an impairment adaptation theory (Kolk, 1991). The covert repair hypothesis assumes that the inner feedback in the speech-language process has a monitoring function, monitoring errors in phonological encoding, and that the attempt to correct a detected error before the articulation begins (the so-called covert repair of an error) is the underlying reason for the occurrence of speech disfluencies (Kolk, 1991; Postma and Kolk 1993; Kolk and Postma, 1997). Like the EXPLAN theory (Howell and Au-Yeung, 2002), this theory falls under the category of monitory theories of stuttering. According to the Covert repair hypothesis, all the disfluencies typical of stuttering (disruptions, hesitations, prolonged articulation of phonemes or syllables, repetitions of monosyllabic words or word segments) are explained in connection with this self-monitoring process.

The covert repair hypothesis builds its interpretation of the occurrence and explanation for the symptoms of stuttering as a speech disorder on Levelt’s model of speech production, in which speech performance is hierarchical and includes lexical and phoneme levels. According to Levelt’s model, fluent speech is a result of an accurate performance on all speech-language production levels. Disfluencies in speech-language production occur if there is an error on any level of such a hierarchical system (Levelt, 1989; Levelt et al., 1983; Erdeljac, 2009).

According to Levelt’s model, the first segment of this hierarchical system is a component the author refers to as the Conceptualizer, in which the intention for the articulation is formed. The communication intention forms a conceptual arrangement in the structure of knowledge of the world, which is stored in the mind in the form of lexical concepts creating a preverbal message. In Levelt’s model this preverbal message is at the same time an output unit of the Conceptualizer. The preverbal message is then passed on to the second component of speech production, the Formulator, in which conceptual information is conveyed into linguistic information, by means of two types of encoding of the message, grammatical and phonological encoding. The first encoding type, the grammatical one, begins in the system of declarative knowledge stored in the mental lexicon by means of lemmas, semantic features of a lexical unit, and the procedures of its syntactic construal. During the grammatical encoding, the surface structure of the utterance is formed, a process involving the second step in the lexical access to the target word, phonological encoding. Phonological encoding forms an inner representation of a sound succession or phonetic plan. Levelt (1993) believes that the phonetic plan is not an already available form retrieved as a whole. In his opinion, speech errors indicate that the final word form is always formed anew. In this way, an error such as peel like flaying instead of the intended phrase feel like playing reveals that only to some
extent can the frame be determined independently of the fillers. In the encoding process of the word feel, the segment information for the phoneme f is lost, and the slot is incorrectly filled with the already available segment p. The fact that the speaker will not say eel but peel indicates that there is an already active word frame enabling that the filler searches for the initial consonant f. Levelt specifies that the most important insight of contemporary research on speech errors is the hypothesis first introduced by Shattuck-Hufnagel in 1979 (according to Erdeljac, 2009), on the mutual independence of the word frame and its segment content.

The phonetic plan is an interphase to the Articulator, the final component of Levelt’s hierarchy of speech production. In the Articulator, the successive segments of inner speech are retrieved from the temporary articulation memory, and those segments are placed in word performance by a series of coordinated moves of the articulatory organs, with the involvement of the respiratory, laryngeal, and supralaryngeal muscular systems. The final formatting of the sounds of a particular word is achieved by the movements of the articulatory organs. Levelt’s model is presented in Figure 8.

![Figure 8. Level’s model of speech production, according to Erdeljac, (2009).](image)

The monitoring of the entire process of speech production, as well as the occurrence of an error within the lexical access phase, phonological encoding, and error repair as potential...
causes of disfluent speech performance, are a crucial part of the interpretation of the occurrence and development of stuttering for models such as the covert repair hypothesis. This theory presupposes an expanded interpretation of speech production control compared to Levelt’s model (1989), because it assumes that the process of speech production is controlled by a monitoring mechanism. This system is wider than the error repair system in the speech comprehension module, as interpreted by Levelt’s model. Levelt’s model suggests that the system of speech comprehension processes both inner speech (i.e., pre-articulated speech) and articulated speech.

It is precisely the comprehension system which, according to Levelt, detects both types of possible errors, those from inner speech and those which are articulated, and the final stage of speech performance monitoring takes place after the system of speech comprehension passes on the information in the form of segmented speech to the control monitor in the Conceptualizer, which then triggers a new encoding for the correct word as a replacement for the incorrectly articulated word. At the moment of the occurrence of error in the control module, the termination of speech takes place and the correction beings.

According to the covert repair hypothesis, there are three degrees of the feedback through which the monitoring system for speech errors functions. The first degree takes place during the conceptualization of a preverbal message, before its grammatical and phonological encoding. This is followed by two feedbacks or loops: an internal loop and external loop (Postma and Kolk, 1993; Horga, 1997). The inner feedback is part of the articulatory program and corresponds to various forms of extra-auditory stimuli (tactile, proprioceptive, kinesthetic, and vibrotactile) (Horga, 1997).

Inner feedback is very rapid, does not reach the cortical centers, and in the interpretation of articulation control is referred to as an “error in advance”, because it enables certain articulatory errors to be corrected at the level of the articulatory program, that is, before the performance itself. The monitoring of errors achieved by the inner feedback system (Postma and Kolk, 1993) can trigger the correction before the articulation itself, but the correction can occur also by the activity of an outer feedback system, that is at the moment of listening to one’s own speech containing an error, after a word has already been articulated.

External feedback is therefore generated by listening to the spoken word.

The covert repair of an error takes place in the first situation, when speech is disrupted, or a speaker hesitates and repeats segments of words (or whole words), as an indication that an
encoding error has appeared. In that case, there is no explicit indicator of an error, and it is covertly corrected before the articulation itself, and what is produced instead of the incorrectly articulated word are symptoms classified as disfluencies similar to stuttering (Postma and Kolk, 1993; Horga, 1997; Howell, 2011).

Kolk and Postma (1997) considered the reaction to a detected error and the attempt to eliminate an error detected by inner speech to be the basis for the occurrence of all verbal behavior in stuttering. Thus, for example, a speaker articulates the sentence *that is (a) planet as that is ... (a) planet* (the three dots signify hesitation in speech). The speaker produces this hesitation because he fails to phonologically correctly encode the word *planet*, since simultaneously with the phoneme selection for the word *planet*, another phonological sequence is activated, such as for the word *planchet*, its “competitor”.

By using monitoring (inner feedback), the speaker detects an error before articulating the word *planet*, and using the covert repair mechanism, achieved in speech as hesitation, corrects the incorrectly selected word *planchet* into *planet* by a repeated encoding.

Although disfluencies as reactions to the inner speech errors also occur in people who do not stutter, the covert repair hypothesis maintains that individuals who stutter are more prone to errors in phonological encoding and reactions to them. Precisely the reactions to the occurrence of errors, that is, their covert repair (hesitating, repeating monosyllabic words, repeating and prolonging word segments) is the reason for the occurrence and development of stuttering (Kolk and Postma, 1997).

In explaining the mechanism behind the occurrence of an error in selecting the target phonological unit, Postma and Kolk employ the concept of spreading activation from Dell’s interactive model of speech production (1997; 1986). In that model, on the lexical level there is a unit corresponding to a word, and on the phonological level one unit corresponds to a phoneme. An activation unit or node spreads the activation to all words containing that phoneme. The activation spreads from the sentence level and the selection of syntactic features to the morphological, and finally, to the phonological level. The activation of the phonological system returns to the higher system levels by feedback, which can lead to the activation of an unsolicited word if the word selection takes place too quickly.

The most common mistakes in the “shortened” selection time are substitutions (the target segment is replaced by an incorrect one, which can, but does not have to, originate from the rest of the utterance; for example, *peoble – people, money – honey*) (Erdeljac, 2008).
According to the covert repair hypothesis, discrepancies within phonological encoding result in phonological representation errors in inner speech, which occur because of the higher activation level of substitutional lexical units or unsolicited words.

Competition between two words and the selection of words of a higher activation is the result of a higher speech rate intention, or the existence of a slower phonological encoding in which there is a reduced possibility that the target node reaches the activation level unambiguously higher than the activation level of the competitive node (Postma and Kolk, 1993).

Phonological encoding begins at the moment when the activated unit or node, at the specified loci, starts to fill the frame. This is possible only for those nodes in the frame which have the highest activation level when the speech motor plan begins. Postma and Kolk (1993) assume that the activation of phonological segments or activation units in individuals who stutter runs too slowly for the target word to be activated on time. That way, when an individual experiencing a slower phonological encoding attempts to speak at the usual speech rate at which the selection of a phoneme occurs in point S, it is more likely that an unsuitable or inadequate phonological node for the forming phonological frame would be activated. In other words, the levels of activation of the target word which is its competitor (the word *rat* for the targeted word *cat*, according to Dell and Seaghdha, 1991), have the same activation strength preventing a timely selection of the target word. Figure 9 presents two types of phonological encoding, one with the usual activation rate and one with a slower activation of phonological units at three points – S- (rapid speech), S (usual speech rate), and S+ (slower speech).

An individual with slow phonological encoding will at the moment when a higher speech rate is expected (displayed as a time point in activation (S-)), experience a higher activation for the competitive word. At the usual speech rate, point (S) will have the same activation level for both the target word and the competitive word, which could in both cases result in certain disfluency symptoms in speech. An individual with a slower phonological encoding will experience, at the moment when the speech rate starts to decline (displayed by the point of activation (S+)), segments of the target word on a higher or a stronger level of activation than the segments of the unsolicited word. This will enable the individual, in the prolonged activation-time, to form the phonetic plan without an error. In Figure 9, the activation levels of the target word and the competitive word are presented along the vertical axis, and point (S-) (activation time-point at a higher speech rate), point (S) (activation point at a usual speech rate), and point (S+) (activation point at a slower speech rate) are presented along the
horizontal axis. The curves present the distribution of results for individuals with normal phonological activation and individuals with slower phonological activation.

![Graph showing activation of target word and competitor word in rapid (S-), usual (S), and slower (S+) speech in individuals with normal and slow phonological activation, according to Kolk and Postma, (1997).]

**Figure 9.** Activation of target word and competitor word in rapid (S-), usual (S), and slower (S+) speech in individuals with normal and slow phonological activation, according to Kolk and Postma, (1997).

The self-monitoring system detects errors which are a result of the activation of the competitor phonological unit. At that point the speech is interrupted and an error is corrected by the mechanism of covert repair before the articulation takes place. The covert repair disrupts fluent speech, resulting in a number of symptoms of disfluent speech. In speech, this can manifest as a repetition of a whole monosyllabic word, or as hesitation and repetition of the first phoneme or syllable in a word. Postma and Kolk (1993) presupposed that the type of error depends on the (size of) the syllable segment realized before the speech interruption, due to the error detection. Therefore, if a speaker intends to articulate the syllable SIT, but there is an error in phoneme selection contributing to the formation of the code for SIT, a number of errors might occur, depending on the point the phonological plan has reached. If the interruption takes place before the syllable onset, this will result in a pause, and if the interruption of the phonological planning takes place after the selected node for the first phoneme, this will result in a prolongation (SSSSSIP) or a consonant repetition (S..S..SIP). If the interruption takes place after a vowel, a repetition of a syllable segment (SLSIP), or a delay (SIIIIP) and a word disruption (SI#P) occur. If the interruption takes place later on, a syllable repetition (SIT...SIT) or an overt repair (SIT...SIP) occurs.
Table 2 presents segments of the syllable SIT up to which encoding took place before speech interruption has occurred.

Table 2. Covert repair after inner-syllable interruption. Relation between syllable planning and type of disfluent articulation, according to Postma and Kolk, (1993).

<table>
<thead>
<tr>
<th>Incorrect plan for syllable SIT</th>
<th>Target syllable SIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produced plan</td>
<td></td>
</tr>
<tr>
<td>Disfluency occurring within syllable</td>
<td></td>
</tr>
<tr>
<td>Without audible sound</td>
<td>#..SIP</td>
</tr>
<tr>
<td>S</td>
<td>SSSSIP</td>
</tr>
<tr>
<td>S</td>
<td>S..S..SIP</td>
</tr>
<tr>
<td>SI</td>
<td>SI..SIP</td>
</tr>
<tr>
<td>SI</td>
<td>SIIIIP</td>
</tr>
<tr>
<td>SI</td>
<td>SI#P</td>
</tr>
<tr>
<td>SIT</td>
<td>SIT…SIT</td>
</tr>
<tr>
<td>SIT</td>
<td>SIT…SIP</td>
</tr>
</tbody>
</table>

An individual who does not stutter can successfully reformulate one’s own speech plan within covert repair during the first or the second attempt, but an individual who stutters has to reformulate his or her own speech plan by the covert repair system with many repetitions of a word onset, and does this much more often than an individual who does not stutter (Postma and Kolk 1993). The two authors are aware that there is a possibility of an error occurring on another segment of linguistic encoding (for example, on the semantic, syntactic, or morphological segment).

Since in the theoretical concept of the covert repair hypothesis slow phonological encoding is considered to be a supporting factor for the occurrence of stuttering, the main research focus dealing with a review of this hypothesis is placed on the problem of the speed rate of
phonological encoding in individuals who stutter, and on the connection between the speed of phonological encoding and the number of phonological errors.

As previously stated, the underlying assumption behind the covert repair hypothesis is that individuals who stutter have a properly developed competence for the perception of their own speech, and that the “errors” they try to correct are actual errors, meaning that they occur in one of the modules of their speech production and are not an illusion due to a wrong assessment of the accuracy of a produced utterance (Blocklehurst, 2008).

3.1 EXPLAN theory

The EXPLAN theory is the second monitory theory of stuttering that accounts for the occurrence and development of stuttering, as does Postma and Kolk’s (1993) covert repair hypothesis, by monitoring one’s own errors and trying to compensate for them. Unlike the covert repair hypothesis, the EXPLAN theory does not consider compensation to be a unified process of covert repair of an error before articulation in individuals who stutter takes place (Hartsuiker and Kolk, 2001). Here, as the name of the theory itself suggests, the compensatory moment of monitoring is divided into two processes: the planning of linguistic representations, whose duration depends on the complexity of the language process, (PLAN) and execution (EX), i.e., the speech performance function following linguistic planning.

This theory attempts to account for the development of the disorder and the exchange relation of symptoms through the years in which those symptoms last or disappear in the form of recovery. The occurrence of disfluencies in speech is explained by the influence of some levels in the hierarchical system of speech-language processing, but also by the influence of features of language structures. According to the EXPLAN theory, the crucial feature of language structures is the distinction between word types, especially between function and content words, and the transition from the disfluent articulation of function words to the disfluent articulation of content words is an indicator of a plausible explanation for the development of stuttering. Speech performance is realized through articulated sounds and word syllables, and its duration is determined by the motor complexity of speech (acts). The EXPLAN theory presupposes independence, but also a mutual influence in a segment of the
According to the authors of the EXPLAN theory, the three key concepts used to describe the occurrence of errors in speech are repair, monitoring, and feedback. Howell (2003) raised the question whether or not it is justified to use the term *error* when it comes to stuttering, if the error is not articulated and there is only a time disruption of speech fluency in the sense of hesitations or pauses. Howell refers to articulated errors as overt errors, and distinguishes them from those not articulated, which he classifies as errors within the covert repair mechanism. Symptoms of stuttering such as the repetition of words or word segments are classified as short overt errors, and are not a part of inner speech, that is, not a part of the inner monitoring feedback (Howell, 2003).

Likewise, Howell (2003) believes that, in the occurrence of disfluent speech, the monitoring of potential errors in linguistic planning and efforts for their correction are not crucial processes, as the Postma and Kolk’s (1997) covert repair hypothesis claimed. Howell (2003) highlights the underlying presumption behind the EXPLAN theory, according to which disfluencies in speech occur due to the time discrepancy between language planning and speech performance. Specifically, the articulation of one word occurs simultaneously with the linguistic planning of the next word. Disfluencies occur if a speaker speaks rapidly and completes the articulation of sounds belonging to one word before planning the segments of the following word. Howell points out the possibility that errors are a result of a time discrepancy in the synchrony between the linguistic plan and motor performance. These claims are supported by research results showing that difficulties with planning (Dworzynski and Howell, 2004) and a local increase in speech rate (Howell et al. 1999b; Howell and Sackin, 2002) are variables that have a significant influence on the occurrence of disfluent speech.

Apart from the postulate of time discrepancy between the linguistic plan and speech performance, the EXPLAN theory, like all theories dealing with the occurrence of stuttering, stresses the importance of comparing the types of disfluency in stuttering children with the disfluencies that are part of regular speech-language development. Taking this into consideration, the EXPLAN theory points out that children who begin to produce disfluencies similar to stuttering do not differ from children with fluent speech, with the exception that their speech planning is slower. Variation in speed rate, according to the EXPLAN theory,
one of the global features of speech production and is not exclusively tied to the speed rate of phonological encoding, as Postma and Kolk (1993) stated in their covert repair hypothesis.

Furthermore, as previously stated, this theory tries to explain the development of the disorder and the exchange relations of symptoms throughout the years during which those symptoms last or disappear in a form of recovery. The occurrences of disfluencies in speech are accounted for by the influence of language planning and motor performance in speech-language processing, but also by the features of the language structures themselves. According to the EXPLAN theory, the key feature of language structures is the distinction between word types – function (structure) and content (lexical) words (Pranjković, 2007). Function (or structure) words in Croatian can include both tonic and atonic words; tonic words are stressed forms of pronouns, some conjunctions, and adverbs, while atonic words (clitics) are proclitics and enclitics. Proclitics are prepositions (all the monosyllabic ones and some of the disyllabic ones), some conjunctions, and the negative particle ‘no, not’. Enclitics are unstressed forms of personal pronouns in the genitive, dative, and accusative; unstressed forms of the reflexive pronoun; and unstressed forms of the auxiliary verbs biti ‘to be’ and htjeti ‘will’ (Barić et al., 2005).

The transition from disfluencies on function words to disfluencies on content words is an indicator of an acceptable explanation for the development of stuttering. The linguistic encoding and motor performance of the two word types differ. Function words have a simple phonological structure, and their articulation is brief, while content words are phonologically more complex and their articulation takes longer. For this reason, the two word types provide the most important insight into the collision between the linguistic and motor segments of speech (Howell, 2011). According to the EXPLAN theory, such underlying mechanisms of stuttering behavior – prolonging in a function word and repeating segments of a content word when its plan is not yet ready – result from certain features of the two word types.

Adults stutter more when it comes to content words (Au-yeung et al., 1998; Brown, 1945; Dayalu et al., 2002; Howell et al., 1999a). “Typical” content words are nouns, verbs, and adjectives. They carry the semantic information of an utterance and are considered to be open classes of words because their number is constantly increasing (Dayalu et al., 2002). Function words include prepositions, conjunctions, the negation ne ‘no’, ‘not’, pronouns, auxiliary verbs, deixis of time or place (such as the adverbs here, there, before, after). Compared to adults, children stutter more when it comes to function words (Bernstein Ratner, 1997; Bloodstein and Grossman, 1981; Howell, 2007). Unlike content words, function words carry
the grammatical and functional information of an utterance and are considered to be a closed word class because of the extremely low chance for their membership to change (Dayalu et al., 2002). Gordon and Dell (2003) believe that the appeal of function words is associated with syntactic processing as opposed to content words, which depend on semantic processing. The EXPLAN theory tries to show that there are modifications or increases in the number of disfluencies from function to content words, and that this phenomenon signifies a progression in stuttering. Specifically, a particular feature of function and content words and their interrelation form the two underlying patterns of verbal behavior in stuttering: the pattern of stalling, characterized by the symptoms of slowing down the speech rate and stalling speech (such as repeating monosyllabic words or hesitating in speech (for example, that, that, that, \(\text{that is} \sim (a) \text{ rhinoceros}\); wavy line signifies hesitation), and the pattern of advancing, characterized by symptoms such as the repetition of word segments (syllables or first phonemes of a word; for example, \(\text{susususun}\)), the prolonging of phonemes (\(\text{suuuuuun}\)), and abrupt disruption of words (\(s_____n\)). These underlying patterns in stuttering behavior arise from particular features of two word types mutually distinctive in a variety of ways (Garrett, 1980, according to Erdeljac, 2009). Electrophysiological studies pointed out differences in the neural responses during the reading of sentences containing content and function words (Brown et al., 1999). Apart from language encoding, the two word classes also differ in the complexity of their motor performance and, therefore, provide an important insight into the collision of linguistic and motor segments of speech (Howell, 2011).

Alongside the above-mentioned lexical classes, the EXPLAN theory is also very interested in the role of prosodic units containing content and function words – phonological words (Selkirk, 1984). A phonological word is a part of prosodic hierarchy starting (from the top) with the utterance, then the intonation phrase, the phonological phrase, or the prosodic word, and finally, the foot and the syllable as the lowest levels of the hierarchy (Selkirk, 1978, 1995, 2009). The prosodic hierarchy is illustrated in Table 3.
Table 3. Prosodic hierarchy, according to Selkirk (1978).

<table>
<thead>
<tr>
<th>Prosodic hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utterance</td>
</tr>
<tr>
<td>Intonation phrase</td>
</tr>
<tr>
<td>Phonological phrase</td>
</tr>
<tr>
<td>Prosodic word</td>
</tr>
<tr>
<td>Foot</td>
</tr>
<tr>
<td>Syllable</td>
</tr>
</tbody>
</table>

The authors of the EXPLAN theory refer to the phonological phrase as a phonological word. The phonological word was first introduced to the theoretical accounts of the occurrence and development of stuttering by Au-Yeung and associates (1998) with an intention to test the hypothesis on the role of repeating a function word according to the already mentioned pattern of advancing in younger individuals who stutter. A phonological word consists of an obligatory content word and a number of function words preceding or following the content word. The phonological word has a general form of \([F_n C F_m]\), where \(n\) and \(m\) are whole numbers greater than or equal to zero (\(F_n\) signifies a function word preceding the content word, and \(F_m\) signifies a function word following the content word \(C\)). In their interpretations of the phonological word, Au-Yeung et al. (1998) and Howell et al. (1999) rely upon the semantic meaning that prosodic units have in relation to the sentences they are a part of. Specifically, the phonological word consists of the relationship between a function word and its accompanying content word, and their role in an intonation phrase at a higher hierarchy level than the phonological word itself. Selkirk’s rule (1984) states the following:

Two constituents \(C_i\) and \(C_j\) form a unit of meaning if (a) or (b) are true for the semantic interpretation of the sentence:

a) \(C_i\) modifies \(C_j\) (nucleus)

Example 1. [I look after] [her cats]

\[
C_i - C_j \quad C_i - C_j
\]
In the examples, square brackets denote the “limits” of phonological words. The words *I* and *her* are respectively associated with the words *look* and *cats* as their modifiers.

An example from Croatian: `[ja jedem] [tu juhicu] ‘[I eat][that soup]’.

C_i - C_j   C_i - C_j

The words *ja* ‘I’ and *tu* ‘that’ are associated with the words *jedem* ‘(I) eat’ and *juhicu* ‘soup’, respectively, as their modifiers.

b) C_i is an argument of C_j (nucleus)

Example 2. [He hit me] [in the face]

C_i - C_j   C_i - C_j

*He* and *me* are arguments of the verb *hit* and segments of the first phonological word; *in the face* is the second phonological word.

An example from Croatian: `[on se kupa] [u bazenu] ‘[he is swimming] [in the pool]’.

C_i - C_j   C_i - C_j

*On* ‘he’ and *se* (reflexive pronoun) are arguments of the verb *kupati* ‘swim’ and segments of the first phonological word; *u bazenu* ‘in (the) pool’ is the second phonological word.

Au-Yeung et al. (1998) proposed two more implicit rules, c) and d), building on the explicit rules a) and b) proposed by Selkirk.

c) Both C_i and C_j modify C_k (nucleus)

Example 3. [This boy] [seems] [poor to me]

C_i   C_k   C_j

*To me* does not directly modify *poor*, but it does modify *seems*, as does *this boy*. 
An example from Croatian: [ta maca] [se boji] [mene] ‘that kitty is afraid of me’.

\[
\begin{array}{ccc}
C_i & C_k & C_j \\
\end{array}
\]

*Mene ‘of me’ and *ta maca* ‘that kitty’ modify *se boji* ‘is scared’.

d) Both \(C_i\) and \(C_j\) are arguments of \(C_k\) (nucleus)

Example 4. [He likes] [the jolly] [waiter]

\[
\begin{array}{ccc}
C_i & C_j & C_k \\
\end{array}
\]

*The* is not directly related to *jolly*, but are both related to *waiter*.

An example from Croatian: [on pije] [od grožđa] [sokić] ‘he drinks grape juice’

\[
\begin{array}{ccc}
C_i & C_j & C_k \\
\end{array}
\]

*On* ‘he’ and *od grožđa* ‘from grapes’ are related to *sokić* ‘juice’.


Experimental manipulating using segments of phonological words enables an insight into the linguistic-motor impact in speech production (Savage and Howell, 2008). In a phonological word, such as *[od grožđa je]’(it)’s from grapes’, function words appearing in the proclitic position, that is, preceding the content word, may be affected by stuttering symptoms. Enclitics (words following content words), are usually not affected by stuttering symptoms. In this way, a three-year-old child is able to articulate, for example, *[od od od od grožđa je] repeating three times the proclitic *od‘from’, but after fluently articulating the word *grožđe ‘grapes’, articulates the enclitic *je‘is’ only once. The fact that the two types of function words may, but do not have to, produce speech disfluencies, as is the case with proclitics and enclitics, makes the role of function words in language planning heuristic, meaning that the impact of function words on the occurrence of disfluencies is not anticipated in every language situation (Howell et. al., 1999a). A similar example in Croatian is the articulation of the content word *lutka* ‘(a) doll’; its articulation will be facilitated by the repetition of the
proclitic za ‘for’ in the phonological word za lutku ‘for (a) doll’, but not by the enclitic će ‘will’ in the phonological word lutka će ‘(a) doll will’.

The phonological word is of special interest for the EXPLAN theory, since it contains words that vary according to the complexity of linguistic planning and speed rate of motor performance. A content word within a phonological word is also referred to as its head (Howell, 2011) or core (Selkirk, 1984). According to Selkirk, content words are the only actual phonological words; function words serve only as their affixes. There is at least one content word in a prosodic word. Content words, due to features that make their grammatical and phonological encoding complex, can cause the occurrence of advancing symptoms, which are considered a marker of chronic stuttering.

According to Howell (2011), those features are:

1. stress – content words, rather than function words, are stressed;
2. complexity – the phonological characteristics of syllables in content words are more complex than those in function words;
3. frequency – content words are less frequently used;
4. high phonological neighborhood density – content words have more phonologically similar words than function words, which makes their retrieval from the mental lexicon more difficult (Vitevitch, 2002; Anderson, 2007).

All these characteristics cause the language processing of content words to be more complex than that of function words. This complexity may also be contributed by the phonological features of a word (such as the manner of articulation of its consonants), but also by the age of acquiring the ability to articulate consonants. Consonants appearing later on in the development of articulation – developmentally late-emerging consonants – such as occlusives, affricates, and liquids are harder for children to articulate. Complexity of articulation is also caused by words with multiple syllables and consonant strings (Thornenburg, 1994). Function words usually require less time for planning and producing, since they are shorter and have more simple phonological features, leading to their role in the occurrence and development of stuttering to be quite different than the role of content words (Howell et al., 2006; Howell, 2011). The impact of phonological features of words on the occurrence of disfluencies will be dealt with further on in the chapter dealing with the effect of phonological complexity on the occurrence of stuttering with the framework of the EXPLAN theory.
As previously stated, the role of function words in the occurrence of stalling symptoms depends on their position in relation to a content word (the symptoms usually occur in proclitics, rather than enclitics\(^5\)). The phenomenon of stuttering symptoms occurring in only one type of function word led the authors of the EXPLAN theory to the conclusion that function words themselves do not have a role in the occurrence of stuttering symptoms, but that their role depends on whether or not they have the function of stalling and preparing the linguistic plan of a content word. A phonological word usually has a single locus of difficulties in planning – its content word. That “complex” word is preceded by a function word, a simpler word in terms of articulation, enabling more rapid access to the content word. Symptoms such as the slowing of the speech rate (pauses in speech, repetitions of whole words or clauses) take place before a content word to slow down the attempt at its articulation. Symptoms such as the repetition of word segments, the prologation of the same, or word disruptions are symptom types that occur in content words. They show that the speaker producing them is not prepared to articulate the content word (Howell, 2007). All of the symptoms listed above are typical of stuttering, and each of them presents one of two different processes: slowing down in proclitics by the mechanism of stalling (e.g., od od od od od grožđa from from from from from grapes’), or transferring the difficulty over to the head of the phonological word (a content word), which is not yet ready for articulation by the mechanisms of speeding up (e.g., od g,g,g,grožđa from g,g,g,grapes’). According to the EXPLAN theory, these different types of symptoms occurring within different types of phonological words are alternations between the simple motor and complex language segments. The phonological word enables an insight into linguistic and motor interrelations, the interaction of language and motor coordination. In the interpretation of the occurrence and development of stuttering, the EXPLAN theory emphasizes this interrelation. Both linguistic processing and speech performance are far less plausible explanations for the occurrence and development of stuttering if they are taken into consideration separately (Howell, 2011).

The EXPLAN theory is an attempt to answer the question of whether the linguistic system in children who stutter differs qualitatively from the linguistic system in children who do not stutter through research using longitudinal monitoring and research using cross-section age groups of children and adults who stutter (Howell, 1999a; Howell, 2007). However, there is

\(^{5}\)In Croatian, proclitics include all of the monosyllabic prepositions; a few disyllabic ones, such as medu ‘between’, mimo ‘past’, preko ‘over’, prema ‘towards’; prepositions containing the preposition iz (izmedu ‘in between’, iznad ‘above’, ispod ‘beneath’, ispred ‘in front of’), the conjunctions a, e, na, da, kad, and the negative word ne ‘no, not’ (Pranjković, 2007).
also a strong tendency within the EXPLAN theory to test the theoretical hypotheses in experimental research. For example, in one study of lexical priming in English, Savage and Howell (2008) designed an experimental schema using selective function- and content-word priming in two groups of children, those who stutter and those who do not stutter.

The selective priming was intended to show how a content-word plan formed “in advance” can contribute to a reduced time needed for planning, and consequently, to more fluent articulation of a content word when children, after having articulated it once after priming, repeat it in a target sentence. Savage and Howell refer to this phenomenon as the priming effect, which is not expected to take place when the words in a sentence are primed using a function word. Savage and Howell’s study from 2008 confirmed that content-word priming leads to more fluent articulation of all words in the articulated sentences, and that this happens in both groups of children, with a stronger effect in children who stutter. According to Savage and Howell’s opinion, the enhanced fluency of an utterance after content-word priming – when the word plan is already “prepared” and is thus not included in the time needed for its repeated articulation in the target sentence – is the first experimental evidence that disfluencies occur due to a time discrepancy between language planning and speech performance.

Apart from the impact of function- and content-words on the occurrence and development of stuttering, the EXPLAN theory is also interested in the impact of time needed to generate a motor output. Motor speech performance in people who stutter differs in a number of ways from motor speech performance in fluent speakers. Individuals who stutter experience different local and global speech rates, variability, and coordination of speech movements (van Lieshout et al., 2004; Max, 2004). As is the case with linguistic processing, motor processing time is shorter for function words than for content words, since their motor process is simpler and therefore faster (Howell, 2011). However, as has already been stated, according to the EXPLAN theory, motor factors alone are not sufficient to generate stuttering symptoms. Hence, Howell et al. (1983) introduced another concept to explain the relation between the linguistic and motor segments of speech production, the disruptive rhythm hypothesis, which is discussed in the next section of this dissertation.
3.1.1 The disruptive rhythm hypothesis in EXPLAN theory

Howell et al. (1983) observed the occurrence of stuttering in connection with the disrupted synchronicity of sequences in speech production and introduced the Disruptive rhythm hypothesis. Their hypothesis is associated with the explanation of Lee’s effect. Lee (1950) discovered the phenomenon in which a fluent speaker, when hearing his or her own speech with a certain interval of delay, begins to speak non-fluently. This phenomenon is accounted for by the fact that an individual perceives the altered sound signal as a speech-language error and tries to correct it by repeating a word or segments of a word in a stuttering-like fashion.

In the disruptive rhythm hypothesis, Howell et al. compare Lee’s effect, occurring when listening to one’s own speech through a delayed auditory feedback (DAF) device, to speech produced when the speaker listens to the rhythms of sounds other than his or her own speech (metronome, different forms of noise, two people speaking at the same time). Both phenomena are interpreted independently of the linguistic segment of feedback. The disruptive rhythm hypothesis implies that speech is regular (not interrupted) when speakers’ listening processes are synchronized with their motor performance or word articulation. Disfluencies occur when an asynchronous interrelation between auditory feedback and speech motor control takes place. Therefore, in the disruptive rhythm hypothesis, the interpretation of the altered auditory feedback effect is an alternative to the linguistic interpretation of Lee’s effect, and it is considered to be a motor interpretation. With this in mind, Howell et al. (1983) refer to G. J. Borden’s research (1979), which analyzed the effect of altered auditory feedback after continuous speech processing to the level of complete linguistic processing. Borden believes that there is a discrepancy between the speed of speech-error correction via the acoustic signal and the rate of speech production.

There is an assumption that auditory processing lasts around 100 to 200 ms, and that auditory output reaches the mechanism of linguistic feedback too late for it to control the encoding of segments. Borden further noted an example of hearing-impaired individuals who had acquired speech before their hearing-loss and continued to speak articulately despite the loss, which suggests that speech control can take place without sensory feedback.

The next question deals with the linguistic interpretation of the altered auditory feedback effect, and specifically refers to the DAF device’s delayed signal. The DAF device enables a subject to listen to his or her speech with an interval of delay (e.g., 40–200 ms). The question in terms of this device is the following: does the signal listened to on a DAF device have to
contain speech sounds, or could it be noise with no phonetic content? Howell and Archer (1984) tried to answer this question by transforming speech into noise with a similar prosodic structure of speech (but not speech). Such a listening mode was compared to the standard disruption of fluent speech using the DAF device.

The two conditions produced identical disruptions of speech fluency. Howell and Archer concluded that the DAF signal does not have to be speech in order to disrupt the fluent speech of an individual simultaneously listening to the signal and speaking and that an non-speech signal can also disrupt speech fluency. They also concluded that such a signal does not reach the system of speech comprehension. This, according to Howell and Sackin (2002), is a very important conclusion, since it brings into question the earlier concept in explaining the impact of the DAF device on the improvement of fluency in people who stutter, whereby the DAF device enables an individual who stutters to improve language processing by influencing the monitoring of articulatory errors. The results of the previous study led them to look for another explanation, other than a linguistic one, for the DAF device’s role in speech fluency improvement in people who stutter. Therefore, Howell and Sackin (2002) introduced the activation of cerebral structures as a mechanism which could be responsible for the occurrence of Lee’s effect through the DAF device. More specifically, they presupposed that a more reliable interpretation of Lee’s effect was that, by listening to one’s own speech through the DAF device, lower neural levels are reached, such as the level of cerebral time alignment, and not cortical structures. Cortical structures should be activated if delayed speech on the continuum of speech planning reaches the level of linguistic processing, which is not shown by the disruptive rhythm hypothesis. According to that hypothesis, speech alignment time is modulated by cerebral processes (Howell and Sackin, 2002).

When a speaker listens to one’s own speech through a DAF device, the asynchronous signals that are produced cause the timekeeper mechanism to be disrupted at the cerebral level. Howell (2002) interprets the asynchronous signals produced by a delayed listening time of one’s own speech as noise competing with speech. The assumption is that a similar asynchrony occurs when the motor instruction for an articulated word is not aligned with the planned language output (that is, when speech is not fluent). Speech is then also adjusted by the cerebral mechanism. This adjustment takes place in the motor process and provides the speaker with more time to plan the forthcoming language segment (repeating a function word by the mechanism of stalling).
Howell (2002) believes that, in order to comprehend synchrony and asynchrony, three questions need to be answered:

1. How does a speaker reveal the movement of asynchrony occurrence in speech performance?
2. How does the synchronous process of motor performance and language planning take place?
3. How does the process of synchrony decay in people who do not rehabilitate their disfluent speech and continue to stutter?

As an answer to the first question, Howell introduced a method of asynchrony verification by proposing the method of subtracting representations. In other words, if two temporary and brief signals of the same amplitude are aligned, then a deduction of one from the other annuls both representations. At the moment of speech, the signal of speech duration, an efferent copy of the motor commands, is aligned with the neural representations of speech recovered from vocal output (Howell, 2011).

If the two copies are equivalent, the copy which performs the motor command and the one recovered from the vocal output, are annulled. The same is true of listening to one’s own speech through the DAF device. Howell (2002) presupposes that the neural representation of an external signal, such as the DAF signal, cannot be annulled at the moment of motor output copy performance, that is, the executive command, since the signal an individual hears and speech he produces are unaligned or asynchronous. Therefore, the DAF signal alerts the speaker that he should align his speech performance with the signal he hears. The DAF signal, as an alert, enables the individual who stutters to extend the time period needed for linguistic planning and reduce chances for the occurrence of disfluency at the moment of listening to his voice through the DAF device.

In an answer to the second question, Howell pointed out that the discrepancy between motor output copy and the neural representation of output speech occurs for two reasons. The first one is the incompleted language processing and disrupted motor output copy at the moment the speech performance had already begun; the second one is due to the motor difficulties taking place after the language processing had already finished, which also led to a disrupted output motor copy. In any case, slowing down the speech rate will annul the alert, allowing a longer period of time for the finalization of both processes, language as well as motor. A speaker who stutters begins the speech performance with an incomplete language plan and an
efferent copy of that plan continues to be upgraded until it is completed. Slowing down the speech rate of an individual who stutters provides him or her with additional time for the synchronization process between motor performance and language planning.

In terms of the third question, the question of how such an alignment process decays in people who do not recover or keep on stuttering, Howell indicated that alerts produced by the discrepancy between the efferent copy of motor commands and the neural representations of speech recovered from vocal output is lost in time, due to an adaptation to the alerting sequence. The adaptation to the alerting sequence means that an individual who stutters is partially aware of the discrepancy between the executive copy and the perception of one’s own speech and is partially adapted to the alerts, resulting in a favorable situation for the occurrence of stuttering, since it occurs quite frequently (Howell et al., 2000b). This phenomenon of adaptation to the alert signals is the very foundation of the permanent stuttering disorder and of the transition to the more complex symptoms of a higher speed rate. The symptoms of a higher speech rate, as previously mentioned, are repetitions and prolongations of word segments, as well as pauses and interruptions of speech (Howell et al., 2000b).

3.1.2 The original EXPLAN schema (Howell and Au-Yeung, 2002)

The original version of the EXPLAN schema by Howell and Au-Yeung (2002) (Figure 10) provides insight into the time relation between planning and speech performance for different types of that relationship: a) fluent speech, b) stalling, and c) higher speech rate. The time relation for all three stages is indicated on the abscissa (X-axis).

The first segment depicts the speech performance for a word starting after its linguistic plan \((n)\) has been completed. During the articulation of the word \((n)\), there is enough time to plan the following word \((n+1)\). Segments b) and c) display a situation in which the performance of a preceding word is finalized before the plan for the next word has been completed, and the two ways in which a speaker may deal with the incomplete language plan. The schema in Figure 10 shows that, after the word \((n+1)\) is articulated for the first time, it is repeated so that its repetition will provide time needed to plan the next word \((n+2)\). The segment c) shows that, after the words \((n)\) and \((n+1)\) are completed, although the plan for the following word \((n+2)\)
is not completed, the speaker begins the articulation of the word \((n+2)\) and the plan is slowly realized, illustrated by the dotted line. The result of word articulation before its linguistic plan has been completed is the repetition of word segments. This leads to a sequence of symptoms referred to as stalling within the EXPLAN theory.

The phonological word *in the morning* (two function words, *in* and *the*, and one content word, *morning*) may be used as a typical example of such a process. The process of word repetition occurrence is associated with the situation of articulating an “easy” motor word, *the*, followed by the word *morning*, a more complex word for linguistic planning.

![Figure 10](image-url)  
*Figure 10.* Three types of synchronization between language plan and speech performance in the phonological word *in the morning* during: a) fluent speech performance, b) during stalling – repetition of the function word *the*, and c) during advancing – repetition of a segment of the word *morning*, according to Howell, (2011).

If during the articulatory performance of the “easier” motor word, the plan for the more complex word is not yet “available”, the compensatory processes of stalling or advancing occur. Stalling is a stuttering symptom occurring when there is a possibility of holding back the language plan for a function word, still available due to it being short and phonologically simple, and enables a repeated motor performance of the function word and additional time for language planning of the following content word. Stalling is realized as repetition of the motor process of articulating the preceding word or as a pause in speech. The repetition of words is possible, since the language plan of every word which can be reissued is still
available, and it is available precisely because it is short and phonologically simple (Blackmer and Mitton, 1991).

In example b), this is the article *the*. When it comes to the stalling types of fluency failure, it is important to point out that the articulatory performance of a word cannot occur before its linguistic plan is completed. This applies to both function and content words (Howell, 2011). Example c) illustrates advancing. The speaker starts the articulation of the word *morning* before its plan has been completed, and that leads to the repetition of the initial phonemes or syllables of a word (Howell, 2011).

### 3.1.3 The revised EXPLAN theory (Howell, 2003, 2007, 2011; Howell and Aknade, 2005)

The EXPLAN theory offers an interpretation of the occurrence of disfluencies in continuous speech that differs from the covert repair hypothesis. Kolk and Postma (1993) are focused on how activation trajectories in the phase of phonological encoding may lead to phonological errors after the lexical selection (already) took place. According to Howell (2003), this is quite logical, since fluent speakers conduct the lexical selection correctly in 99.99% of cases (Garnham et al., 1981, according to Howell, 2003). Howell highlights the important presumption of Dell’s (1986) model of spreading activation in speech production – competitive activation of phonologically similar words (for example, *cat* and *rat*). Howell (2003) is interested in why speech is interrupted at the point of an anticipatory selection, and why it does not continue after the activation at the highest point has already taken place. He believes that the error would be suppressed if the activation of a word coming after a point of selection has already taken place continued immediately after. Here Howell criticizes the theory of covert repair, according to which the moment when the competitive word has a higher activation than the target word, leading to the interruption and restarting of speech and the speaker repeating a word segment (a symptom of stuttering), takes place in the system of speech monitoring. According to Howell, continuous activation seems like a more plausible “solution”. He believes that, once the activation begins, it continues to the point of the completion of the linguistic plan; the inclusion of a monitoring system (internal and external
loops), and the restarting of activation construal for the target word are considered unnecessary (Howell, 2003).

The revised schema of the EXPLAN theory (Howell, 2003, 2007, 2011; Howell and Aknade, 2005) noted two new principles dealing with the spreading activation:

1. The following word has a higher activation level than the preceding words even when its activation has not yet been completed.
2. The plan of the previously articulated word or a word segment can be activated again if its activation has not faded yet and is still higher than the activation of the following word (Howell, 2011).

Likewise, as already mentioned, there is an emphasis on the redundancy of the error monitoring system (internal and external feedback) if the activation of certain units continues after the selection point of the target word is emphasized.

Figure 11 shows how the activation and decay of the word *he* and the incomplete activation of the word *stood* in the phonological word *he stood* lead to the stalling mechanism. The decay is a gradual process, meaning that the activation level of an articulated word will be in the process of decaying, i.e. will gradually tend to a descend below the activation level of the next activated word. This is illustrated in Figure 11 by a broken straight line transecting it and descending below the dashed line.

The y-axis presents the raising of activation and its decay for the function word *he* and the activation of the content word *stood*. The transition from activation to decay is shown as the point where the solid line abruptly changes direction. The broken line shows the activation of the content word *stood*, starting during the articulation of the function word and not being completed but is on its way to achieving complete activation. The x-axis represents the activation time. In this case, the symptom of stalling occurs, due to the activation of the function word being of a higher level than the content word, and therefore, the function word can be repeated (*he, he stood*), obtaining more time for the realization of the linguistic plan of the content word. In Figure 11 this is illustrated by the straight line descending after the point of the highest activation, but still remaining above the broken line representing the incomplete activation of the content word.
Figure 11. Activation of the phonological word *he stood* in the event of the occurrence of stalling symptoms, when the function word *he* is repeated. The solid line represents the activation and decay of the function word (*he*) and the broken line represents the incomplete activation of a content word (*stood*), according to Howell, (2011).

Figure 12 shows the activation and decay of activation in advancing for the phonological word *he stood*. The solid line represents the rise and fall of the function-word activation, and the onset of the content-word activation up to the point when the function word activation decayed and fell below the activation level of the content word. The complete decay or fall of the activation of the content word is shown by the transection of the solid line. The activation of the content word begins as a solid line, but continues as a broken line. The broken line represents the further progress of the content-word activation; its linguistic plan is incomplete, leading to the occurrence of symptoms connected with a higher speech rate. Those symptoms are a result of the decay of function-word activation and the fall of its activation below the activation level of the content word (illustrated by the transection of the activation line for the content word). The articulation of the content word begins despite its linguistic plan not having reached its full activation level, i.e. not being completed (illustrated by the broken line).
Figure 12. Activation of the phonological word *he stood* in a case where symptoms of advancing occur, namely, repetition or prolongation of the segment of word *stood*, or the disruption of its articulation. The solid line represents the activation and decay of phonological word activation (*he*), and the broken line represents content-word activation (*stood*), according to Howell (2011).

In this representation, the speech rate of articulation is reflected in the complexity of the articulatory constituents. If the speech rate corresponds to the complexity of the constituents, the phonological word will be articulated fluently.

If the speaker initiates the articulation of the content word based on its incomplete plan, the symptoms of a higher speech rate will be included in the first segment of the word. The question which then arises is how the advancing mechanism can be used to account for all the forms of stuttering (prolongation, repetition of word segments, disrupted words).

The EXPLAN theory presupposes that advancing as a segment of the plan or an incomplete word plan leads to the prolongation and repetition of word segments. In order to account for the occurrence within syllable constituents, the authors of the EXPLAN theory refer to segments of a universal syllable pattern: onset (O), nucleus (N), and coda (C). The nucleus and coda together form the rhyme, usually marked as R (Jelaska, 2004). The symptom of prolongation will occur when the plan includes only the syllable onset. The prolongation takes place particularly in continuant consonants and vowels. Continuants are phonemes with a fixed and continuous flow of air – the fricatives /f, s, š, h, z, ž/ and the vowels /a, e, i, o, u/.
Precisely the fixed and continuous air flow enables their prolonged articulation, for example in Croatian word *sat* (*watch*) – *sssat*, as illustrated in Figure 13 (Howell et al., 1986).

![Figure 13. The prolonged phoneme *s* in the word *sat* ‘watch’.

The repetition of a word segment will occur when the plan is finalized beyond the onset-nucleus boundaries and usually takes place on interrupted consonants or occlusives (the phonemes *p, t, k, b, d, g*). An example of this in Croatian is the word *kokokošara* ‘basket’ (Howell et al., 1986). The disruption of a word will occur when the plan is finalized up to the nucleus of the syllable (onset + nucleus), but not beyond this point in the syllable. An example of this in Croatian is the word *s_at* ‘watch’, in which the syllable onset *s* is articulated, followed by a disruption, and finally by the nucleus and coda.

In the revised version of the EXPLAN schema, difficulties in language planning leading to stalling and advancing are accounted for. The activation speed of lexical classes leads to the occurrence of difficulties with speech fluency. Specific difficulties connected with lexical retrieval or phonological encoding in people who stutter represent only additional variants of the activation rate. The motor component of speech performance is presented by the rate of activation decay, and this rate is the inverse of the building up of activation. The building up phase precedes full activation, during which the selection of a target word takes place (Howell, 2003).

Function words are activated quickly due to their more “simple” phonological encoding, but their activation decays at a slower rate than those of phonologically more complex content words. Content word activation takes more time, but its decay occurs more quickly. As stated previously, the occurrence of stuttering is related to an adaptation to alert signals appearing when there is a discrepancy between the executive plan for motor performance and the neural representation of an utterance.
The possibility of an alignment between speech rhythm and a completed language plan is disrupted by the reduced sensibility to alert signals, all together reducing the chances for spontaneous recovery from stuttering and causing an increase in the number of symptoms associated with a higher speech rate (Howell, 2011).

3.1.4 Summary of EXPLAN theory hypotheses

According to the authors of the EXPLAN theory, disfluencies occurring in function and content words are two different types of speech performance. Both occur as the result of a discrepancy between linguistic and motor segments of speech. One is stalling and the other is advancing. These two patterns are not the result of errors in phonological encoding, error detections, or attempts at error annulment by covert repair, but of a correct but slower phonological encoding. By stalling (or repeating) a function word, an individual obtains more time to finalize a completed content-word plan. At the beginning of stuttering, the speaker has the information about the slower phonological encoding offered by the alert signal system; however, as the effect of alarm signals starts to fade, articulation of a content word without a completed plan takes place. When articulation begins without a completed plan, advancing symptoms occur, indicating the development of stuttering. The EXPLAN model, and the authors supporting it (Howell and Au-Yeung, 2002), suggest that the development of the disorder is accompanied by different types of symptoms based upon different mechanisms. Therefore, a change in the symptom type could not be accounted for by the covert repair hypothesis, since, according to this theory, all the symptoms result from a single mechanism – the covert repair of an error – existing in the same form at the onset of stuttering, as well as in the more advanced stages of the disorder.
3.2 Research overview of lexical priming in picture–word interference tasks

In this dissertation the key research concept of selective lexical priming using two types of words is associated with the possibility of observing language planning in realtime. The method of lexical priming, or the method using an interfering stimulus or a primer, meets the requirements of this concept. The method represents a shift in the research paradigm in research on language processing in stuttering. Previous studies obtained data on, for example, the phonological development of a group of children who stutter only using standardized tests in which a phonological impairment was measured by a rank or a number of errors, and not the speech rate of phonological encoding, leading to a different insight into the phonological encoding of children who stutter.

In his report on phonological development in children who stutter conducted over a period of several years, Nippold (2002) stated that there were no statistically relevant qualitative or quantitative differences in stuttering symptoms in children who stutter and experience a phonological impairment, and their peers who stutter but do not experience other phonological difficulties. Nippold concludes that children who stutter make the same number of unsystematic phonological errors as their peers who do not stutter. Bernstein Ratner (1997) was the first to state that the shift in the research paradigm would lead to a different insight into the phonological encoding in children who stutter. In the new paradigm, the most important phenomenon is the occurrence of the psycholinguistic method of measuring real-time speech reaction using picture–word interference tasks with an interfering stimulus or a primer (Conture, 2004; Erdeljac, 2009).

The method of linguistic priming is based on the presumption that, if words or syntactic structures are adequately primed using a primer such as a phoneme, a word, or a sentence phonologically, syntactically, or semantically related to a target word or a sentence, the prime would speed up or slow down the representation of the target word or a syntactic structure in the mental lexicon, and/or its phonological encoding. Consequently, the primer will speed up or slow down the reaction time needed for its articulation. The target word or a sentence can be “produced” with a longer or shorter latency time in a picture naming task. The interfering stimulus or primer can be heard before, during, or after a picture appears, and will lead to the activation of a word or a syntactic structure in the mental lexicon, in a way that will depend upon some of the above-mentioned linguistic relations to the priming word.
A faster or a slower encoding of a target word, as a result of the linguistic relation between the primer and the target word, will occur in one of the constituents of language processing. The paradigm is particularly “useful” if the effect of linguistic planning needs to be separated from motor planning, since motor planning and articulation are equally affected by both experimental conditions – when the primer is used, as well as when it is not used. Thus, the methodological procedure of an interfering stimulus or a primer in picture–word interference tasks enables the isolated observance of everything (in terms of linguistic planning) preceding the final speech act, i.e., its motor performance (Conture, 2004; Brocklehurst, 2008).

3.2.1 Phonological priming

One of the first studies of phonological priming was conducted by Melnick et al. (2003). The study was intended to measure reaction time in a picture-naming task. Picture-naming was primed by listening to the same phonemes that the target words from the pictures begin with (for example, children hear the phoneme /f/, look at a picture of a flower, and then name the picture – flower). The study’s results showed that the average speed rate of phonological encoding was similar in children who stutter and the control group, but that the children from the control group showed a significant negative correlation between the time of speech reaction and the articulatory competence measured by a test of articulation. The children who stutter did not demonstrate such a negative correlation between duration of speech reaction time and articulatory capacity calculated by articulation test. This means that those children who do not stutter, and had been faster in the speech-time response, were better in the results of a standardized test of articulation (Goldman-Fristoe Test of Articulation-2; GFTA-2; Goldman&Fristoe, 2000). Children who stutter did not show this negative correlation. Melnick et al. concluded that the phonological systems of children who stutter is poorly or less well organized than those of children who do not stutter. Anderson and Byrd (2008) believe that this conclusion by Melnick et al. (2003) is not sufficiently established, since the criteria underlying it were not provided. Anderson and Byrd believe that Melnick et al.’s study did not offer a clear explanation for the presumption that the absence of a negative correlation between duration of speech reaction time and articulatory capacity calculated by articulation test. This means that those children who do not stutter, and had been faster in the speech-time response, were better in the results of a standardized test of articulation (Goldman-Fristoe Test of Articulation-2; GFTA-2; Goldman&Fristoe, 2000). Children who stutter did not show this negative correlation.

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6Two variables that we look at to determine their correlation relationship can be in four different relationships, and when a small value of one variable corresponds to a large value of the other and vice versa, this is a negative correlation (Price, 2000).
correlation in children who stutter would imply that they have a “less” organized phonological encoding.

Byrd and associates (2007) also used picture–word interference tasks in which target words in the pictures were preceded by segment primers (the first phoneme of a word) or holistic primers (the whole priming word), in order to observe phonological encoding in preschool children who stutter and their peers who do not stutter.

Byrd et al. (2007) found that children who stutter are significantly faster in naming words than children who do not stutter in experiments using whole-word priming, that is, in the holistic prime condition, but that they are slower under conditions of segmental or incremental priming, using the first phoneme of a target word. Byrd et al. (2007) account for this phenomenon by stating that segmental phonological encoding develops later than holistic encoding (Walley, 1988). Holistic processing (Charles–Luce and Luce, 1990) refers to the processing of a word as a single unit, while incremental processing refers to the processing of a word according to the “one-by-one” principle, that is, retrieving phoneme after phoneme. In research on children’s phonological development, there are records of children up to the age of three, thus at an early stage of their speech-language development, who process a word as a single unit, holistically. After the age of three, a gradual transition over to incremental processing takes place, which is accounted for by the fact that at that age the need for better distinguishing among a higher number of phonologically similar words arises, following a rapid growth of vocabulary (Walley, 1993, 1998).

For children who stutter, the holistic phase of phonological encoding development lasts longer. Such a mode of phonological encoding of words in the speech production of children who stutter produces difficulties in fluency, especially at the stage of language development in which there is a growth in vocabulary and in the length and complexity of speech (Byrd et al., 2007).
3.2.2 Lexical priming

Apart from phonological encoding, for the understanding of specific features of language development and speech-language functioning in children who stutter, the results of lexical-semantic priming research are also significant. Pellowski and Conture (2005) measured reaction time in the presence and absence of a primer in a semantic relation to the target word in order to test lexical processing in preschool children who stutter. The results of their study showed that children who stutter name pictures more slowly than their peers who do not stutter in the presence of a primer with a semantic relation to the target word. Children who do not stutter showed a significant negative correlation between the “size” of the receptive lexicon and reaction time in both conditions, while children who stutter do not show this kind of correlation. Pellowski and Conture (2005) concluded, as did Melnick et al. (2003), that lexical processing in children who stutter is not so developed and organized as in children who do not stutter.

Hartfield and Conture (2006) tested the effect of conceptual features of words (words belonging to a same category and having a same function; for example, sun – star or sun – light) and words of same perceptive features (same physical parameters; for example, sun – ball) on the naming speed rate and the articulatory precision of words in children who stutter and children in the control group. Children who stutter are faster than children who do not stutter in naming words primed using a primer functionally similar to the target word, opposed to the categorically or perceptively similar primers. These results imply that preschool children who stutter rely more on conceptual features of words, such as functional features (for example, sun – light) than perceptive word features (for example, sun – ball). Harfield and Conture associate this result with K. Nelson’s (1973) functional core hypothesis, according to which early semantic development in children is primarily based on the functional characteristics of words.

This also coincides with the tendency of children who stutter to make “mistakes” in a functional relation to the “correct” word in the standardized vocabulary test Peabody—for example, instead of the word knife, they will use the word cut (functionally related to the word knife), but not the word stick, which is perceptually similar. Harfield and Conture concluded that the metal lexicon of children who stutter is organized more on functional features of words than on their perceptual features, and that they therefore use functional relationships between words during lexical retrieval, for a longer period of time than do
children who do not stutter, rather than the perceptual or categorical relationships. This leads to the conclusion that the early stage of lexical development lasts longer for children who stutter (Hartfield and Conture, 2006).

### 3.2.3 Syntactic priming

In their research on syntactic priming, Anderson and Conture (2004) provided data that children who stutter are faster in repeating sentences primed using a syntactic priming rule than children who do not stutter, accounting for this phenomenon by slower retrieval and encoding of syntactic structures. This interpretation is in accordance with the study by Bernstein Ratner (1997), who claimed that disfluencies often occur or are enhanced at the moment when a child starts to produce more complex syntactic structures, and that younger children seldom stutter on single words. Bloodstein (2006) highlighted the connection between the onset of stuttering and the acquirement of syntax. Children stutter on the first word of a complex phrase, but do not stutter frequently on utterances consisting of only one word. Bloodstein concludes that stuttering is not a result of the articulatory complexity of words, but that it occurs in relation to the articulation of a particular word compound. The earliest period for the occurrence of stuttering is 18 months, the point in the speech-language development of the child when she starts to put words in sequences, that is, when she first articulates syntagmatic relations between language units. Likewise, spontaneous recovery occurs at the moment when most children successfully acquire combinations of language units, i.e. syntax (Bloodstein, 2006).

Brocklehurst (2008) stated that the results of research on syntactic priming can also be interpreted by a possible effect of phonological encoding and incremental phonological encoding skills on syntactic encoding in children who stutter.

It can be concluded that standardized phonological tests shown in various studies indicate that the level and precision of phonological realizations in children who stutter and children who do not stutter can be compared (Nippold, 2002), but also that some of the capabilities in children who stutter differ, for example the delay in the transition from holistic to incremental phonological encoding (Byrd et al., 2007). Children who stutter also experience a different rate of sentence structure encoding (Anderson and Conture, 2004).
3.2.4 Overview of research on selective lexical priming in children who stutter and children who do not stutter in English

The aim of the study by Savage and Howell (2008) was to determine whether or not disfluencies in children who stutter could be compared to those of children who do not stutter. Likewise, they wanted to determine whether or not children who stutter experience more covert repairs, as stated by the covert repair hypothesis, or the cause of their disfluencies is their susceptibility to a less successful alignment of time needed for language planning and speech performance.

The EXPLAN theory, as already mentioned, suggests that precisely the less successful alignment of time needed for language planning and speech performance is the reason why children who use the pattern of advancing for a longer period of time develop permanent stuttering. Savage and Howell stated that neither the EXPLAN theory, nor the covert repair hypothesis have complete empirical evidence for their hypotheses, since they are mostly based on data obtained from reports on verbal behavior in children who stutter, and not on data obtained under experimental conditions.

Therefore, Savage and Howell constructed an experimental schema using selective priming, i.e., priming using different word types and measuring speech initiation time after the priming. The study included 24 children, 12 children who stutter, and 12 children who do not stutter, aged 3;10 to 8;11. The upper limit was set at 9 years because Howell et al. (1999) believed that transition to a higher number of disfluencies in content words or the exchange relation takes place at the age of 9.

The children in the study were tasked with listening to priming words under two conditions – listening to and repeating a function word, and listening to and repeating a content word. Such selective priming was intended to confirm a distinction between the two word types in speech production in both groups of children. The research hypotheses predicted that content-word priming would lead to a higher overall number of fluently articulated words, both function and content words. Such an effect was not expected when it came to function-word priming.

The effect of content-word priming is the result of lowering the chances of the occurrence of a time discrepancy between planning and performing. However, it was not expected that function-word priming, which should make the plan of a function word “easier”, would reduce the number of disfluencies in either functionor content words – function words
because they appear first in a sentence and because they are easy to plan (so the chances for the occurrence of time discrepancy between the plan and speech performance stay the same), and content words because function-word priming will not cause any significant reductions in the above-mentioned discrepancy and facilitate language planning of content words.

The study confirmed that all children experience more fluent articulation of content and function words after content-word priming, but also that the priming effect was stronger in children who stutter than in children who do not stutter. The same results and conclusion were not met when it came to function-word priming.

Savage and Howell concluded that the same mechanism supports the occurrence of disfluencies in both children who stutter and children who do not stutter, and that this mechanism was associated with a time discrepancy between language planning and speech performance.

In a wider discussion on the results of the study, Savage and Howell point out that the obtained data influence further comprehension of disfluency occurrence and provide the first experimental evidence that speech disfluencies occur due to a time discrepancy between language planning and speech performance. Savage and Howell introduce the term trade-off between the time needed for performance and planning different types of words. According to them, the hypotheses of the covert repair theory cannot account for the fact that briefer planning, enabled by content-word priming, also reduces the time needed for the performance of function words, so content-word priming leads to less disfluencies in speech in both content and function words.

More specifically, if all words of both word types in children who stutter are more susceptible to anticipatory phonological selection, there is no reason to expect that priming using one word type would lead to more benefits than priming using the other word type. In their conclusion, Savage and Howell point out that the covert repair hypothesis does not include in its presumptions any mechanism that would imply a connection in phonological planning of both word types, phonologically simpler function words and phonologically more complex content words.

The trade-off scenario between different parts of a sentence shows this connection. According to Savage and Howell, such a scenario is needed to explain why priming using one segment of the phonological word – its content word – affects its other segment – the function word. Savage and Howell in their conclusion also point out that the study supports the EXPLAN
model of speech production; they highlight that the key question remains whether the language system of children who stutter qualitatively differs from the language system of children who do not stutter.
4. THE RESEARCH OF LEXICAL PRIMING IN CHILDREN WHO STUTTER AND CHILDREN WHO DO NOT STUTTER IN THE EXAMPLE OF THE EXPLAN DEVELOPMENT MODEL OF STUTTERING

4.1 Aims

Within the framework of the EXPLAN model, the impact of two lexical priming conditions on language planning, measured by two priming effects, will be determined:

- the priming effect on the articulation of content words (effect A) in the conditions of function- and content-word priming;
- the priming effect on the articulation of function words (the effect B) in the conditions of function- and content-word priming.

The intensity of both effects (effect A and effect B) in two age groups of children who stutter and children who do not stutter will also be examined and compared.

4.2 The targeted questions and problems

This study aims to answer the following questions:

1. Is there a difference between (a) the duration of articulation, and (b) the number of disfluencies on content words (effect A) in the condition of content-word priming (CW condition), compared to the condition of function-word priming (FW condition) ? Is the intensity of effect A, defined by the number of disfluencies and the duration of content-word articulation in a sentence which a child articulates after priming, higher in children who stutter compared to children who do not stutter?

2. Is there a difference in (a) the duration of articulation and (b) the number of disfluencies on function words and the duration of silent pauses preceding the articulation of content words (effect B) in the condition of content-word priming (CW), compared to the condition of function-word priming (FW)? Is the intensity of effect B, defined by the
duration of articulation and the number of disfluencies on function words, and the duration of silent pauses preceding the articulation of content words, higher in children who stutter compared to children who do not stutter?

3. Does the Speech initiation time (SIT) for the first word in the target sentence in both conditions (the conditions of content- and function-word priming) last longer in children who stutter than in children who do not stutter?

4. Is there a difference in the intensity of the two lexical priming effects (effects A and B) between the younger and older groups of children who stutter, as well as a difference between younger and older children who do not stutter?
4.3 Hypotheses

In accordance with the research problems, the proposed hypotheses are as follows:

**H1:** The duration of the articulation and the number of disfluencies on content words changes in the condition of content-word priming as compared to the condition of function-word priming.

**H 1.1:** The duration of the content-word articulation is shorter after content-word priming than after function-word priming.

**H 1.2:** The number of disfluencies on content words is lower after content-word priming than after function-word priming.

**H 1.3:** Effect A is higher in both groups of children who stutter as compared to both groups of children who do not stutter.

**H2:** The duration of articulation and the number of disfluencies on function words, as well as the duration of silent pauses preceding the content-word articulation changes in the condition of content-word priming as compared to the condition of function-word priming.

**H 2.1:** The articulation duration of function words preceding a content word is shorter after content-word priming than after function-word priming.

**H 2.2:** The number of disfluencies on function words is lower after content-word priming than after function-word priming.

**H 2.3:** The duration of silent pauses preceding the articulation of content words is shorter after content-word priming than after function-word priming.

**H 2.4:** Effect B is higher in both groups of children who stutter as compared to both groups of children who do not stutter.
**H3:** Children who stutter will experience a slower speech initiation time (SIT) for the first word in the target sentence than children who do not stutter under both priming conditions (content-word [CW] priming and function-word [FW] priming).

**H4:** The difference in the intensity of the lexical priming effects (effect A and effect B) between the groups of younger and older children who stutter will be higher than the difference in the intensity of effects A and B between the groups of younger and older children who do not stutter.
4.4 Research procedure

4.4.1 Participants

The research was conducted on 80 participants; the experimental group consisted of 40 children who stutter, and the control group consisted of 40 children who do not stutter. Each group was divided according to the age (aged 3 to 6; 5 and aged 6; 5 to 9).

All children were tested using the Peabody picture vocabulary test (Croatian 3rd edition) (Dunn, et al., 2009), the test of articulation (Vuletić, 1990), and the TROG test for the reception of grammar (Bishop, et al., 2013).

The groups of children with typical speech-language development and children who stutter were matched according to their chronological age and gender.

The criterion for including children within the group of children who stutter was that, in spontaneous speech with the researcher lasting up to twenty minutes, the child had made three or more stuttering-like disfluencies (whole-word repetition, word-segment repetition, phoneme prolongation, stalling, or abrupt pauses during speech) in 100 words, and that his overall average result measured by Stuttering Severity Instrument 3 (SSI-3) was 11 or higher, meaning that he falls under the category of mild stuttering.

For children who stutter, the age of the onset of stuttering and the course of the disorder were noted. For children who stutter according to Riley’s test, the final result was obtained from the sum of the table values of non-fluent syllable percentage in a sample of 200 or more syllables, from a value obtained by measuring the average duration of the three longest disfluencies, and from added points for additional behavior, if there was any (tics, audible breathing, or tense articulation). Those children, who were able to read, read a short passage that was appropriate for their reading level.

Children who do not stutter were included within the participant sample if they had made two or less disfluencies in 100 words of their speech, and if they obtained an overall average result of 8 or below on the Stuttering Severity Instrument 3 (SSI-3), classifying them as belonging to the category of very mild stuttering.

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7 The pronoun his hereinafter will mean his or her.
8 The SSI-3 is a stuttering severity instrument designed by Glyndon D. Riley.
4.4.2 Research material and experiment design – a modified naming test using the lexical priming method

This study used the phonological word as proposed by Selkirk (1984) according to the following rule: two constituents $C_i$ and $C_j$ comprise a unit of meaning if the correct semantic interpretation of a prosodic unit is true: $C_i$ is the argument of $C_j$ (nucleus).

According to this rule, a phonological word with a reflexive verb was used, for example on se igra’he is playing’ and ona se igra’she is playing’.

The research material consisted of the following:

a) 23 recordings of priming words, consisting of 2 function words in the form of reflexive constructions (personal pronoun + reflexive pronoun) on se (masculine) or ona se (feminine) and twenty content words, all of which are third-person present tense forms of reflexive verbs, (e.g. ljulja se’swings’). All of the verbs that the children heard as content priming words were also depicted in animations shown to the participants in the experiment. These are the verbs: smije se ‘is laughing’, boji se ‘is scared’, igra se ‘is playing’, penje se ‘is climbing’, češlja se ‘is combing his/her hair’, budi se ‘is waking up’, ljuti se ‘is angry’, spušta se ‘is coming down’, vrti se ‘is spinning around’, tušira se ‘is showering’, ljulja se ‘is swinging’, gleda se ‘is looking at himself/herself’, oblači se ‘is getting dressed’, češe se ‘is scratching himself/herself’, veže se ‘is fastening his/her seatbelt’, znoji se ‘is sweating’, svlači se ‘is getting undressed’, kliže se ‘is ice-skating’, umiva se ‘is washing his/her face’, pokriva se ‘is covering himself/herself’, plus lupa se ‘is kicking himself/herself’, and briše se ‘is drying himself/herself’ off as two testing examples. Recordings of the function words on se ‘he is … himself’ and ona se ‘she is … herself’, as well as the recordings of content words (3rd person present form of reflexive verbs) were used as auditory primers for children’s descriptions of the following animations. The animations all illustrated actions described by the twenty reflexive verbs. The primers were either function or content words. The reflexive verbs used in the experiment were adjusted according to their frequency (Moguš et al., 1999). Tables 4 and 5 list the names of the animations in the first and the second part of the experiment.
Table 4. Names of recordings and animations from the first part of the experiment

<table>
<thead>
<tr>
<th>Recording FR Condition</th>
<th>Animation</th>
<th>Recording SR Condition</th>
<th>Animation</th>
</tr>
</thead>
<tbody>
<tr>
<td>He is</td>
<td>he is playing</td>
<td>is getting dressed</td>
<td>he is getting dressed</td>
</tr>
<tr>
<td>He is</td>
<td>he is getting dressed</td>
<td>is swinging</td>
<td>she is swinging</td>
</tr>
<tr>
<td>He is</td>
<td>he is laughing</td>
<td>is spinning</td>
<td>he is spinning</td>
</tr>
<tr>
<td>She is</td>
<td>she is coming down</td>
<td>is ice-skating</td>
<td>she is ice-skating</td>
</tr>
<tr>
<td>She is</td>
<td>she is swinging</td>
<td>is fastening his seat belt</td>
<td>he is fastening his seatbelt</td>
</tr>
<tr>
<td>She is</td>
<td>she is climbing</td>
<td>is looking at herself</td>
<td>she is looking at herself</td>
</tr>
<tr>
<td>He is</td>
<td>he is spinning</td>
<td>is laughing</td>
<td>he is laughing</td>
</tr>
<tr>
<td>She is</td>
<td>she is ice-skating</td>
<td>is coming down</td>
<td>she is coming down</td>
</tr>
<tr>
<td>He is</td>
<td>he is fastening his seatbelt</td>
<td>is playing</td>
<td>he is playing</td>
</tr>
<tr>
<td>She is</td>
<td>she is looking at herself</td>
<td>is climbing</td>
<td>she is climbing</td>
</tr>
</tbody>
</table>

Table 5. Names of recordings and animations from the second part of the experiment

<table>
<thead>
<tr>
<th>Recording FR Condition</th>
<th>Animation</th>
<th>Recording SR Condition</th>
<th>Animation</th>
</tr>
</thead>
<tbody>
<tr>
<td>She is</td>
<td>she is scared</td>
<td>is angry</td>
<td>he is angry</td>
</tr>
<tr>
<td>He is</td>
<td>he is angry</td>
<td>is showering</td>
<td>he is showering</td>
</tr>
<tr>
<td>She is</td>
<td>she is scratching herself</td>
<td>is wakingup</td>
<td>she is waking up</td>
</tr>
<tr>
<td>He is</td>
<td>he is getting undressed</td>
<td>is combing her hair</td>
<td>she is combing her hair</td>
</tr>
<tr>
<td>He is</td>
<td>he is washing his face</td>
<td>is sweating</td>
<td>he is sweating</td>
</tr>
<tr>
<td>She is</td>
<td>she is combing her hair</td>
<td>is scratching herself</td>
<td>she is scratching herself</td>
</tr>
<tr>
<td>She is</td>
<td>she is covering her hair</td>
<td>is washing his face</td>
<td>he is washing his face</td>
</tr>
<tr>
<td>He is</td>
<td>he is showering</td>
<td>is getting undressed</td>
<td>he is getting undressed</td>
</tr>
<tr>
<td>She is</td>
<td>she is waking up</td>
<td>is covering herself</td>
<td>she is covering herself</td>
</tr>
<tr>
<td>He is</td>
<td>he is sweating</td>
<td>is scared</td>
<td>she is scared</td>
</tr>
</tbody>
</table>

b) Twenty animations in the experiment presented actions performed by either a boy or a girl, which could be illustrated by a reflexive verb. The animations were naming stimuli, or in other words, they were used to elicit speech performance in (and from) children. Speech initiation time, duration, and fluency of articulated words, as well as the pauses
preceding the speech initiation of the content words were measured. Each animation lasted 2400 ms and consisted of 6 connected pictures, lasting for 400 ms each.

c) Fillers – The experiment included 40 pictures of animals, of which 37 were different and 3 were the same image. The introduction of this type of task is a standard procedure in the priming paradigm and is used to avoid a cumulative effect of an uninterrupted series of priming tasks, which may affect the reliability of the measured values of dependent variables (Bock and Griffin, 2000, according to Howell, 2008). All noun-fillers, as well as all the verbs used in the experiment, were adjusted according to the absolute frequency (Moguš et al., 1999). The frequency table for the experimental words and fillers is given in the Appendices 1 and 2.
4.4.3 Experimental design

The key research concept in this experiment is selective lexical priming using two word types, with the aim of observing language planning in realtime. The method of language priming, or the method using an interfering stimulus or primer, meets the criteria of this concept.

The experiment began with an auditory priming-word, either a function word (on se‘he + reflexive pronoun’or ona se‘she + reflexive pronoun’) or a content word (e.g., penje se‘is climbing’). In the first condition, function words (FW) on se or ona se occurred as primers in 50% of cases. In the second condition, in the remaining 50% of cases, the primers were content words (CW) (twenty reflexive verbs in the 3rd person present form). In the first (FW) condition, after hearing on se or ona se the child repeated what he or she heard. In the second (CW) condition, the child heard a content word, such as the verb penje se ‘is climbing’, and repeated that word.

After hearing the FW primers or the CW primers and repeating them, the child would be shown an animation lasting 2400 ms of a boy climbing (or a different animation among the 20 animations illustrating a boy or a girl performing an action described by one of the above-mentioned reflexive verbs). The child was told to name the action he or she sees. The verb the child heard as an auditory word and repeated it as a primer was always the same as the action shown in the animation following in the CW condition. In the FW condition, after priming using function word on se or ona se the child also saw one of the 20 animations on the screen. Before the beginning of the experiment, each child was told to pronounce the word after watching the animation, regardless of maybe previously already hearing and repeating the same word. Every animation began with an auditory signal and the simultaneous appearance of a boy or a girl performing an action (laughing, dressing, climbing, etc.) on the screen. Examples of the animations are presented in Figure 14.
Figure 14. Examples of the animations briše se (is drying herself off) and ljuti se (is angry).

After the animation used as the target stimulus, a neutral stimulus, or filler, appeared on the screen – an animation of an animal from the group of 37 animations, of which three are repeated randomly, leading to a total of 40 animations. The child also had to name all animations which included animals. Fillers appeared after each experimental animation. Examples of these animations are presented in Figure 15.
The research procedure and notation of children’s responses were conducted using the E-prime computer program developed by Psychology Software Use in 1996. The program performs every given procedure and notes response time in milliseconds. It also notes all differences between given processes. The program can note up to 10,000 pieces of information. Its software part includes: E-Studio, a program for designing research processes and also for shaping data obtained for/from individual participants; E-Basic, an advanced program for users using more complex programs and research processes; E-Run, a program enabling installation on the computer used during the experiment itself and in which all research procedures are stored; E-Merge, a program enabling the effective merging of multiple test results; E-DataAid, a program enabling the use of all stored results; and E-recovery – the program for activating data in case of errors within other programs of the E-prime system.
Both conditions, function-word (FW) priming and content-word (CW) priming, took place in two presentations out of 40 testing examples in total; 10 function words and 10 content words in 20 tasks in two presentations, meaning that every animation was repeated twice; once in the condition of function-word priming (FW condition), and the second time in the condition of content-word priming (CW condition). The order of occurrence of the priming words under both FW and CW conditions, in both presentations, was random with an inserted filler between every target stimulus. Figure 16 shows the procedure of the E-prime program from the experiment design.
4.4.4 Testing procedure

The testing was conducted individually, in a prepared room in the kindergarten or in the researcher’s office. The child was seated in front of a computer screen, and the researcher manually adjusted the conduct of all segments dealing with events on the screen. Every child was told that he or she would hear a single word, for example oblači (‘is dressing’), or two words together, for example on se or ona se (‘he is … himself’ or ‘she is … herself’), which he or she was asked to repeat correctly. The repetition of priming words is a common practice in the original priming paradigm (Bock, 1986, according to Savage and Howell, 2008). The repetition of priming words is important because it enables the verification of whether priming directly affects the mechanisms of language production.

After the child repeated the priming word, the researcher instructed him or her to say what the girl or boy in the cartoon was doing, using the form on se or ona se, as quickly as possible. The children were told to articulate the words as quickly as possible while at the same time paying attention to the accuracy of what they were saying. Between the target experimental tasks, pictures of animals appeared on the screen, and the children were instructed to name them, too. After detailed instructions, the children were shown two testing examples in which they heard a priming word and saw an animation associated with that priming word (for example, they heard the word budi ‘is waking up’), repeat that word, and saw an animation in which a girl is waking up), and had to name it. In the testing example with a function word, children heard on se or ona se, which they had to repeat aloud, and then they saw a cartoon that they needed to name.

The experiment always began with three testing tasks. The first one included an instruction that the child should repeat the words glava (head), glijiva (mushroom) as fast as possible. After that the child was told to repeat a phrase, consisting of two words the researcher pronounced, four times in a row. Only after these repetitions did the child listen to four testing examples (a content word two times, and a function word two times), and watched the associated four cartoons not included in the experiment. The researcher commented on the way the child repeated words, saying things like well done, but can you say correctly everything you heard as fast as you can. After the testing examples, experimental tasks in two presentations consisting of twenty experimental and 40 filler tasks took place. If it was needed during the experiment, short breaks were made. Every presentation lasted from 5 to 10 minutes. Two presentations were separated by a break lasting a few minutes.
At the beginning of the testing, the screen was empty, and the child heard a recording of a priming word he or she was supposed to repeat (for example, on se or ona sein the FW condition). In the the content-word (CW) condition, the child heard and repeated one of the verbs. Child’s repetition of a word he or she heard was the primer of/for his or her speech production. After the auditory part of the stimulus began, the researcher initiated the target stimulus by a click of a button – the animation on the screen. All target stimuli or animations lasted for 2400 ms.

During the last stage of testing examples, the child heard auditory stimuli on a HP laptop using a Microsoft Life Chat LX-3000 Headset. The intensity of auditory stimuli was set to the volume checked with every child in advance, to eliminate the possibility of stimuli being too quiet or too loud. Everything the child articulated during or after watching a cartoon lasting for 2400 ms was recorded using a microphone installed with the headphones placed within 10 centimeters of the child’s mouth.

When the researcher clicked the button to initiate an animation, an auditory signal was heard. It indicated the beginning of the target stimulus, but also signaled the child to react. In order to eliminate the difference between the speed and accuracy between the participants, which would have taken place if the experiment had been conducted automatically, the beginning was marked manually by the researcher. This is because, in a set interval, children speaking fluently would be much faster and would have a long pause following priming words, which would make the task boring for them, and data obtained by such an automatic adjustment would be liable to systematic variation when it comes to the two groups of children.

Every utterance made by the child was recorded and transcribed using the Audacity program, which enabled the analysis of time distribution of speech after target stimuli began, i.e., after the animation that the child watched. For every sentence the child performed, speech initiation was measured under both conditions (the variables FCI and CCI; F – function condition, C – content condition, I – initiation of speech), as well as the duration of function and content words under both conditions (FCDF, FCDC, CCDF, CCDC), and the duration of the pause preceding the content word (FCDP, CCDP) (Figure 17).

The Audacity program also enabled the notation of disfluency duration in both function words and content words under both conditions (FCDSF, FCDSC, CCDSF, CCDSC; S – stuttering). Although the variable of stuttering duration was not taken into consideration in the research hypotheses, it was measured. For the variable of function-word duration, the duration of two
words \((on \ se \ or \ ona \ se)\) was measured, and for content-word duration, the duration of the verb the child articulated was measured. The variable of pauses was not included in the analysis if the pause in a particular sentence did not precede the content word. All the duration values were marked in seconds and fractions of seconds with five digits to the right of the decimal point.

**Figure 17.** Duration of experiment in Audacity program with tags FCI (speech initiation under FW condition), FCDSF (stuttering duration under FW condition on a function word), FCDP (a pause preceding a content word under FW condition), FCDC (content-word duration under FW condition), and CCDSF (stuttering duration on content word under FW condition).

Figure 18 shows the time duration of the experiment.
Figure 18. Time duration of the experiment: auditory word lasting 300 ms under FW or CW condition and repetition of auditory word lasting 300 ms, animation lasting 2400 ms, and child’s naming the action depicted in the animations.

4.4.5 Disfluency classification

The experiment measured all disfluency types characteristic of fluent articulation, except for silent pauses. The observed disfluencies included whole-word repetition, word-segment repetition, phoneme prolongation, tense pauses, disrupted word articulation, and fillers such as hm.
4.4.6 Research variables

The study included a mixed ANOVA designs. Mixed two-way ANOVA with groups of children as between group of participants factor and conditions of priming as within group of participants factor. Two groups of children were children who stutter (CWS) and children who do not stutter (CWDNS). Conditions of priming were 40 priming-word units, 20 in the condition of function-word priming (FW condition) and 20 in the condition of content-word priming (CW condition).

Also, mixed three-way ANOVA was performed with age as additional between group of participants factor, with two levels (age groups): an older group of children (who stutter (oCWS), and an group of children who do not stutter (oCWDNS)), as well as, a younger group of children (who stutter (yCWS), and a group of children who do not stutter (yCWDNS)).

The study included five dependent variables for each research task:

1. Disfluency;
2. Duration of silent pauses preceding the content-word articulation;
3. Speech initiation time (SIT);
4. Duration of content words;
5. Duration of function words.

4.4.7 Data processing methods

To test the differences between the groups of results – that is, between the higher number of arithmetic means for the variables: duration of articulation, stuttering duration, and speech initiation time for the first word in a target sentence, as well as duration of silent pauses preceding content-word articulation during function- and content-word priming in children who stutter and children who do not stutter – mixed designed (ANOVA) with repeated measure in the second variable (FW priming condition and CW priming condition) were used.

The main effects implied by the models are (1) priming effects, or the differences between the duration of articulation, number of disfluencies, and stuttering duration in the two priming conditions (function-word priming and content-word priming) and (2) stuttering effects, or the differences between the observed competence of children who stutter and children who do not
stutter. The interaction also included by the model enables an insight into the interrelation between priming effects (the interrelation of the differences between function- and content-word priming) in stuttering, or in other words, an insight into the differentiation between the two priming conditions in the two observed groups of children, and the priming effects in both groups of children.

For all of the observed variables in a target sentence under two priming conditions (FW and CW), the associated tables and graphical illustrations provide the arithmetic means and standard errors for arithmetic means, as well as the results of the testing significance of the main effects and their interactions. In all analyses, a level of statistical significance (p) of 0.05 was used.

To test the differences in the intensity of lexical priming (or duration of articulation), the number of disfluencies and stuttering duration under both the FW condition and the CW condition in children who stutter and who do not stutter belonging to different age groups (younger and older), in the first step of the three-way variance analysis with repeated measure in the last variable (function- and content-word priming) was conducted. The obtained statistical procedure provided insight into the potential (triple) interaction between stuttering, age, and priming. If such an interaction were not found, it would have been reasonable to conduct a two-way variance analysis with age groups and priming as independent variables, separately for children who stutter and children who do not stutter. In other words, when it comes to observing the age effect, or the difference between younger and older children (those who stutter and those who do not stutter), it was appropriate to form two separate combining models with repeated measure in the priming variable in children who stutter and children who do not stutter.

The complete data was presented in tables or as graphs in the next chapter. In order for the graphical illustrations to be clearer, priming conditions were marked by abbreviated tags. All tags dealing with priming conditions are listed in Table 6.
Table 6. Tags and meaning of tags in text in graphical illustrations.

<table>
<thead>
<tr>
<th>priming condition</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW</td>
<td>condition under which the child hears and repeats the function word he is or she is, after which they name the action depicted in the cartoon – for example, she is swinging.</td>
</tr>
<tr>
<td>CW</td>
<td>condition under which the child hears and repeats the content word – for example, is swinging – after which they name the same action in the cartoon</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>group</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWS</td>
<td>children who stutter</td>
</tr>
<tr>
<td>oCWS</td>
<td>older children who stutter</td>
</tr>
<tr>
<td>yCWS</td>
<td>younger children who stutter</td>
</tr>
<tr>
<td>CWDNS</td>
<td>children who do not stutter</td>
</tr>
<tr>
<td>oCWDNS</td>
<td>older children who do not stutter</td>
</tr>
<tr>
<td>yCWDNS</td>
<td>younger children who do not stutter</td>
</tr>
</tbody>
</table>
5. RESULTS AND DISCUSSION

According to the EXPLAN theory, the occurrence of disfluencies in speech can be accounted for by the influence of language planning and motor performance on speech-language processing, but also by the features of language structures themselves.

Efforts were made to verify that, in the Croatian language, function and content words participate in different ways in the underlying patterns of language planning and performance by the obtainment of more time in language planning after content- or function-word priming. Likewise, the study was aimed to determine whether or not these two types of words also have a different role in the occurrence of stuttering – that is, whether the obtained results could verify that in Croatian (as well) less time is needed for language planning after content-word priming, and that this enabled a shorter speech initiation time, shorter duration of words and pauses, and less disfluencies on content and function words in an utterance, and that, after function-word priming, all of this did not occur in a considerable or significant manner (as predicted by the EXPLAN theory), this would be a significant contribution to the comprehension of the clash between language planning and speech performance in the occurrence and development of stuttering. The significance of findings with the effect of content words would be enhanced thereby if, after function-word priming, all of this could not be significantly confirmed.

During the experiment, it was established that some children from all participant groups omitted function words in the position of a proclitic and articulated only the content words (for example, a child instead of saying on se znoji’he is sweating’) articulated only znoji‘sweating’, or znoji se‘is sweating’). There were around one hundred of these sentences, and they were included in the analysis only as the duration of content words or stuttering on content words, if disfluencies occurred on them. This aspect of the experiment will be dealt in more detail in the discussion and conclusions.

In order for the data to be clearer and “easier” to detect, the variables duration, disfluencies, pauses preceding content words, and speech-initiation time were analyzed separately, following the sequence of the first three hypotheses. The final part of the dissertation, the results and discussion on the three dependent variables (duration, number of disfluencies, and duration of pauses), also includes results and discussion of the fourth hypothesis – the difference in the intensity of lexical priming (effects A and B) between groups of younger and
older children who stutter compared to the difference between effects A and B in groups of younger and older children who do not stutter.

5.1 The variable of duration

The analysis of the variable duration of content and duration of function words excluded those words in which disfluencies occurred. In other words, a disfluent articulation of content or function words would prolong its duration, ultimately not providing a trustworthy result for this variable.

This part of the dissertation will provide an overview of the results and a discussion of the duration of content words in both priming conditions in CWS and CWDNS, as well as the results and discussion of the duration of content words in age groups (in the groups of oCWS and yCWS, and in the groups of oCWDNS and yCWDNS). Likewise, results and discussion of the duration of function words in both priming conditions, as well as the results of the duration of function words in age groups (in the groups of oCWS and yCWS, and in the groups of oCWDNS and yCWDNS) will be presented.

5.2. Content word duration in CW and FW conditions-effect A

The results of a two-way variance analysis with repeated measure in the second variable (Table 7) indicate a statistically significant priming effect on the duration of content-word articulation ($F=25.956$, $p<0.001$, $\eta^2=0.250$). In other words, a different duration of content-word articulation was determined in the CW priming condition than in the FW priming condition, wherein the average duration of content-word articulation in the CW condition is shorter ($M=0.734$) than the duration of content-word articulation in the FW condition ($M=0.782$).

Such a result would imply that all children are faster in the language planning of content words under a condition in which they are presented with the word in advance, which would imply that priming has a facilitating effect.
Such a facilitating priming effect, demonstrated equally in children who stutter and children who do not stutter, was also found in a study by Melnick et al. (2003), mentioned in chapter 3.2.1, in which the phonological congruence of the primer was manipulated. The study showed that listening to a similar stimulus preceding the occurrence of a picture increased the speed of naming in both groups of children.

Contrary to these results, the research by Hartfield and Conture (2006) demonstrated that children who stutter are slower at picture-naming than those in a control group. An inhibitory effect of priming on children who stuttered was obtained after the children heard a conceptually associated primer. The children who did not stutter did not demonstrate such an inhibitory effect. The results of this research showed that CWS experience a higher mutual competitiveness of conceptual information and are, therefore, less successful in semantic-lexical activation. Similar results are seen in the research by Pellowski and Conture from 2005. Younger children who stuttered were not only slower than their peers who did not stutter in the reaction time of picture-naming, but also demonstrated a significant inhibitory effect when they heard a semantically similar priming word. Pellowski and Conture (2005) concluded that their results indicate that children who stutter demonstrate a subtle deficit in lexical encoding, and that those difficulties in language planning may be a variable contributing to the children’s stuttering.

In effect A, the variable *duration of content word*, a statistically significant main effect of stuttering was demonstrated ($F=4.137$, $p=0.045$, $\eta^2=0.05$), indicating a shorter average duration of content-word articulation in the two priming conditions combined in CWDNS ($M=0.729$) than among children who stutter ($M=0.787$).
Table 7. Average duration of content-word articulation and testing results on differences in duration of content-word articulation in CW and FW priming conditions in CWDNS and CWS (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDm)</th>
<th>Content word M (SDm)</th>
<th>Total M (SDm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stuttering (children groups)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children who do not stutter</td>
<td>0.753 (0.021)</td>
<td>0.705 (0.022)</td>
<td>0.729 (0.020)</td>
</tr>
<tr>
<td>oCWS (6.5 to 9 years)</td>
<td>0.810 (0.021)</td>
<td>0.764 (0.022)</td>
<td>0.787 (0.020)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.782 (0.015)</td>
<td>0.734 (0.015)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>25.956</td>
<td>0.000</td>
<td>0.250</td>
</tr>
<tr>
<td>Stuttering</td>
<td>4,137</td>
<td>0.045</td>
<td>0.050</td>
</tr>
</tbody>
</table>

The obtained statistically insignificant interaction affirms the equal or identical difference in the average duration of content words in CWS and CWDNS in the FW and CW conditions (F<1) (Figure 19).
The results suggest the following conclusions:

a) CWS produce significantly shorter content words in the CW condition than in the FW condition.

b) CWDNS produce significantly shorter content words in the CW condition than in the FW condition.

c) The average duration of content words in CWS is longer in both conditions than in CWDNS.

d) The difference between CWS and CWDNS in the average duration of content words in both priming conditions is identical.

All of the above cannot lead to a conclusion that priming effect A in the dependent variable duration of content words is stronger in children who stutter. Effect A in the variable duration of content words is equal in children who stutter and in children who do not stutter. In other words, all children are faster in language planning of content words in the condition in which
they hear and articulate a content word in advance, than when they hear and articulate a function word in advance. This result implies that the CW condition enables the aforementioned facilitating priming effect, contrary to the FW condition.

If a parallel was drawn with the aforementioned research in which phonological and semantic primers were used (Hartfield and Conture, 2006; Pellowski and Conture, 2005), such a facilitating effect would be of a phonological nature. In other words, it is possible that the content-word primer speeds up precisely the phonological encoding of a content word in both groups of children. Despite this, children who stutter are on average still slower in this segment of language planning.

Approximately the same effect A in the variable *duration of content words* in children who stutter and in children who do not stutter is not in accordance with the hypotheses of the EXPLAN theory, which hypothesized that effect A in the variable *duration of content words* would be stronger in children who stutter. This was not demonstrated by the results of this dissertation.

Children who stutter are significantly slower in the production of content words in both conditions, as predicted by the EXPLAN theory (Savage and Howell, 2008). The prolonged articulation time can be interpreted as a “protection” from the occurrence of disfluencies, which will be dealt with more in the final part of the chapter on *word duration*. 
5.2.1 Duration of content-word articulation in age groups

The results of testing differences in the duration of content-word articulation in two priming conditions in younger and older children who stutter and those who do not stutter, obtained by a three-way variance analysis, are presented in Table 8.

Table 8. Testing results on differences in duration of content-word articulation in FW and CW conditions in younger and older children who do not stutter and those who stutter (2x2x2 ANOVA with repeated measure in the last variable).

<table>
<thead>
<tr>
<th>Effects</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>28.402</td>
<td>0.000</td>
<td>0.272</td>
</tr>
<tr>
<td>Stuttering</td>
<td>4.908</td>
<td>0.030</td>
<td>0.061</td>
</tr>
<tr>
<td>Age</td>
<td>13.336</td>
<td>0.000</td>
<td>0.149</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>0.026</td>
<td>0.873</td>
<td>0.000</td>
</tr>
<tr>
<td>Interaction Age x Stuttering</td>
<td>3.202</td>
<td>0.078</td>
<td>0.040</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>8.392</td>
<td>0.005</td>
<td>0.099</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming x Age</td>
<td>0.958</td>
<td>0.331</td>
<td>0.012</td>
</tr>
</tbody>
</table>

The established statistically significant effect of age implies the different duration of content-word articulation in the two priming conditions (F=28.402, p<0.001, η²=0.272). The duration of content-word articulation is on average shorter in the older group of children (M=0.710) than that of the younger group (M=0.806) (Table 9).

Table 9. Average duration of content-word articulation in younger and older children in the function-word priming condition and content priming condition.

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDm)</th>
<th>Content word M (SDm)</th>
<th>Total M (SDm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (younger and older children)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Younger children (3 to 6.5 years)</td>
<td>0.817 (0.020)</td>
<td>0.795 (0.019)</td>
<td>0.806 (0.019)</td>
</tr>
<tr>
<td>Older children (6.5 to 9 years)</td>
<td>0.746 (0.020)</td>
<td>0.674 (0.010)</td>
<td>0.710 (0.019)</td>
</tr>
<tr>
<td>Total</td>
<td>0.782 (0.014)</td>
<td>0.734 (0.014)</td>
<td></td>
</tr>
</tbody>
</table>

The obtained statistically significant interaction between age and priming indicates different priming effects in younger and older children (F=8.392, p=0.005, η²=0.099). The analysis of
simple effects demonstrates a shorter duration of articulation in content-word priming (M=674) than in function-word priming (M=0.746) only in older children (F=33.839, p<0.000, η²=0.308). In younger children, no difference was determined, or in other words, an equal duration of content words in both priming effects (F=2.959, p=0.089) (Table 10) was determined.

Table 10. Analysis of simple effects in two priming conditions on duration of content-word articulation in stuttering in younger and older children.

<table>
<thead>
<tr>
<th>Age</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger children</td>
<td>2.959</td>
<td>0.089</td>
<td>0.037</td>
</tr>
<tr>
<td>Older children</td>
<td>33.839</td>
<td>0.000</td>
<td>0.308</td>
</tr>
</tbody>
</table>

No statistically significant interaction between age and stuttering was determined (F=3.202, p=0.087), nor a statistically significant interaction between stuttering, priming, and age (F<1). As already mentioned, in order to achieve a clearer insight into the interaction between age and stuttering, especially in children who stutter and children who do not stutter, the effect of age and priming was observed using a two-way variance analysis. Considering that the overview of earlier research problems tried to explain the priming effects in both groups of children, these analyses will address the age effect and the interaction between age and priming.

5.2.2 Duration of content-word articulation in younger and older children who stutter

The results of a two-way variance analysis with a repeated measure in the second variable in CWS (Table 11) indicate a statistically insignificant effect of age on the duration of content-word articulation in children who stutter (F=1.878, p=0.125). In other words, the duration of content-word articulation in the two priming conditions in younger and older children who stutter, does not statistically differ in a significant manner.

The established statistically significant interaction between age and priming implies a different priming effect in younger and older children who stutter (F=5.438, p=0.025, η²=0.125).
Table 11. Average duration of content-word articulation and testing results on duration of content-word articulation in function priming condition and content priming conditions in younger and older children who stutter (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDM)</th>
<th>Content word M (SDM)</th>
<th>Total M (SDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (younger and older children)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yCWS (3 to 6.5 years)</td>
<td>0.817 (0.028)</td>
<td>0.803 (0.028)</td>
<td>0.812 (0.025)</td>
</tr>
<tr>
<td>oCWS (6.5 to 9 years)</td>
<td>0.806 (0.027)</td>
<td>0.732 (0.027)</td>
<td>0.763 (0.025)</td>
</tr>
<tr>
<td>Total</td>
<td>0.810 (0.020)</td>
<td>0.764 (0.019)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>9.647</td>
<td>0.004</td>
<td>0.202</td>
</tr>
<tr>
<td>Age</td>
<td>1.878</td>
<td>0.179</td>
<td>0.047</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>5.438</td>
<td>0.025</td>
<td>0.125</td>
</tr>
</tbody>
</table>

The analysis of simple effects (Table 12) indicates a shorter duration of content-word articulation in the condition of content-word priming (M=0.732) compared to function-word priming (M=0.806) only in older children who stutter (F=14.786, p<0.001, η²=0.000), while there is no difference in the duration of content-word articulation in the two priming conditions (F<1) in the younger group of children.

Table 12. Analysis of simple effects of two priming conditions on duration of content-word articulation in younger and older children who stutter.

<table>
<thead>
<tr>
<th>Age</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger children</td>
<td>0.300</td>
<td>0.587</td>
<td>0.008</td>
</tr>
<tr>
<td>Older children</td>
<td>14.786</td>
<td>0.000</td>
<td>0.280</td>
</tr>
</tbody>
</table>
Figure 20: Two-way interaction between age groups of children who stutter and duration of content words in FW and CW conditions.

The interaction between the age groups and the duration of content words in the FW and CW condition are illustrated in Figure 20. The results suggest the following conclusions:

a) oCWS experience considerably shorter duration of content-word articulation in the CW condition compared to yCWS.

b) The difference in the duration of articulation between the groups of children who stutter (younger and older), is almost insignificant in the FW priming condition. This could be accounted for by the fact that function-word priming does not significantly affect language planning of content words in both groups of children who stutter. It can be concluded from the results that it is precisely, in the group of children who stutter, the content-word priming which “provides” a significant advantage in the alignment between language plan and speech rate. The fact that the priming effect is stronger in older children who stutter indicates that the stuttering symptoms in that age
group may have transitioned over to content words which are then partially prolonged or include other symptoms of typical disfluencies. In the priming situation when their plan can be obtained in advance, there is no need for either symptom of non-fluent/disfluent speech. This can be used to account for the shorter articulation of content words in the CW priming condition in oCWS.

5.2.3 Duration of content-word articulation in younger and older children who do not stutter

The results of a two-way variance analysis with a repeated measure in the second variable in CWDNS (Table 13) indicate a statistically significant effect of age on the duration of content-word articulation in CWDNS (F=13.755, p=0.000, $\eta^2=0.266$). Older children who do not stutter experience on average a shorter duration of content-word articulation (M=0.657) than younger children who do not stutter (M=0.800).

The determined statistically insignificant interaction between age and priming demonstrates that the difference is equal in both priming conditions (F=2.973, p=0.093) (Figure 21).

**Table 13.** Average duration of content-word articulation and testing results of differences in duration of content-word articulation in FW and CW priming conditions in yCWDNS and oCWDNS (2X2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDM)</th>
<th>Content word M (SDM)</th>
<th>Total M (SDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (older and younger children)</td>
<td>0.816 (0.029)</td>
<td>0.785 (0.028)</td>
<td>0.800 (0.027)</td>
</tr>
<tr>
<td>Younger children (3 to 6.5 years)</td>
<td>0.690 (0.029)</td>
<td>0.625 (0.028)</td>
<td>0.657 (0.027)</td>
</tr>
<tr>
<td>Older children (6.5 to 9 years)</td>
<td>0.753 (0.020)</td>
<td>0.705 (0.020)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>24.410</td>
<td>0.000</td>
<td>0.391</td>
</tr>
<tr>
<td>Age</td>
<td>13.755</td>
<td>0.001</td>
<td>0.266</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>2.973</td>
<td>0.093</td>
<td>0.073</td>
</tr>
</tbody>
</table>
The results suggest the following conclusions:

a) yCWDNS and oCWDNS experience a slight difference in the duration of content words in both priming conditions.

b) oCWDNS on average experience a shorter duration of content-word articulation than yCWDNS.

It can be said that the significance of the facilitating priming effect is not reflected in a significantly shorter duration of content words in the CW priming condition compared to the FW condition, if the groups of CWDNS are taken into consideration separately. If their results are compared to the results of groups of children who stutter, it can be seen that such a difference is more prominent in both groups of children who stutter (Figure 20). Thus, older children who stutter experience considerably shorter articulation of content words in the CW condition than younger children who stutter. It can be stated
that older children who stutter express the “gain” of a plan obtained in advance by reducing content-word articulation. As already mentioned, this could mean that it is precisely that word which carries the main focus of the complexity of language planning within a phonological word in older children who stutter. As the further results will show, the difference in the duration of function words between older and younger children who stutter is not a significant one.
5.3 Duration of function-word articulation in CW and FW conditions – effect B

The results of a two-way variance analysis with repeated measure in the second variable (Table 14) indicate a statistically significant priming effect on the duration of function-word articulation ($F=10.895$, $p=0.001$, $\eta^2=0.127$), verifying the different duration of function-word articulation in the priming word condition and in the content-word priming condition. The duration of function-word articulation in the CW condition is on average shorter (M=0.607) than the duration of function-word articulation in the FW condition (M=0.651).

The results also demonstrate a statistically significant main effect of stuttering, indicating an average shorter duration of function-word articulation in both priming conditions in children who do not stutter (M=0.591), as opposed to children who do stutter (M=0.668).

This statistically insignificant interaction verifies the equivalence of the demonstrated difference in the duration of function-word articulation in both priming conditions in children who stutter and children who do not stutter, or in other words, an identical shorter time of function-word articulation in content-word priming compared to function-word priming in both children who stutter and children who do not stutter ($F=2.998$, $p>0.05$) (Figure 22).

Table 14. Average duration of function-word articulation and testing results on difference between function-word articulation in FW priming condition and CW priming condition in CWDNS and CWS (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDM)</th>
<th>Content word M (SDM)</th>
<th>Total M (SDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stuttering (groups of children)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children who do not stutter</td>
<td>0.601 (0.023)</td>
<td>0.580 (0.023)</td>
<td>0.591 (0.021)</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>0.701 (0.024)</td>
<td>0.634 (0.024)</td>
<td>0.668 (0.022)</td>
</tr>
<tr>
<td>Total</td>
<td>0.651 (0.017)</td>
<td>0.607 (0.017)</td>
<td></td>
</tr>
<tr>
<td>Effect</td>
<td>$F$</td>
<td>$p$</td>
<td>$\eta^2$</td>
</tr>
<tr>
<td>Priming</td>
<td>10.895</td>
<td>0.001</td>
<td>0.127</td>
</tr>
<tr>
<td>Stuttering</td>
<td>6.389</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>2.988</td>
<td>0.088</td>
<td>0.038</td>
</tr>
</tbody>
</table>
Figure 22. The average duration of function word of children who stutter and groups of children who do not stutter in FW and CW priming conditions

The average duration of function word of children who stutter and groups of children who do not stutter in FW and CW priming conditions (Figure 22). The results suggest the following conclusions:

a) The average duration of function words in the CW condition is shorter in CWS and CWDNS compared to the FW priming condition.

b) The average duration of content words in CWS is longer than in CWDNS in both conditions.

c) CWS experience a bigger difference in the average duration of function words in both priming conditions, and that difference of the average duration of function words in both conditions is similar to the difference in the production of content words in the FW and CW conditions ((0.810 - 0.764) and (0.701 – 0.634)).

d) CWDNS, during the articulation of function words in the two priming conditions, experience a slighter difference between the average duration of function words than
in the average duration of content words in the FW and CW conditions ((0.753- 0.705) and (0.601 – 0.580)).

The results demonstrate that, despite a slightly greater difference between the average duration of function words in both priming conditions in CWS, the difference between the average duration of function words in both conditions is similar to the one in content word production. As it was the case in content word duration, it cannot be concluded that the priming effect B in the variable function word duration is significantly stronger in children who stutter. As previously mentioned, the statistically insignificant interaction (Table 14) (F=2.998, p>0.05) implies the equivalence between the demonstrated difference in the duration of function-word articulation in both priming conditions in children who stutter and children who do not stutter.

The effect B in the variable function word duration is identical in children who stutter and children who do not stutter. In other words, all children are faster in language planning of function words in the condition in which its articulation is preceded by hearing and articulating a content word, as opposed to hearing in advance and articulating a function word.

Such a result implies that the CW condition enables all children to experience an equally strong facilitating priming effect achieved by a shorter duration of function-word articulation. This result is not in accordance with presumptions of the EXPLAN theory, which claims that effect B – when the duration of function words is shorter after content-word priming – in the variable duration of function words will be stronger in children who stutter. The results of this research do not demonstrate such a phenomenon.

Children who stutter are significantly slower in function-word production in both conditions, as proposed by the EXPLAN theory.
5.3.1 Duration of function-word articulation in age groups of children who stutter and children who do not stutter

As in the duration of content-word articulation, the results of a three-way variance analysis indicating age difference in the duration of function-word articulation, the role of stuttering and priming in potential age differences (interaction between age and stuttering, interaction between age and priming), and the interaction between age, stuttering, and priming in function-word articulation were observed. The results of the analysis are presented in Table 15.

Table 15. Testing results on the difference between the duration of function-word articulation in FW and CW priming conditions in younger and older children who do not stutter and children who stutter (2x2x2x ANOVA with repeated measure in the last variable).

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>10.560</td>
<td>0.002</td>
<td>0.126</td>
</tr>
<tr>
<td>Stuttering</td>
<td>6.272</td>
<td>0.014</td>
<td>0.079</td>
</tr>
<tr>
<td>Age</td>
<td>1.176</td>
<td>0.282</td>
<td>0.016</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>2.949</td>
<td>0.090</td>
<td>0.039</td>
</tr>
<tr>
<td>Interaction Age x Stuttering</td>
<td>0.988</td>
<td>0.324</td>
<td>0.013</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>2.490</td>
<td>0.119</td>
<td>0.033</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming x Age</td>
<td>0.021</td>
<td>0.884</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The determined statistically insignificant effect of age implies equal duration of function-word articulation in younger and older children (F=1.176, p=0.282). The statistically insignificant interactions between age and stuttering and between age and priming demonstrate that such absence of age differences is present in both children who stutter and in children who do not stutter (F<1) in both priming conditions (F=2.490, p=0.119). Also, no specific feature of priming was detected in any particular group of children who stutter or do not stutter, observed using three-way interaction between age, stuttering, and priming(F<1).
5.4 Conclusion on the variable word duration

The results dealing with the variable word duration in this research imply several conclusions:

Firstly, the duration of content and function words is shorter in CW priming conditions, meaning that all children obtain more time for language planning when their articulation is preceded by content-word priming.

Secondly, children who stutter did not demonstrate a stronger priming effect in the variable word duration of content and function words in either effect A or effect B than children who do not stutter, implied by the statistically insignificant interactions (F<1, F=2.998. p>0.05). This absence of interactions verifies the equivalence of the demonstrated difference in the duration of function- and content-word articulation in both priming conditions, i.e. CWS and CWDNS.

The obtained results cannot completely confirm hypotheses H1.3 and H2.4. It is not confirmed that the duration of the content-word articulation (effect A) and the duration of function-word articulation (effect B), in the variable word duration, are stronger in CWS.

Both obtained results may imply that the obtained time after content-word priming – the content word being more phonologically complex for both groups of children (CWS and CWDNS) – can be regarded as a facilitating priming effect. Such a facilitating effect, measured by a shorter word duration after priming, was already reported on in research using a phonological primer, as opposed to a semantic one, which produces an inhibitory effect. The established analogy implies a presumption that maybe the phonological segment of language planning benefits the most in this lexical priming as well.

Thirdly, children who stutter experienced on average longer durations of target words in both priming conditions. This result can be associated with the symptoms of syllable prolongation in stuttering, as the typical stuttering symptom, but also with therapy procedures in which children who stutter practice speaking more slowly (Galić–Jušić, 2001). This means that, for children who stutter, prolonged word duration is one of the compensatory mechanisms in speech production, “protecting” them from the potential occurrence of disfluent speech.

As already mentioned in Chapter 3, the disrupted rhythm hypothesis from the EXPLAN theory states that the time alignment of speech is modulated by cerebral processes (Howell and Sackin, 2002). In accounting for the key presumptions of this hypothesis, the influence of a device for slowing down the feedback on listening to one’s own speech is analyzed in great
detail. Howell and Sackin (2002) claim that, in the case of listening to one’s own speech using the device for slowing down the feedback, the timekeeper is disrupted on the cerebral level by asynchronous signals. Howell (2002) interprets the asynchronous signals occurring due to the prolonged time of listening to one’s own voice as a noise competing with the speech. Therefore, the DAF signal leads to alerts warning the speaker that he or she should synchronize the speech performance with the signal he or she hears. The DAF signal, serving as an alert signal, enables the individual who stutters to prolong the time needed for language planning, and hence reduces the possibility of the occurrence of disfluency at the moment of listening to his or her speech through the DAF device.

It is assumed that a similar asynchrony also occurs when motor instructions for an articulated word are not aligned with the planned language output (i.e., when speech is not fluent). The speech is then also aligned by the cerebral mechanism. This alignment takes place during the motor process and provides the speaker with more time to plan the following language segment (by repeating a function word using the stalling mechanism, or by prolonging the content-word articulation).

In stuttering, there is a discrepancy between the output motor command and neural representation, i.e., there is incomplete language processing of output speech. It can be concluded that in the case of a faster speech rate, the alert signal will be shut down, enabling a longer time for both processes, language and motor, to complete. The speaker who stutters begins the speech performance with an incomplete language plan, and the efferent copy of that plan is being updated until it is finally finished. Slowing down one’s speech provides the individual who stutters with more time to synchronize the processes of motor performance and language planning.

The question of whether it is justified or not to offer such an explanation for the occurrence of disfluent speech in children who stutter has yet to be answered.

The same can be said when it comes to the question of whether or not disfluencies in children who stutter are a result of a disrupted timekeeper mechanism in the cerebellum. The answers to these questions should definitely be considered in the light of neuromorphological research on the brain in children and adults who stutter. One of them was mentioned in Chapter 2.2.1. That study tested a group of 12 children who stutter and 12 children who do not stutter using diffusion tensor imaging (Watkins et al., 2008). The study detected an increased level of activity in the area of the midbrain called the anterior insula and in the area of cerebellum, but
also a decreased level of activity in the left pre-motor cortex, right in the Rolandic fissure, in
the sensor-motoric cortex and on the right side of the cortex, as well as on the left side of the
auditory cortex. Such findings in neuromorphological research on children who stutter
provide a link to the theoretical hypothesis on the disrupted time synchrony in stuttering in the
disrupted rhythm hypothesis for the authors of the EXPLAN theory.

Fourthly, this research demonstrated that older children who stutter benefit more from
priming in the CW condition, measured by a shorter duration of the content word. This means
that planning in advance ensured (to a greater degree) their efficiency in word articulation and
reduced the need to extend the time needed to articulate content words in order to prevent the
occurrence of stuttering symptoms on those words. This higher gain in the CW condition,
achieved by a shorter duration of content words, indirectly also implies that in the older
children the transition of stuttering symptoms from function to content words had already
begun, as claimed in the EXPLAN theory.

Specifically, Howell et al. (1999) refer to the age of nine as the upper limit after which
children who continue to stutter begin to produce symptoms of repeating or prolonging
content-word segments as typical symptoms of more developed stuttering to a greater extent.
As mentioned in Chapter 2.4, dealing with lexical research on stuttering on the intersection of
age groups, there is a proven transition from stuttering symptoms on function words in
children’s stuttering to content words in older children and adult speakers who stutter (Howell
et al., 1999a; Dworzynski and Howell, 2004; Dworzynski et al., 2004; Au–Yeung et al., 2003;
Howell, 2004).

As already mentioned, research results on the word-duration segment showed a difference in
content-word duration in the CW condition only in older children who stutter, which may
imply that, in the Croatian language, the age effect in the symptom transition from function to
content words takes place earlier than in English.

Croatian, as a pro-drop language, possesses a possibility of omitting the personal pronoun in
the subject position before the verb. Likewise, it does not have the same frequency of a front
position of an unstressed function word compared to a stressed content word as English.

In other words, in the Croatian language, as well as in a number of other languages, the
personal pronoun does not have to be used when it has the function of a subject. These are the
languages with personal verbal forms indicating the person of the subject; for example (in
Croatian), 1st person singular – *gleda-m* ‘I watch’, 2nd person singular – *gleda-s* ‘You watch’,
1st person plural – *gleda-mo* ‘We watch’, 2nd person plural – *gleda-te* ‘You watch’ (Kordić, 2002).

In addition, in Croatian the frequency of the front position of a function word is not the same as in English. Wackernagel’s rule (Peti–Stantić, 2007; 2013) claiming that unstressed words tend to fall into the second place in the phonological word, and not only the first one, applies in the Croatian language. In many languages, such as English, this rule has been lost, so the placing of the function word – e.g., a reflexive pronoun or an auxiliary verb – is always before the content word, whereas this is not the case in Croatian. The position of sentence components, syntactic constituents, and pronominal and verbal clitics in Croatian is an open possibility. Wackernagel’s rule is applied, depending on the phonological and prosodic-syntactic restrictions (Peti–Stantić, 2013). That means that a word such as an unstressed reflexive pronoun can be found both preceding and following the verb. Since in Croatian, a pro-drop language, the third-person pronoun is often left out, it is possible to transform the sentence *ona se boji* (She is scared) into *boji se* (Is scared).

Therefore, the frequency of the function word preceding the content word in Croatian is lower than in English. This reduces the chances for the effect of the symptom of stalling, one of the two key symptoms of the EXPLAN theory in stuttering (*stalling vs. advancing*).

Taking into the consideration the already-mentioned language feature (Croatian being a pro-drop language), it is possible that such a change in Croatian takes place earlier on, due to the possibility of leaving out the pronoun in the subject position and moving the function word (in this thesis the reflexive pronoun *se* following a verb; for example, *češlja se* ‘combing her hair instead of *ona se češlja* ‘she is combing her hair’).

In other words, it may be possible in Croatian that, due to the “weaker” protective role of the repetition of a function word, permanent stuttering with a symptom of advancing (repeating, prolonging, or stopping) segments of a content word occurs in children even before the age of 9. This brings into question the universality of the EXPLAN theory about the predominant symptoms of stalling in children up to the age of 9.

Therefore, if the group of oCWS differs from the group of yCWS in the shorter duration of content words in the CW condition, it may imply an earlier occurrence of symptom transition to content words. It also implies the difference between the meaning of stalling symptoms and the repetition of function words, and advancing symptoms, which is the repetition of content word segments.
The advantage of the plan in advance, achieved by a shorter duration of content words, also implies that in Croatian, as well as in some other languages such as Jordanian Arabic and Persian, the occurrence of disfluencies began before the age of nine. In languages such as Jordanian Arabic, which have function-content words, stuttering on content words also begins earlier (Al-Tamimi et al., 2013; Attieh, 2010). A similar case is the Persian language (Vahab et al., 2013), an agglutinative pro-drop language, a language in which it is possible (as in Croatian) to omit the personal pronouns and is possible for the clitics to follow a stressed content word. These features of the mentioned languages reduce the possibility of the occurrence of stalling symptoms.

Fifthly, the study demonstrated that there is only a slight difference in the content word duration in both priming conditions between young children who stutter and older children who stutter and that older children who stutter experience on average a shorter duration of content-word articulation than young children who stutter. It can be stated that the significance of the facilitating priming effect is not reflected in a significantly shorter duration of content words in the CW priming condition compared to the FW priming condition, if the groups of children who stutter are observed separately. This result would imply that there are significant differences precisely in the duration of content words between the age groups of younger and older children who stutter, and younger and older children who do not stutter.

A question which emerges is that of whether groups of older and younger children who stutter already differ significantly from each other when it comes to language planning and performance, while younger and older children who do not stutter do not. Does this mean that the group of young children who stutter is actually more similar to the groups of children who do not stutter than to the older group of children who stutter?

Is this difference between younger and older children who stutter an indicator of an onset of persistent stuttering, already taking place in older children who stutter? These questions are important for further research on stuttering in Croatian and still have yet to be answered.

Sixthly, the study showed a statistically insignificant effect of age on function words, implying equal duration of function-word articulation in younger and older children. Statistically insignificant interactions between age and stuttering, and age and priming shows that such absence of differences in age is also present in both children who stutter and children who do not stutter in both priming conditions.
In addition, no specific feature of priming for any particular group of children who stutter or do not stutter, analyzed by a three-way interaction between age, stuttering, and priming was detected. The duration of function words does not seem to be a significant factor for any of the aforementioned groups of children. This can be accounted for by those words being shorter, frequent, and “easier” to articulate. The repetition of these words is of greater importance and has greater positive effects than mere prolongation when it comes to stuttering. According to the EXPLAN theory, this presents a strong compensatory effect in obtaining (more) time for planning and articulating content words. Function words are activated fast, due to simpler phonological encoding, but their activation fades more slowly than the activation of phonologically more complex content words. If those words are repeated, it can be assumed that the length of their activation is increasing, obtaining more time for the language planning of a content word (Howell, 2003).
5.5 The variable number of disfluencies

This chapter will present the results and discussion on the number of disfluencies on content words in both priming conditions, as well as the result of the number of disfluencies on content words in age groups (the number of disfluencies on content words in the groups of oCWS and yCWS, and the groups of oCWDNS and yCWDNS). Likewise, the results and discussion on the number of disfluencies on function words in both priming effects, as well as the number of disfluencies in age groups will be presented (the number of disfluencies on function words in the groups of oCWS and yCWS, and in the groups of oCWDNS and yCWDNS).

5.6 Number of disfluencies on content words in CW and FW priming conditions – effect A

A two-way variance analysis (Table 16) indicates a statistically significant main priming effect on the number of disfluencies in content-word articulation (F=9.996, p=0.002, \( \eta^2 = 0.157 \)), demonstrating, on average, a lower number of disfluencies on content words in the CW priming condition (M=0.175) compared to the FW condition (M=0.600). The determined statistically significant interaction implies that the obtained priming effect depends on whether we are observing CWS or CWDNS (F=8.86, p=0.004, \( \eta^2 = 0.102 \)).

All children on average experience a higher number of disfluencies on function words (M=2.126) than on content words ([M=0.775], [t= 3.676, p<0.001]). This result implies that repeating a function word in Croatian “serves” as a protecting mechanism against the occurrence of stuttering in the first place, or as a protecting mechanism against the transition of disfluencies onto content words. However, the obtained data does not offer a conclusion on the precise group of children who stutter in which this symptom is more frequent or common. Such a conclusion will be possible after the differences in the number of disfluencies in oCWS and yCWS are presented further on in the dissertation.

The analysis of the simple effect (Table 17) indicates that the priming effect (the difference between the number of disfluencies after content-word priming and after function-word priming) is present only in CWS (F=18.834,p<0.001, \( \eta^2 = 0.194 \)). In other words, CWS
experience on average a higher number of disfluencies in content-word articulation in the FW condition (M=1.175) than in the CW condition (M=0.350) (Figure 23). The number of disfluencies in CWDNS does not differ statistically in a significant manner in the two priming conditions (F<1).

When it comes to the main priming effect, it may be stated that in the case of content-word articulation, as well as in the case of function-word articulation, all children benefit more from the CW priming conditions. This is how Savage & Howell (2008) also account for the significance of the main effect of the prime type. However, we should be careful when dealing with such an interpretation. It can be said that all children benefit from priming in the CW condition, in both content- and function-word articulation; however, statistically significant interaction, or the analysis of the simple effects, urges a more detailed insight. Therefore, the interaction between stuttering, priming, and the number of disfluencies implies that only the group of CWS stutter significantly less on function and content words in the CW priming condition.

The determined statistically significant main effect of stuttering indicates a higher number of disfluencies in content-word articulation in two priming conditions together in children who stutter (M=0.763) compared to children who do not stutter ([M=0.175], [F=11.435, p=0.001, \( \eta^2=0.128 \)], wherein the statistically significant interaction, or the analysis of the simple effects (Table 18) indicates a more prominent difference in the number of disfluencies on content words in CWS and CWDNS in the FW priming condition ([M_{stuttering}=1.175, M_{not-stuttering}=0.025], [F=11.289, p=0.001, \( \eta^2=0.126 \)]) compared to priming in the CW condition ([M_{stuttering}=1.350, M_{not-stuttering}=0.000], [F=7.052, p=0.001, \( \eta^2=0.083 \)]) (Figure 23). Therefore, as previously stated, CWS stutter significantly more in the FW priming condition.
Table 16. Average number of disfluencies in content-word articulation and testing results on disfluencies in content-word articulation in FW and CW conditions in CWDNS and CWS (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Priming</th>
<th>Function word M (SDM)</th>
<th>Content word M (SDM)</th>
<th>Total M (SDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stuttering (groups of children)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children who do not stutter</td>
<td>0.025 (0.242)</td>
<td>0.000 (0.093)</td>
<td>0.013 (0.157)</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>1.175 (0.242)</td>
<td>0.350 (0.093)</td>
<td>0.763 (0.157)</td>
</tr>
<tr>
<td>Total</td>
<td>0.600 (0.171)</td>
<td>0.175 (0.066)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>9.996</td>
<td>0.002</td>
<td>0.114</td>
</tr>
<tr>
<td>Stuttering</td>
<td>11.435</td>
<td>0.001</td>
<td>0.128</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>8.855</td>
<td>0.004</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Table 17. Analysis of simple effects of two priming conditions on the number of disfluencies in content-word articulation in children who do not stutter and children who stutter.

<table>
<thead>
<tr>
<th>Group</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children who do not stutter</td>
<td>0.017</td>
<td>0.896</td>
<td>0.000</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>18.834</td>
<td>0.000</td>
<td>0.194</td>
</tr>
</tbody>
</table>

Table 18. Analysis of simple stuttering effects on number of disfluencies in content-word articulation in two priming conditions.

<table>
<thead>
<tr>
<th>Group</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function-word priming</td>
<td>11.289</td>
<td>0.001</td>
<td>0.126</td>
</tr>
<tr>
<td>Content-word priming</td>
<td>7.052</td>
<td>0.010</td>
<td>0.083</td>
</tr>
</tbody>
</table>
The two-way interaction between the groups of children who stutter and children who do not stutter and disfluencies on content words in the CW and FW conditions (Figure 23) demonstrates the average number of disfluencies in content-word articulation in CWS and CWDNS considering the two priming conditions. The results suggest the following conclusions:

a) CWDNS experience the same number of disfluencies on content words in both priming conditions.

b) CWS experience significantly fewer disfluencies on content words in the CW priming condition than in the FW priming condition.

c) The intensity of priming effect A measured by the difference of an average number of disfluencies in the FW and CW conditions depends on whether we are observing CWS or CWDNS, and exists only in CWS.

Figure 23. Interaction between groups of children who do not stutter and children who stutter and disfluencies on content words in FW and CW conditions.
The significant interaction between stuttering and priming implies that content-word priming has a crucial influence on the reduction of the number of disfluencies on content words only in children who stutter. This is a very important feature of the variable number of disfluencies on content words in effect A. According to the EXPLAN theory, it is expected that children who stutter in both conditions experience on average a higher number of disfluencies and, likewise, that in the CW priming condition the number of disfluencies would be reduced in content words.

As pointed out in Chapter 5.1 (variable of duration), this study showed that children who stutter have a longer duration of articulation of both word types, regardless of the priming condition, which is consistent with the predictions of the EXPLAN theory, and which is also verified by Savage and Howell’s (2008) study on selective lexical priming in English. Likewise, the research showed that all children experience a shorter duration of content words in the CW priming condition. The significance of the slower phonological encoding as a segment of language planning preceding the articulation and having to be aligned with it, is more prominent for content words, as already noted in Chapter 2.3.1 dealing with the effect of phonological complexity on the occurrence of disfluencies. A study by Howell et al. (2000a) showed that younger participants, as well as both older groups of participants in the study, stuttered significantly more on content words beginning with a consonant cluster than on those which did not. Likewise, the youngest participants in the study stuttered significantly more on words beginning with late-emerging consonants.

That study demonstrated that none of the factors of phonological complexity affected the occurrence of disfluencies on function words. Howell et al. (2000a) concluded that factors which make content words (more) susceptible to the occurrence of disfluencies are of an inner nature and that they emerge from the phonological complexity of the initial syllables of content words. Phonological complexity is definitely a factor that significantly affects the occurrence of more prominent disfluencies on content words.
5.6.1 Number of disfluencies on content words in age groups of CWS and CWDNS

The results of a three-way variance analysis (Table 19) indicate a statistically insignificant effect of age, or an equal number of disfluencies in content-word articulation in younger and older children (F=1.863, p=0.176). Likewise, no statistically significant interaction between age and stuttering was detected, indicating an equal effect of stuttering (an equal difference between children who stutter and children who do not stutter) in younger and in older children (F=1.566, p=0.215). In addition, no interaction between age and priming, demonstrating the equal priming effect in both younger and older children (a lower number of disfluencies in content-word priming [F<1]), nor interaction between age, stuttering, and priming were determined (F<1). Considering the established absence of a difference between younger and older children in the number of disfluencies, regardless of whether they stutter or not and depending on the priming condition, it can be concluded that the obtained results are identical in children who stutter and children who do not stutter, and that there is no need to form separate statistical models.

Such a result is somewhat unexpected when it comes to older children who stutter. It implies that their average number of disfluencies on content words is not higher than the one in the group of younger children who stutter, and it also implies that CWDNS in the CW condition do not produce content words with a lower number of disfluencies than in the FW condition. The main feature of the benefits they achieve after priming may be the shorter duration of content words in the CW priming condition, but not a lower number of disfluencies. Of higher significance seems to be the average number of disfluencies on function words, as will be demonstrated in Chapter 5.4.4, which discusses with the number of disfluencies on function words in the age groups of CWS.
Table 19. Testing results on the difference in number of disfluencies in function-word articulation in FW and CW priming conditions in younger and older children who do not stutter and children who do stutter (2x2x2 ANOVA with repeated measure in the last variable).

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>9.849</td>
<td>0.002</td>
<td>0.115</td>
</tr>
<tr>
<td>Stuttering</td>
<td>11.645</td>
<td>0.001</td>
<td>0.133</td>
</tr>
<tr>
<td>Age</td>
<td>1.863</td>
<td>0.176</td>
<td>0.024</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>8.725</td>
<td>0.004</td>
<td>0.103</td>
</tr>
<tr>
<td>Interaction Age x Stuttering</td>
<td>1.566</td>
<td>0.215</td>
<td>0.020</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>0.545</td>
<td>0.463</td>
<td>0.007</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming x Age</td>
<td>0.307</td>
<td>0.581</td>
<td>0.004</td>
</tr>
</tbody>
</table>

5.7 Number of disfluencies on function words in CW and FW priming conditions – effect B

A two-way variance analysis with repeated measuring in the second variable (Table 20) demonstrated a statistically significant priming effect on the number of disfluencies in function-word articulation (F=23.597, p<0.001, η²=0.232), which indicates a different number of disfluencies on function words in two priming conditions, function-word priming, and content-word priming. The number of disfluencies in function-word articulation is on average lower in the CW condition (M=0.613) than in the FW priming condition (M=1.513). This is certainly the most important result of the thesis – priming using one word type affects the occurrence of a lower number of disfluencies even in the other word type. The same result was obtained in research on selective lexical priming in the English language (Savage and Howell, 2008).

The obtained statistically significant interaction between stuttering and priming implies the dependence of the determined priming effect on the number of disfluencies and stuttering (F=16.387, p<0.001, η²=0.174). Furthermore, the analysis of the simple effects (Table 21) indicates a difference in the number of disfluencies in function-word articulation in the two priming conditions only in CWS (F=39.655, p<0.001, η²=0.337), while the number of disfluencies in function-word articulation in the two priming conditions is the same (F<1). In other words, children who stutter demonstrate a higher number of disfluencies in function-
word articulation in the FW priming condition (M=2.875) than in the CW condition (M=1.225), while in children who do not stutter the number of disfluencies is the same in both priming conditions.

The determined statistical main effect of stuttering demonstrates a lower number of disfluencies in function-word articulation in the two priming conditions together in children who stutter (M= 0.075) compared to children who do not stutter ((M=2.050), (F=32.950, p<0.001, \( \eta^2=0.297 \)). The described statistically significant interaction (Figure 24), that is, the analysis of the simple effects (Table 22), shows that the lower number of disfluencies in function-word articulation in CWDNS compared to CWS is present not only in the function-word priming condition ((M_{stuttering}=2.875, M_{not-stuttering}=0.150), (F=33.923, p<0.001, \( \eta^2=0.303 \)), but also in the content-word priming condition ((M_{stuttering}=1.225, M_{not-stuttering}=0.000), (F=17.344, p<0.001, \( \eta^2=0.182 \)), wherein that difference is more prominent in the function-word priming condition.

Table 20. Average number of disfluencies in function-word articulation and testing results on differences in function-word articulation in FW and CW priming conditions in CWDNS and CWS (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Stuttering (groups of children)</th>
<th>Function word M (SDm)</th>
<th>Content word M (SDm)</th>
<th>Total M (SDm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children who do not stutter</td>
<td>0.150 (0.331)</td>
<td>0.000 (0.208)</td>
<td>0.075 (0.243)</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>2.875 (0.331)</td>
<td>1.225 (0.208)</td>
<td>2.050 (0.243)</td>
</tr>
<tr>
<td>Total</td>
<td>1.513 (0.234)</td>
<td>0.613 (0.147)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>23.597</td>
<td>0.000</td>
<td>0.232</td>
</tr>
<tr>
<td>Stuttering</td>
<td>32.950</td>
<td>0.000</td>
<td>0.297</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>16.387</td>
<td>0.000</td>
<td>0.174</td>
</tr>
</tbody>
</table>
Table 21. Analysis of simple effects of two priming conditions on the number of disfluencies in function-word articulation in children who do not stutter and children who stutter.

<table>
<thead>
<tr>
<th>Group</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children who do not stutter</td>
<td>0.328</td>
<td>0.569</td>
<td>0.004</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>39.655</td>
<td>0.000</td>
<td>0.337</td>
</tr>
</tbody>
</table>

Table 22. Analysis of simple stuttering effects on the number of disfluencies in function-word articulation in two priming conditions.

<table>
<thead>
<tr>
<th>Groups</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function-word priming</td>
<td>33.923</td>
<td>0.000</td>
<td>0.303</td>
</tr>
<tr>
<td>Content-word priming</td>
<td>17.344</td>
<td>0.000</td>
<td>0.182</td>
</tr>
</tbody>
</table>

Figure 24. Two-way interaction between groups of children who do not stutter and children who stutter and disfluencies in function-word articulation in FW and CW priming condition.
The interaction between the groups of children who do not stutter and children who stutter and disfluencies in function-word articulation in the FW and CW priming conditions (Figure 24) implies the following conclusions:

a) CWS experience a significantly lower number of disfluencies on function words in the CW condition that in the FW condition.

b) The intensity of the priming effect B, measured by the difference between the average number of disfluencies on function words in the FW and in the CW conditions, depends on whether CWS or CWDNS are observed, and is stronger in CWS.

A significant interaction between stuttering and priming (Figure 24) states that content-word priming has a decisive influence on the reduction of the number of disfluencies on function words in children who stutter. This is certainly the most important experimental indicator of the priming effect in advance using one word type on the production of the other word type in the Croatian language.

Such a result was predicted by the EXPLAN theory, and its authors (Howell, 2010) consider it to be the most important and significant experimental evidence that priming using one word type affects (and leads to) a more fluent production of the other word type, which abolishes the need for stuttering symptoms on that word type, in this case, function words.

Such a benefit in priming is considered by the authors as an indicator of the clash between language planning and speech performance (Savage and Howell, 2008). Specifically, “gain” can be expected to occur on content words since they are “harder” and more complex to articulate, so planning in advance makes the occurrence of their disfluent articulation less plausible, and for function words, the planning in advance means that there is no need to repeat the word (repeating function words is a disfluency type associated with the stalling symptom).

It can be concluded that content-word priming abolishes the need for function-word repetition, or in other words, that the stalling symptom would reduce the potential occurrence of disfluencies in content words.
5.7.1 *Number of disfluencies in function words in age groups of CWS and CWDNS*

The results of observing the difference between the number of disfluencies in function-word articulation in the two priming conditions in younger and older CWS and CWDNS is presented in Table 23.

**Table 23.** Testing results on number of disfluencies in function-word articulation in function-word priming condition and content-word priming condition in younger and older children who do not stutter and children who stutter (2x2x2 ANOVA with repeated measure in the last variable).

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>23.045</td>
<td>0.000</td>
<td>0.232</td>
</tr>
<tr>
<td>Stuttering</td>
<td>36.235</td>
<td>0.000</td>
<td>0.323</td>
</tr>
<tr>
<td>Age</td>
<td>5.225</td>
<td>0.025</td>
<td>0.064</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>16.004</td>
<td>0.000</td>
<td>0.174</td>
</tr>
<tr>
<td>Interaction Age x Stuttering</td>
<td>4.552</td>
<td>0.036</td>
<td>0.057</td>
</tr>
<tr>
<td>Interaction Age x Priming</td>
<td>0.160</td>
<td>0.690</td>
<td>0.002</td>
</tr>
<tr>
<td>Interaction Stuttering x Age x Priming</td>
<td>0.018</td>
<td>0.894</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The obtained statistically significant effect of age demonstrates a lower average number of disfluencies in function-word articulation in younger children (M=0.687) in older children ([M=1.437], [F=23.045, p<0.001, $\eta^2=0.232$]). The statistically significant correlation between age and stuttering demonstrates the dependence between the established difference regardless of whether children who do not stutter or children who stutter are observed (F=4.552, p=0.036, $\eta^2=0.057$).

The results, which show an average lower number of disfluencies in function-word articulation in young children who stutter, were not predicted by the EXPLAN theory. As already mentioned in Chapter 2.4.1 dealing with lexical research based on the intersection of age groups, younger children who stutter experience more disfluencies on initial function words than on content words, and the age of the transition of symptoms from mostly function words to content words in the English language takes place around the age of nine (Howell, 1999, 2011). Data on the symptom transition from function to content words was also obtained for German (Dworzynski and Howell, 2004; Dworzynski et al., 2004) and Spanish (Au-Yeung et al., 2003; Howell, 2004).
The results of this research showing that older CWS experience a higher number of disfluencies on function words seem unexpected. They are contradictory to the results of oCWS on the greater benefit from priming in the CW condition than in the FW condition measured by an average shorter duration of content words. The latter, as mentioned in the conclusion on the variable *duration*, can be accounted for by the transition of the focus of disfluent speech symptoms from function to content words. It is possible that words more susceptible to disfluent articulation in specific stages of stuttering development benefit more from priming and articulation “in advance”. The benefit means that there is no need for a longer articulation of those words in order to prevent disfluencies which may occur on them. Thus, it seems possible that older children who stutter experience a shorter duration of content words in the FW condition, which improves their phonological encoding.

On the other hand, this result showed that older children who stutter demonstrate an opposite tendency, or that they experience more disfluencies on function words. The question may be raised as to how it is possible that, in older children who stutter, the focus of disfluencies in a phonological word is on both on the content and the function word. It was already mentioned that repeating function words is a “protective” mechanism against the occurrence of disfluencies on content words, and according to the EXPLAN model, it is used by younger children not yet experiencing the transition over to permanent stuttering.

Older children who stutter demonstrate that their stuttering is still in the phase in which the “protective” role of a higher number of disfluencies on function words is possible, while at the same time they demonstrate a significant advantage in reducing content-word duration under the influence of priming in the CW condition. The latter implies their need to “protect” fluent articulation of content words by planning in advance, so they articulate it faster in the CW condition.

The younger group of CWS did not demonstrate an advantage in the shorter articulation of content words in the CW condition. However, as the analysis of the variable *duration of silent pauses* will show, younger children who stutter experience longer pauses than older children who stutter and, by using prolonged pauses, possibly ensure their fluency in content-word articulation.

Likewise, younger children who stutter, according to the results of this research, also do not produce more disfluencies on function words, as predicted by the EXPLAN theory. This result can possibly be accounted for by the restrictions of this research, which did not predict...
that a specific number of children (in about 100 sentences out of the total number of sentences, a function word was missing) would omit the function word, articulating only the content word. Further research should choose as primers those function words with less chances of being omitted, which would lead to more clear insight into the relation between function and content words in different age groups in the Croatian language.
5.8 Conclusion on the variable number of disfluencies

The research on selective priming in the Croatian language confirmed that the variable *number of disfluencies* (as part of effects A and B dealing with the number of disfluencies on content and on function words) is significantly dependent on the priming condition ($F=9.996$, $F=23.597$, $p<0.001$).

Considering the main priming effect, it could be stated that both in the case of content-word articulation and in the case of function-word articulation, all children are more “successful” in the CW priming condition. This is also how Savage and Howell (2008) interpret the significance of the main effect. However, researchers should be careful when it comes to this type of interpretation. It can be said that all children benefit from priming in the CW condition, in both producing content and function words, but that the statistically significant interaction, or the analysis of the simple effect, implies a need for further analysis. Therefore, the interaction between stuttering, priming, and the number of disfluencies indicates only that the group of CWS stutters significantly less on function and content words in the CW priming condition.

All the obtained differences on the intensity of the effects are higher in children who stutter than in children who do not stutter. This has confirmed hypotheses **H1.3 and H2.4** that the effects A and B in the variable *number of disfluencies on content and function words* are stronger in both groups of children who stutter compared to both groups of children who do not stutter.

The obtained results on the variable *disfluencies* are in accordance with the hypothesis of the EXPLAN model which states that the “gain” of the plan in advance for one word type can be seen from the lower number of disfluencies (on both function and content words) in the target sentence. The “gain” on content words can be expected because they are “harder” and more complex to articulate, so the plan in advance makes the occurrence of non-fluent articulation on that word type less plausible. For function words the plan in advance means that words do not have to be repeated (which is in function words a typical disfluency type, associated with stalling symptoms). This would mean that content-word priming diminishes the need for function word repetition in order for the stalling symptom to reduce disfluency on content words. Therefore, precisely the gain on a smaller number of disfluencies on function words after content-word priming provides the strongest experimental evidence that selective lexical...
priming can be used to influence the relation between language planning and speech performance itself (Savage and Howell, 2008).

The covert repair hypothesis (Kolk and Postma, 1997), as a model opposed to the EXPLAN theory in accounting for the cause of the occurrence of disfluencies, could not be used to explain this kind of gain in planning and articulating both word types. If disfluencies are only a result of errors within phonological encoding, then errors should, especially on function words, occur equally after priming using both word types. Why would function words after content-word priming be less susceptible to such errors of the phonological plan than after the condition of function-word priming?

The more fluent articulation of function words after content-word priming is harder to explain using the covert repair hypothesis, that is, the explanations that, for phonologically simpler words, priming benefits differ in favor of one word type and that they are stronger in the CW priming condition, are less plausible.

A question can be raised dealing with the level of language planning reached by the priming gain using one word type, seen in the lower number of disfluencies in both word types. Is it only a benefit dealing with facilitating phonological activation of words during language encoding, or is that benefit also realized as the results of a faster retrieval of lexical units? As mentioned in Chapter 3.2.2, dealing with the conceptual framework of this dissertation, the results of research on lexical priming in children who stutter and children who do not stutter showed that children who stutter “remain” longer on an earlier stage of lexical development (Hartfield and Conture, 2006), and that their lexical processing is organized differently than in children with orderly speech-language development (Melnick et al., 2003; Pellowski and Conture, 2005). It is thus possible that the benefit from priming in the CW condition for both word types is the result of quicker retrieval of lexical units in CWS.

An explanation for the relation between lexical retrieval and the retrieval of a phonological code was offered by the connectionist interactive model of Dell et al. (1997). This model resolves in an acceptable manner the dilemma around the retrieval of lexical units or lemmas representing semantic and syntactic features (Erdeljac, 2009) and morpho-phonological features of word forms. The dilemma about the way in which the activation of lexical units and the activation of their phonological code takes place is in Dell’s model (Dell et al., 1997) accounted for by suggesting a two-step spreading activation. Specifically, the key question of whether the activation spreads successively or simultaneously is resolved by predicting that
the lexical retrieval is the result of a two-way excitatory spreading of a network including three interrelated levels (Dell et al. 1997). One of these levels is comprised of semantic features (a concept or meaning); the second level, of lexical features (a word or lemma); while the third level is comprised of sub-lexical features or phonemes (Dell et al., 1997; Schwartz et al., 2006).

The model does not presuppose separated retrieval levels of word forms or lexemes, but reduces retrieval to a two-way relation between lexical and sub-lexical units (Schwartz et al., 2006). In other words, the lexical retrieval takes place in two mutually separated, but mutually connected steps: word (lemma) retrieval and phonological retrieval (Dell et al., 1997; Dell et al., 2004; Schwartz et al., 2006).

The word retrieval begins, as already mentioned in the overview of one of the earlier versions of this model (Dell and O’Seaghdha, 1991) in Chapter 3, when the target word in activated by its meaning, while the person is looking at it, listening to it, or thinking about it. This activation spreads throughout the network from the semantic feature to the word selection and phoneme selection and backwards, until the strongest activation coincides with the adequate syntactic category (for example, in the semantic field of the meaning to play, the selected units in is playing). The selected unit igrase ‘is playing’ is associated with the strongest activation, and it simultaneously signifies the beginning of the phonological activation and phoneme retrieval for that word. The activation spreads once again throughout the network top-down and bottom-up. The phonological activation lasts until the “strongest” phonemes are selected (Sevald and Dell, 1994; Anderson and Byrd, 2007).

It is possible that, in the segment of lexical retrieval which includes semantic activation, word retrieval takes place in a less adequate, slower, or a more competitive manner. Such a slower or more competitive manner may be facilitated by an overall sequence of language planning in advance.

In the conclusion on the variable disfluencies, as well as in the conclusion on the variable duration in this dissertation, it is certainly necessary to mention the interpretation of the occurrence of disfluencies and the prolongation of content-word duration offered by the disrupted rhythm hypothesis in the EXPLAN model. That is, the primer or content-word articulation can be considered in advance as a kind of an alarm reminder.

A person who stutters begins a speech performance with an incomplete language plan, and the efferent copy of that plan is updated until it is (finally) complete. A slower speech rate enables
the individual who stutters to obtain more time for the process of synchrony between motor performance and language planning. Individuals who stutter (the older groups of children beginning to experience advancing symptoms in a certain number of their disfluencies) are in a process in which their alignment between planning and performing collapses. The alert signal, which occurs if a discrepancy between the efferent copy of motor commands and the neural representation of speech recovered from vocal output takes place, fades with time. The loss of the role of the alert signal for the discrepancy between the efferent copy of motor commands and the neural representation of speech occurs because an adaptation to the alerting sequence takes place.

The adaptation to the alerting sequence means that the individual who stutters partially feels the discrepancy between the efferent copy and perception of one’s own speech, and is partially adapted to that alert, which creates a good opportunity for the development of stuttering, since it occurs too often (Howell et al., 2000b).

The adaptation to the alerting sequence is the basis of a permanent disorder in stuttering and the transition to the more complex symptoms of accelerated speech. Symptoms of speech acceleration, as previously stated, are repetitions and prolongations of word segments, delays, and disruptions (Howell et al., 2000b). The articulated primer is reminiscent of an alert signal which a child uses to benefit from planning in advance on one hand, but also to obtain a repeated activation of alerts which “reminds” him or her of the need to align efferent copies of motor commands with phases of the aforementioned lexicalization and phonological encoding on the other hand. Thus, in the CW priming condition, they articulate words faster and stutter less on them.

As already mentioned in the conclusion on the variable duration, the results of older children who stutter, dealing with their “gain” in the CW priming condition and the shorter duration of content words implies that, perhaps precisely because their stuttering is moving onto advancing symptoms, that gain is higher than in younger children who stutter. Specifically, older children belong to the group in which transition of the advancing symptoms to content words with an untimely performance (that is, while the lexicalization with an activation of a lemma and a phonological code are still in progress) have already taken place. If planning takes place faster and ends up as a word articulation in advance, this reduces the need for a prolonged articulation, but also the occurrence of disfluencies on content words. The occurrence of disfluencies on function words is abolished by the same process.
According to the EXPLAN theory, disfluencies occurring on function words are actually of a compensatory nature, somewhat like “buying (more) time” to complete the plan of the following content word. The plan in advance provides older children who stutter with a “gain” precisely on a content word. Those words are “harder” to encode lexically and phonologically, which leads to a higher chance for a discrepancy between their language planning and speech performance.

The results of this research have an implication on the underlying processes of disfluent speech. The obtained results on the number of disfluencies after selective priming demonstrate what lies in the basis of disfluent speech, and that the fluency of a sentence articulation increases when the time needed for the language planning of content words is excluded in advance from the time needed for planning in general. When a word is already planned, the trace of that neural process still lasts, and it is transmitted to the duration of the following articulation.

The results on the number of disfluencies in this research offer the second piece of experimental evidence that speech fluency is a result of a time discrepancy in the clash between language planning and speech performance, and not only a result of an incomplete phonological segment of language planning, as interpreted by the Covert repair hypothesis. In that sense, the study on Croatian verifies the assumption of the EXPLAN theory as the one by Savage and Howell from 2008 did in English.

The result showing the higher number of disfluencies on function words in older children who stutter compared to younger children who stutter is not in accordance with the hypothesis of the EXPLAN theory. Thus, the result is also in a kind of contradiction with the results of older children who stutter, who benefit more from priming in the CW condition, measured by an average shorter duration of content words.

A question can also be raised as to how it is possible that, in older children who stutter, the symptom of disfluencies in a phonological word is both a function and a content word, i.e. the repetition of a function word. Repeating a function word is a “protective” effect from the occurrence of disfluencies on a content word. But how can the reduced duration of a content word under the influence of priming in the CW priming condition in older children who stutter be related to this phenomenon?

It is possible that the two phenomena are not related. For instance, it might be the case that the higher number of disfluencies on function words in oCWS compared to yCWS is a result of
the methodological restrictions of this research. As already mentioned, the research did not anticipate that a certain number of children (the research does not include data on the number of children from particular groups) would leave out the function word in the target sentence, articulating only the content word, which is a considerable restriction of the thesis.

Further research should select as primers those function words for which there is a low possibility of them being omitted. This would provide a more clear insight into the relation between disfluencies on function and content words in different age groups after priming in the FW and CW conditions in the Croatian language as well.
5.9 The variable duration of silent pauses

This chapter will present the results and discussion on the duration of silent pauses preceding a content word in CWS and CWDNS as part of effect B. Differences in the duration of silent pauses between older and younger children who stutter and children who do not stutter will also be presented.

5.9.1 Duration of silent pauses in FW and CW priming conditions

As was pointed out earlier, due to the features of distribution and the variance of the obtained results, in answering the research questions, the results of parametric and also nonparametric statistical methods were observed. If the conclusions of the two statistical methods were identical, due to a greater statistical strength and the possibility of observing interactions as a dominant focus of the thesis, then the results of parametric statistical methods were provided. In the testing of differences in the duration of silent pauses preceding content-word articulation in FW and CW priming conditions, parametric and nonparametric statistical methods led to different conclusions.

A t-test for the repeated measurement, as a parametric statistical method, did not find a statistically significant difference in the duration of silent pauses preceding content-word articulation in content-word priming compared to function-word priming (t=1.226, p=0.224). On the other hand, the results of a Wilcoxon signed-rank test, as a nonparametric test, imply a statistically significant difference in the duration of silent pauses in the condition of function-word priming compared to content-word priming (Z=3.29, p=0.001), wherein the duration of pauses is on average shorter in content-word priming.

Due to the features of the distribution and variance of the two conditions (the more prominent variance in the condition of content-word priming), the parametric statistical method did not succeed in demonstrating the difference. Therefore, it is more appropriate to report on the obtained results from the Wilcoxon test, which does not depend on obtained distributions and variances, and conclude that the duration of pauses is on average shorter in content-word priming (C=1) than in function-word priming (C=3.5).
5.9.2 Duration of silent pauses in CW and FW conditions in CWS and CWDNS

Due to the adequacy of a nonparametric statistical method for the comparison of the duration of silent pauses in the two priming conditions, the difference in the duration of silent pauses between children who do not stutter and children who stutter was also observed using another nonparametric statistical method, the Mann-Whitney U-test.

The results imply the absence of a statistically significant difference between the duration of silent pauses in children who do not stutter and children who do stutter, in the function-word priming condition (Z=1.70, p=0.089) and in the content-word priming condition (Z=1.72, p=0.086).

5.9.3 Duration of silent pauses in CW and FW conditions in younger and older CWS and CWDNS

The difference in the duration of silent pauses was also observed between younger and older CWS and CWDNS. Based on the results of the signed-rank test, it can be concluded that the duration of silent pauses in younger and older children who do not stutter does not statistically differ in a significant manner in either the FW priming condition (Z=1.43, p>0.05), or in the CW priming condition (Z=1.44, p>0.05).

When it comes to younger and older children who stutter, the results imply a shorter duration of silent pauses in the CW condition in older children (C=1) than in younger children (C=3.5) who stutter (Z=2.374, p=0.018), while the difference in the duration of silent pauses in the FW condition in younger and older children who do not stutter was not statistically significant (Z=0.41, p=0.698).
5.10 Conclusion on the variable duration of silent pauses

As previously mentioned, the results of the Wilcoxon signed-rank test, which does not depend on the obtained distributions and variances, demonstrate that the duration of pauses is on average shorter in content-word priming (C=1) than in function-word priming (C=3.5).

The benefit of the CW condition once again verifies that, if a content word is “received” in advance, this leads to a kind of “gain” in language planning and speech performance, shown in the case of silent pauses as a reduction of their duration.

Every pause in speech is in a way a reflection of less fluent speech, so it can be pointed out once more that the results of this dissertation lead to a conclusion that all children are more fluent after content-word priming. Effect B in the variable duration of silent pauses preceding a content word is not stronger in children who stutter. The same results were obtained in research in the English language (Savage and Howell, 2008). Research results confirm the hypothesis H2.3: The duration of silent pauses preceding content-word articulation is shorter after content-word priming than after function-word priming.

In a further explanation, it can be stated that these results suggest that content-word priming reduced the complexity of the language planning and performance of both function and content words. When it comes to content words, the benefit from priming in the CW condition is also reflected in shorter pauses. During the speech act, pauses reflect speech performance planning.

Butterworth (1989), according to Erdeljac (2009), considered pauses to be segments of the word-planning stage of a concrete idea. In the stage of fluent speech performance, when a word was already selected from the semantic lexicon, a pause “covers” its retrieval from the phonological output lexicon. Pauses occurring in the stage of lexical planning are 50% longer than pauses occurring in the stage in which speech performance has already begun. It can be assumed that, in the case of a primer articulation in the CW condition, the reduced duration of a silent pause implies a completed lexical stage of semantic selection and the beginning of a retrieval from the phonological lexicon.

The results demonstrate that the only difference between the groups of CWS and CWDNS, as well as between older and younger CWS and CWDNS, is demonstrated only in the case of comparing older and younger CWS. Older children who stutter experience significantly shorter pauses in the CW priming condition than younger CWS (C=1, Z=2.374, p=0.018).
This is another indicator that, in this study, older children who stutter already experienced some difficulties with the alignment of language planning and performance, with the focus precisely on content-word articulation. The fact that the focus of their difficulties lies exactly in content words is demonstrated by greater gain in priming.

This greater gain in the CW priming condition is expressed in several ways:

a) through shorter durations of content words in the CW condition compared to yCWS.

b) through lower numbers of disfluencies in the CW condition compared to CWDNS.

c) through shorter durations of the silent pauses preceding content words in the CW priming condition compared to yCWS.

All of the above leads one to the conclusion that older children who stutter experience a stronger focus of the intensity of language planning precisely on content words. The shorter duration of the stage of selection from the semantic lexicon provides more time for phonological retrieval, which altogether enables the possibility for the occurrence of a shorter pause within the target sentence. This way, for example, the sentence *ona se češlja* ‘she is combing her hair’ is articulated with a shorter pause in the CW condition, after the child heard and repeated the primer *češlja* ‘combing’, than in the FW condition, when the child heard and repeated *ona se* ‘she … herself’.
5.11 The variable speech initiation time of the first target word in fw and cw conditions in cws and cwdns

The results of a two-way variance analysis (Table 24) demonstrate a statistically significant priming effect on the speech initiation time of the first word in the target sentence (F=25.173, p<0.001, \(\eta^2=0.244\)). The speech initiation time of the first word in the target sentence is on average shorter in the content-word priming condition (M=1.931) than in the condition of function-word priming (M=0.084).

The stuttering effect was not detected as statistically significant (F<1); in other words, the speech initiation times of the first word in the target sentence in CWS and CWDNS were identical.

The obtained statistically insignificant interaction between stuttering and priming suggests that the detected priming effect on the speech initiation time of the first word in the target sentence is identical in both groups of children (F<1) (Figure 25).

Table 24. Speech initiation time of the first word in the target sentence in FW and CW priming conditions in CWS and CWDNS (2x2 ANOVA with repeated measure in the second variable).

<table>
<thead>
<tr>
<th>Stuttering (groups of children)</th>
<th>Function word M (SDm)</th>
<th>Content word M (SDm)</th>
<th>Total M (SDm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children who do not stutter</td>
<td>2.150 (0.119)</td>
<td>1.847 (0.126)</td>
<td>1.999 (0.113)</td>
</tr>
<tr>
<td>Children who stutter</td>
<td>2.318 (0.119)</td>
<td>1.931 (0.126)</td>
<td>2.124 (0.113)</td>
</tr>
<tr>
<td>Total</td>
<td>2.234 (0.084)</td>
<td>1.931 (0.089)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect</th>
<th>F</th>
<th>p</th>
<th>(\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>25.173</td>
<td>0.000</td>
<td>0.244</td>
</tr>
<tr>
<td>Stuttering</td>
<td>0.623</td>
<td>0.432</td>
<td>0.005</td>
</tr>
<tr>
<td>Interaction Stuttering x Priming</td>
<td>0.364</td>
<td>0.548</td>
<td>0.005</td>
</tr>
</tbody>
</table>
Figure 25. Speech initiation time of the first word in the target sentence in FW and CW priming conditions in CWS and CWDNS

The speech initiation time of the first word in the target sentence in FW and CW priming conditions in CWS and CWDNS (Figure 25) demonstrates the following:

a) CWS and CWDNS initiate words significantly earlier in the CW condition than in the FW condition.

b) The difference between the speech initiation time between CWS and CWDNS in the FW condition is identical to the equivalent difference in CW condition.

c) CWDNS experience statistically insignificant shorter speech initiation time than CWS.

The obtained statistically insignificant interaction between stuttering and priming suggests that the established priming effect on the speech initiation time of the first word in the target sentence is equal in children who stutter and children who do not stutter. Therefore, both groups experience an advantage in speech initiation when a plan in advance is obtained for content words. This statistical significance of the shorter speech initiation time in both groups of children in the CW condition differs from the results of selective lexical priming in the English language, where no significant priming effect (either for the group of CWS, or for the group of CWDNS) and no significant interaction was verified.
Savage and Howell (2008) did not find a difference between the two priming conditions in the speech initiation time for any group of children. The occurrence of a difference between the results of this study and the one on the English language may have taken place due to a larger sample and a higher number of older children in this study. The study by Savage & Howell (2008) included 24 children aged 3;10 to 8;11, while this research included 80 children divided into two age groups, one ranging from 3;5 to 6;5 and the other from 6;5 to 9 years.
5.12 Conclusion on the variable speech initiation time (SIT)

Hypothesis H3 – Children who stutter will experience a slower speech initiation time (SIT) for the first word in the target sentence than children who do not stutter in both priming conditions – the condition of content-word priming (the CW condition) and the condition of function-word priming (the FW condition) – was not confirmed.

The results of a two-way variance analysis demonstrate a statistically significant priming effect on the speech initiation time of the first word in the target sentence (F= 25.173). It is on average shorter in the CW condition when compared to the FW condition. However, the main effect of stuttering was not found to be statistically significant (F= 0.623); in other words, the speech initiation time of the first word in the target sentence was equal for children who stutter and children who do not stutter.

The priming “gain” in the form of faster speech initiation in the condition in which the primer is a content word is part of the priming effect, as pointed out in Chapter 3.

The method of lexical priming is based on the presumption that, if words or syntactic structures are adequately primed using a primer such as a phoneme, a word, or a sentence in a phonological, syntactic, or semantic relation with the target word or sentence, that primer will speed up or slow down the representation of the target word or syntactic structure in the mental lexicon and/or its phonological encoding.

Correspondingly, the primer will speed up or slow down the reaction time needed for the articulation. The target word or sentence can be produced with a longer or shorter latency time in naming while watching the presented picture. The interfering stimulus or primer can be heard before, during, or after the occurrence of the picture, and will lead to the activation of a word or a syntactic structure in the mental lexicon in a way which depends on one of the above-mentioned language relations with the priming word. The speeding up or slowing down of the target word encoding, as a result of a language relation between the primer and the target word, will take place in one of the components of language processing.

The results of this study can be compared to the results of a study by Munson and Babel (2005) which observed phonological processing in two groups of children compared to adult participants in an experiment using priming with repeated sequences with a different phonological similarity. Munson and Babel (2005) in this research concluded that children “remain” longer on their lexical and phonological encoding, and that in children the growth of
vocabulary has a great effect on the phonological encoding. The authors of that study themselves referred to a 1994 study by Sevald and Dell which used a specific experimental paradigm of reiterating speech. The experiment conducted by Sevald and Dell showed that final consonants in a word facilitate or produce a facilitating effect in the fluent speech performance of a word preceding such priming, and in a word including consonants in the same position at the end of the word. The repeated word beginning with the same consonants as the word preceding it (for example, bed bell bed bell) inhibits initiation time and prolongs the word itself. Sevald and Dell (1994) interpreted these results using their model of speech production referred to as the *sequential cueing model*. This model presupposes that during a speech performance the movements are faster and more connected if they can be continued on the motor patterns activated immediately before those movements. The authors offered an analogy with speech performance. Sevald and Dell’s model deals precisely with the sequential activation of lexical units and the phonological code those units include. Speech production thus begins when the activated lexical units are included in the representation of included phonemes. According to the theory by Sevald and Dell, all phonemes are activated sequentially, rather than simultaneously. Their activation fades gradually. Some of the phonemes in lexical units can remain partially active even after their articulation.

The idea of sequential cueing from Sevald and Dell’s model (1994) can be related to the revised version of the EXPLAN model in which a different speed of lexical class activation results in the occurrence of difficulties with fluent speech. Content-word priming enables a facilitating effect for the speech initiation time. The content word, its phonemes, or lexical units can remain partially active after being articulated and can therefore lead to a faster speech initiation in the way suggested by Sevald and Dell (1994). This dissertation has shown that both groups of children who stutter, as well as the children who do not stutter (CWS and CWDNS) have an advantage in speech initiation when a plan for the content word is obtained in advance. This statistical significance of the shorter initiation time in both groups of children in the CW condition differs from the results of research on selective lexical priming in English in which no statistically significant priming effect, nor even a significant interaction, was detected either in the group of CWS, or in the group of CWDNS. The identical benefit in the CW priming condition in both groups of children may be explained by an equal facilitating effect produced by the CW condition in the speech initiation time. As previously stated, the content word, its phonemes, or lexical units can remain partially active
after being articulated, and may therefore lead to a faster speech initialization in the manner proposed by Savage and Dell (1994) in both CWDNS and CWS.
6. CONFIRMATION OF HYPOTHESES

**H1:** The duration of articulation and the number of disfluencies on content words is changed in the condition of content-word priming compared to the condition of function-word priming.

**H1.1:** The duration of the content-word articulation is shorter after content-word priming than after function-word priming.

**H1.2:** The number of disfluencies on content words is lower after content-word priming than after function-word priming.

**H1.3:** Effect A is stronger in both groups of children who stutter compared to both groups of children who do not stutter.

The hypothesis **has been partially confirmed.**

The statistical analysis of the dependent variable *duration of articulation of content words* indicates a shorter duration of content words after content-word priming than after function-word priming. Hypothesis **H1.1 has been completely confirmed.**

The statistical analysis of the dependent variable *number of disfluencies on content words* indicates that the number of disfluencies is lower in the condition of content-word priming than in the condition of function-word priming. Hypothesis **H1.2 has been completely confirmed.**

Children who stutter did not demonstrate a stronger priming effect in the variable *duration of content words* in the effect A than children who do not stutter, which is also indicated by a statistically insignificant interaction. Children who stutter demonstrated a stronger priming effect in the variable *number of disfluencies* in the effect A, indicated by a statistically significant interaction. Therefore, the hypothesis **H1.3 has been partially confirmed.**
**H2**: The duration of articulation and the number of disfluencies on function words, as well as the duration of silent pauses preceding the content-word articulation is changed in the condition of content-word priming compared to the condition of function-word priming.

**H2.1**: The articulation duration of function words preceding a content word is shorter after content-word priming than after function-word priming.

**H2.2**: The number of disfluencies on function words is lower after content-word priming than after function-word priming.

**H2.3**: The duration of silent pauses preceding the articulation of content words is shorter after content-word priming than after function-word priming.

**H2.4**: Effect B is stronger in both groups of children who stutter than in both groups of children who do not stutter.

This hypothesis has been partially confirmed.

The statistical analysis of the dependent variable *duration of articulation* of function words indicates a shorter duration of function words after content-word priming than after function-word priming. Hypothesis **H2.1 has been completely confirmed**.

The statistical analysis of the dependent variable *number of disfluencies on function words* indicates that the number of disfluencies is lower in the condition of content-word priming than in the condition of function-word priming. Hypothesis **H2.2 has been completely confirmed**.

The statistical analysis of the dependent variable *duration of silent pauses* preceding the articulation of content words indicates a shorter duration of a silent pause after content-word priming than after function priming. Hypothesis **H2.3 has been completely confirmed**.

Children who stutter did not demonstrate a stronger priming effect in the variable *duration of function words* in effect B than children who do not stutter, which is also indicated by a statistically insignificant interaction. Children who stutter demonstrated a stronger priming effect in the variable *number of disfluencies* in effect B, indicated by a statistically significant
interaction. The results of the statistical analysis indicate that there is no statistically significant difference between the duration of silent pauses in children who stutter and children who do not stutter in both priming conditions. Therefore, hypothesis H2.4 has been partially confirmed.

H3: Children who stutter will experience a slower speech initiation time (SIT) for the first word in the target sentence than children who do not stutter in both priming conditions – the condition of content-word priming (the CW condition) and the condition of function-word priming (the FW condition).

This hypothesis has not been confirmed. The difference in speech initiation time (SIT) of the first word in the target sentence in both of the above-mentioned priming conditions between children who stutter and children who do not stutter is not statistically significant.

H4: The difference in the intensity of the lexical priming effects (effect A and effect B) between the groups of younger and older children who stutter will be higher than the difference between effects A and B between the groups of younger and older children who do not stutter.

This hypothesis has been partially confirmed.

The statistical analysis determined that the dependent variable articulation duration of content words in the two priming conditions in younger and older children who stutter is not statistically significantly different. However, the established statistically significant interaction between age and priming indicates a different priming effect in younger and older children who stutter. Older children who stutter demonstrated a shorter articulation duration of content words in the condition of content-word priming than in the condition of function-word priming, while there was no difference in the duration of articulation of content words between the two priming conditions in younger children who stutter.

There is a statistically significant effect of age on the duration of articulation of content words in children who do not stutter, but no statistically significant interaction between age and priming was determined, meaning that the duration of content words in oCWDNS and in yCWDNS is equally shorter in the CW priming condition than in the FW priming condition. If these results are compared to older and younger children who stutter, it is clear that such a difference is more prominent in both groups of children who stutter. Thus, it can be stated that
the difference in the intensity of effect A of lexical priming in the variable *duration of content words* is higher between older and younger children who stutter than between older and younger children who do not stutter.

The difference in the variable *duration of function words* in both priming conditions in children who stutter, as well as in children who do not stutter, in both age groups is not statistically significant. Thus, it can be stated that the difference in the intensity of effect B of lexical priming in the variable *duration of function words* is not higher between the groups of younger and older children who stutter compared to older and younger children who do not stutter.

The results of a three-way variance analysis indicate a statistically insignificant effect of age, or an equal number of disfluencies in content-word articulation in younger and older children. There was no statistically significant interaction between age and stuttering, implying the existence of the same stuttering effect (the same difference between children who stutter and children who do not stutter) in younger and older children.

Also, no interaction between age and priming was determined, implying the existence of the same priming effect in younger and older children (producing a lower number of disfluencies in content-word priming), as well as no interaction between age, stuttering, and priming. Therefore, there is no difference in the intensity of effect A between older and younger children who stutter and children who do not stutter.

The statistical analysis determined that there is a statistically significant difference in the dependent variable *number of disfluencies* only in the number of disfluencies between older and younger children who stutter in the articulation of function words, but not in the intensity of the priming effect. Specifically, older children who stutter have a higher number of disfluencies on function words than younger children who stutter. When it comes to younger and older children who stutter, the results indicate a shorter duration of silent pauses in the CW condition in older children than in younger children who stutter, while the difference in the duration of silent pauses in the FW condition in younger and older children who stutter is not statistically significant.

Likewise, the analysis determined that there is no statistically significant difference between the duration of silent pauses in younger and older children who do not stutter. It can be concluded that in effect A the significant difference is in the duration of content words
between older and younger children who stutter, and in effect B it is the duration of silent pauses in the CW condition that is significantly shorter in older children who stutter. There was no statistically significant difference in the intensity of effect A and effect B in priming between younger and older children who do not stutter. It can be stated that the difference in the intensity of effect A and effect B in younger and older children who stutter is only partially determined compared to younger and older children who do not stutter. Hypothesis H4 has, therefore, been partially confirmed.
7. CONCLUSION

Every speech act, even a disfluent one, is a result of a clash between language planning and speech performance itself. This dissertation has shown that within the framework of the EXPLAN theory, the effect of language planning on motor performance can be singled out in the occurrence of disfluencies. This effect of language planning has been confirmed by obtaining more time for language planning after content-word priming, than after function-word priming.

The gained results indicate that less time is needed for language planning after content-word priming, and that this can lead to a shorter speech initiation time, shorter word duration, shorter duration of pauses, and fewer disfluencies on both content and function words in an utterance, which does not occur in a significant manner after function-word priming, as predicted by the EXPLAN theory.

This study, which included participants divided into two groups of children who stutter and two groups of children who do not stutter (younger and older), obtaining more time for language planning in the variable duration. This has been demonstrated by a shorter duration of content and function words in the content word or CW priming condition. This higher gain in the CW condition his means that planning in advance ensured their efficiency in word articulation and reduced the need to extend the time needed to articulate content words in order to prevent the occurrence of stuttering symptoms on those words. In other words, all children obtained more time for language planning when the articulation of both word types in a sentence was preceded by content-word priming. Children who stutter did not demonstrate a stronger priming effect in the variable duration of content words (effect A) or in the variable duration of function words (effect B) compared to children who do not stutter.

The results in the variable duration indicate that obtaining more time after priming on content words, which are phonologically more complex for both children who stutter and children who do not stutter, can be regarded as a facilitating priming effect. The results may imply that, when it comes to language planning itself, its phonological component “benefits” the most from this type of lexical priming.
Children who stutter demonstrated on average longer duration of the target word in both priming conditions. One of the possible explanations is that children who stutter experience a prolonged duration of words as a compensatory mechanism in speech production, “protecting” them against the potential occurrence of disfluent speech. Research on adults who stutter has shown that slowing down speech enables more time for the synchronous process between motor performance and language planning. The question of whether or not such an explanation may be offered as a plausible one when it comes to the occurrence of disfluent speech in children who stutter has yet to be answered, as does the question of whether or not disfluencies in children who stutter are really the result of a disrupted mechanism of the timekeeper in the cerebellum, as assumed when it comes to adults who stutter. The answers to these questions should be considered in light of neuromorphological research on the brain in children and adults who stutter.

This study included older and younger children who stutter and has demonstrated that older children who stutter “benefit” more from priming in the content word condition, measured as shorter duration of the content word. This means that, for them, planning in advance enabled efficiency in word articulation and reduced the requisite for the prolongation of the articulation time of content words in order to prevent the occurrence of stuttering symptoms on the content word to a greater extent than for younger children. The “higher gain” in the content word condition, achieved by a shorter duration of the content word, also indirectly implies that, in older children, the transition from stuttering symptoms from function to content words already took place, as proposed by the EXPLAN theory. Since the older group of children included children up to the age of 9, this study has demonstrated that, in the Croatian language, due to its specific (linguistic) features, the change in stuttering symptoms occurs earlier than it does in the English language, i.e., that there is an earlier transition from stalling symptoms (function-word repetitions) to advancing symptoms (repetitions or prolongations of content-word segments).

In the variable duration, in the group of children who do not stutter, the study has demonstrated that younger children who do not stutter and older children who do not stutter experience only a slight difference in the duration of content word in both priming conditions. In other words, the significance of the facilitating priming effect is not demonstrated by a significantly shorter duration of the content word in the content word priming condition when compared to the function word priming condition if the groups of children who do not stutter are observed separately. In the duration of function words, the study has demonstrated a
statistically insignificant age effect for this word type, suggesting an equal duration of function-word articulation in younger and older children. The statistically insignificant interactions between age and stuttering and age and priming demonstrate that the absence of age differences is present in both children who stutter and children who do not stutter in both priming conditions. It can be concluded that only the duration of function-word articulation does not have a compensatory role. These words are either repeated, or disfluency symptoms are transferred over to the following words in the sentence – the content words.

In the variable number of disfluencies, all children “benefited” more from the content word priming condition, but only the group of children who stutter stuttered significantly less on function and content words in the content word priming condition. In other words, all obtained differences in the intensity of the effect were greater in children who stutter than in children who do not stutter.

The analysis of the data on the variable number of disfluencies has demonstrated that content-word priming abolishes the need for function-word repetition in order for the stalling symptoms to reduce the number of disfluencies on content words. Therefore, precisely the “gain” in terms of the lower number of disfluencies on function words, after content-word priming, provides the experimental evidence that selective lexical priming can be used to affect the relation between language planning and motor performance itself. Slower or less efficient phonological planning, used by the covert repair hypothesis to account for the occurrence of disfluencies, is set aside by these results, giving the priority to the hypotheses of the EXPLAN theory on the exceptional significance of the relation between language planning and motor performance as two indivisible processes of each and every speech act.

The hypotheses of the EXPLAN theory about a large number of disfluencies on functional words in younger children than in older children have not been confirmed here. The data analysis on the variable number of disfluencies on function words shows a higher number of function-word disfluencies in older children who stutter than in younger children who stutter. Much effort is needed to relate these results with the aforementioned results in the variable duration of content word in older children who stutter – in that variable, older children benefited more from priming in the content word condition, measured by a shorter average duration of content words.

The questions of the existence of two possible foci of disfluencies within a phonological word in older children who stutter, function word repetitions, and changes in the speed rate of
content-word articulation still remain unanswered. The repetition of a function word is a “protective” effect against the occurrence of disfluencies on a content word. Further research should verify whether or not older children who stutter repeat the function word more than younger children who stutter, as well as whether they experience a shorter duration of the content word under the influence of the content word priming condition as the second focus of disfluency. Further research should aim to evade the restrictions of this study in the selection of function words which can be omitted or moved to the position following the content word, which may reduce the significance of the hypotheses of the EXPLAN theory on the role of function words dealing with obtaining more time for content-word planning.

In the end, the issue mentioned in the chapter on EXPLAN theory – whether children who begin to produce disfluencies like stuttering differ from children who speak fluently – remains unresolved. According to the EXPLAN theory, the two groups are similar because both of them produce more disfluencies on function words. This study suggests that young children who stutter have a different distribution of disfluencies than older children who stutter. But whether this distribution of disfluencies in younger children who stutter is essentially different from disfluencies in younger children who speak fluently remains an open question. Older and younger children who do not stutter did not show a statistically significant difference in the number of disfluencies, and it can be said that they are indisputably more similar to each other in the production of disfluencies than the groups of older and younger children who stutter.

The analysis of the results in the variable *duration of silent pauses* has demonstrated that the duration of pauses was on average shorter in content-word priming than in function-word priming.

The “gain” in the content word condition confirms once again that, if a content word is obtained in advance, a “benefit” in language planning and speech performance is achieved as well, which in the case of silent pauses is seen in their reduced duration. The priming effect in the variable *duration of silent pauses* preceding the content word has not been demonstrated as having a stronger intensity in children who stutter.

In the comparison between older and younger children who stutter, older children experienced significantly shorter pauses in the content word priming condition than younger children. This is another indicator of the complexity of aligning language planning and speech performance in content-word articulation in older children who stutter. No such differences in the variable
duration of silent pauses between younger and older children who do not stutter have been found.

In the variable speech initiation time, a significant priming effect has been confirmed in both groups of children in the content word condition, meaning that the equal “benefit” in the content word priming condition could be explained by a facilitating effect of equal intensity created by the content word condition in speech initiation time.

This dissertation has confirmed that there is a time “gain” in language planning after content-word priming, and that function and content words are involved in the underlying patterns of language planning and performance in a different way in the Croatian language, as well. Moreover, this study has established that these two word types have a different role in the occurrence of stuttering, which is of great importance for further research on stuttering.

The dissertation contributes to the verification of EXPLAN theory hypothesis dealing with the occurrences of disfluencies taking place because of the time discrepancy between language planning and speech performance. The confirmation of this hypothesis indicates a universal nature of stuttering, regardless of language features and the language a child speaks.
8. REFERENCES


Jiang, J., Lu, Ch., Peng, D., Zhu, Ch., and Howell, P. (2012). Classification of Types of Stuttering Symptoms Based on Brain Activity, Plos One http://dx.doi.org/10.1371/


APPENDIX
## APPENDIX 1

**Absolute frequency ranked in numbers: 90–280 = 1; 30–90 = 2; 1–30= 3**

<table>
<thead>
<tr>
<th>Verb</th>
<th>Rank</th>
<th>Absolute frequency</th>
<th>Relative frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ljulja se</td>
<td>3</td>
<td>548</td>
<td>22</td>
</tr>
<tr>
<td>‘is swinging’</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>gleda se</td>
<td>3</td>
<td>552</td>
<td>18</td>
</tr>
<tr>
<td>‘is looking at himself’</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>oblači se</td>
<td>3</td>
<td>554</td>
<td>16</td>
</tr>
<tr>
<td>‘is dressing himself’</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>češlja se</td>
<td>3</td>
<td>567</td>
<td>3</td>
</tr>
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<td>‘is combing himself’</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>veže se</td>
<td>3</td>
<td>558</td>
<td>12</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>tušira se</td>
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<td>569</td>
<td>1</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>svlači se</td>
<td>3</td>
<td>557</td>
<td>13</td>
</tr>
<tr>
<td>‘is undressing himself’</td>
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<td></td>
</tr>
<tr>
<td>kliže se</td>
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<td>‘is ice-skating’</td>
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</tr>
<tr>
<td>umiva se</td>
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<td></td>
<td></td>
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<tr>
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<td>1</td>
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<td>‘is scratching himself’</td>
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<td></td>
</tr>
<tr>
<td>pokriva se</td>
<td>3</td>
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<td>5</td>
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<td>‘is covering himself’</td>
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<td></td>
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<tr>
<td>vrti se</td>
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<td>‘is spinning’</td>
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<td>Meaning</td>
<td>Time (minutes)</td>
<td>Frequency</td>
</tr>
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<td>---------</td>
<td>---------------</td>
<td>------------</td>
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<tr>
<td>spušta se</td>
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<td>48</td>
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<td>ljuti se</td>
<td>'is being angry'</td>
<td>525</td>
<td>45</td>
</tr>
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<td>budi se</td>
<td>'is waking up'</td>
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<td>'is sweating'</td>
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<td>penje se</td>
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<td>igra se</td>
<td>'is playing with himself'</td>
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<td>86</td>
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<td>'is being scared'</td>
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<td>smije se</td>
<td>'is laughing'</td>
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<td>briše se</td>
<td>'is drying himself off'</td>
<td>514</td>
<td>56</td>
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## APPENDIX 2

Absolute frequency ranked in numbers: 90 - 280 = 1; 30 - 90 = 2; 1 - 30 = 3

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<th>Relative frequency</th>
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<td></td>
</tr>
<tr>
<td>krokodil</td>
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<td></td>
<td></td>
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<tr>
<td>lav</td>
<td>546</td>
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<td>'lion'</td>
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<td>majmun</td>
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APPENDIX 3

Absolute frequency ranked in numbers: 90-280 = 1; 30-90 = 2; 1 – 30 = 3

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EXPLAN teorija (Howell i Au-Yeung, 2002) nastoji objasniti osobitosti govorne proizvodnje koja vodi nastanku i razvoju mucanja. Ime teorije označava dva procesa koji se nalaze u podlozi fluentne govorne kontrole: planiranje lingvističkih reprezentacija čije trajanje ovisi o kompleksnosti jezičnog procesa (engl. plan, PLAN) i izvedbu (engl. execution, EX), tj. govornu izvršnu funkciju koja slijedi nakon jezičnog planiranja. Prema EXPLAN teoriji, temeljenu odrednicu jezičnih struktura čini podjela na funkcionalne i sadržajne riječi, a prijelaz netečnoga izgovora s funkcionalnih na netečan izgovor sadržajnih riječi pokazatelj je prihvatljivoga objašnjenja razvoja mucanja. Selektivno jezično usmjeravanje dvjema vrstama riječi može pokazati da simptomi mucanja nastaju na dva različita načina, budući da se očekuje različiti ishod na dvjema vrstama riječi.

U ovome je istraživanju temeljni istraživački koncept upravo selektivno leksičko usmjeravanje dvjema vrstama riječi s ciljem promatranja jezičnoga planiranja u stvarnom vremenu. Time se nastojalo omogućiti bolje razumijevanje pojave ili iščezavanja netečnosti te kraćeg ili duljeg trajanja dviju vrsta riječi u slučajevima leksičkog usmjeravanja različitim tipovima riječi u hrvatskom jeziku.

U istraživanju se mjerio učinak usmjeravanja na izgovor sadržajnih riječi (A učinak) u uvjetima usmjeravanja funkcionalnom riječju (FR) i sadržajnom riječju (SR), kao i učinak usmjeravanja na izgovor funkcionalnih riječi (B učinak) u uvjetima usmjeravanja funkcionalnom i sadržajnom riječju. Ispitala se i usporedila jakost obaju učinaka (A i B učinaka) u eksperimentalnoj i kontrolnoj skupini. Djeca koja mucaju (eksperimentalna skupina) i djeca urednog jezično-govornog razvoja (kontrolna skupina) svrstana su u dvije dobne skupine od 3 do 6;5 i od 6;5 do 9 godina. U svakoj je dobnoj skupini bilo dvadesetoro djece. U istraživanju se koristila fonološka riječ kako to predlaže Selkirk (1984) prema pravilu: Dvije konstituente C_i, C_j činile su značenjsku jedinicu ako je točna semantička interpretacija prozodijske riječi C_i je argument od C_j (jezgra).

Prema tom pravilu koristila se fonološka riječ s povratnim glagolima, npr. *on se igra* i *ona se igra*.
Eksperiment je započinjao slušnom riječi-usmjerivačem koja je mogla biti funkcionalna (npr. on se ili ona se) ili sadržajna (npr. penje). U prvom (FR) uvjetu funkcionalne riječi, on ili ona se pojavljivale su se kao usmjerivači i to u 50% slučajeva. U drugom (SR) uvjetu, u preostalih 50% slučajeva, kao usmjerivači su se pojavljivale sadržajne riječi (dvadeset povratnih glagola u trećem licu prezenta).

U prvom ili FR uvjetu, nakon što je odslušalo on se ili ona se, dijete je ponavljalo to što čuje. U drugom ili SR uvjetu, dijete je čulo sadržajnu riječ, npr. glagol penje, te ju ponavljalo. U eksperimentu su se promatrali svi tipovi netečnosti koji karakteriziraju tečan izgovor osim tih pauza: ponavljanje čitave riječi, ponavljanje dijela riječi, produljivanja glasova, napete pauze, prekidi izgovora riječi te umetanja kao što su hm i slično.

Istraživanje je imalo miješane modele analize varijance ili ANOVA nacrte. Dvosmjerna analiza varijance je korištena sa skupinama djece kao faktor između skupine ispitanika, a uvjeti usmjeravanja su korišteni kao faktor unutar skupine ispitanika. Dvije skupine ispitanika bile su skupina djece koja mucaju (DKM) i skupina djece koja ne mucaju (DKNM). Uvjeti usmjeravanja bile su 40 jedinica riječi-usmjerivača, 20 u uvjetu usmjeravanja funkcionalnom riječju (FR uvjetu) i 20 u uvjetu usmjeravanja sadržajnom riječju ili (SR uvjetu). Trostruka analiza varijance korištena je za dob kao dodatni faktor između skupine ispitanika s dvije razine ili dvije dobne skupine; starije skupine djece (koja mucaju (sDKM) i starije skupine djece koja ne mucaju (sDKnM)) te mlađe skupine djece (koja mucaju (mDKM) i mlađe skupine djece koja ne mucaju (mDKnM)).

U istraživanju je bilo pet zavisnih varijabli za svaki istraživački zadatak: trajanje sadržajnih riječi, trajanje funkcionalnih riječi, netečnosti na sadržajnim i funkcionalnim riječima, trajanje tih pauza prije izgovora sadržajne riječi i vrijeme započinjanja izgovora (VZI).

Statistička obrada zavisne varijable trajanje izgovora sadržajnih i funkcionalnih riječi upućuje na sljedeće zaključke:

- Kraće trajanje sadržajnih riječi nakon usmjeravanja sadržajnom riječju u odnosu na usmjeravanje funkcionalnom riječju upućuje na zaključak da sva djeca dobivaju na vremenu planiranja kad njihovom izgovoru prethodi usmjeravanje sadržajnom riječi. Djeca koja mucaju nisu pokazala jači efekt usmjeravanja u varijabli trajanje sadržajne i funkcionalne riječi ni u A ni u B učinku od djece koja ne mucaju, na što upućuju statistički neznačajne interakcije.
Istraživanje je pokazalo kako starija djeca koja mucaju više dobivaju usmjeravanjem u SR uvjetu usmjeravanja, mjereno kraćim trajanjem sadržajne riječi. To znači da im je jezični plan dobiven ranije, u većoj mjeri nego u mlađe djece koja mucaju, osigurao efikasnost u izgovoru riječi i smanjio potrebu za produljenjem vremena izgovora sadržajne riječi, ne bi li se spriječili simptomi mucanja na toj riječi. Taj veći dobitak u SR uvjetu, ostvaren kraćim trajanjem sadržajne riječi, posredno upućuje i na to da je u starije djece već počeo prijelaz simptoma mucanja s funkcionalnih riječi na one sadržajne, kao što to tvrdi EXPLAN teorija.

U hrvatskom kao pro-drop jeziku postoji mogućnost izostavljanja osobne zamjenice na mjestu subjekta ispred glagola čime se smanjuje učestalost funkcionalne riječi u položaju ispred sadržajne riječi u odnosu na engleski jezik. Time su smanjene prilike za djelovanje simptoma zadržavanja, jednog od dvaju ključnih simptoma prema EXPLAN teoriji (zadržavanje–napredovanje, engl. *stalling-advancing*).

Istraživanje je pokazalo statistički neznačajan efekt dobi za funkcionalne riječi koji upućuje na podjednako trajanje izgovora funkcionalnih riječi mlađe i starije djece koja mucaju i koja ne mucaju.

Statistička obrada zavisne varijable *broj netečnosti* upućuje na sljedeće zaključke:

- Dobiveni rezultati u varijabli *netečnosti* u skladu su s pretpostavkom EXPLAN modela koji objašnjava da je dobitak unaprijed za planiranje jedne vrste riječi moguće vidjeti na manjem broju netečnosti (i funkcionalne i sadržajne riječi) u ciljanoj rečenici.

- Moglo bi se reći da u slučaju izgovora sadržajnih riječi, kao i u slučaju izgovora funkcionalnih riječi, sva djeca imaju prednost u SR uvjetu usmjeravanja. No, takvom je tumačenju potrebno pristupiti s dozom opreza. Može se reći kako sva djeca dobivaju usmjeravanjem u SR uvjetu, i u proizvodnji sadržajnih i funkcionalnih riječi, međutim statistički značajna interakcija, odnosno analiza jednostavnih efekata, upućuje na detaljniji uvid. Naime, interakcija mucanja, usmjeravanja i broja netečnosti kazuje, da samo skupina djece koja mucaju značajno manje muca na funkcionalnim i sadržajnim riječima u uvjetu usmjeravanja sadržajnom riječju (SR uvjet).

- Dobitak vidljiv na manjem broju netečnosti na funkcionalnim riječima nakon usmjeravanja sadržajnom riječju daje najjači eksperimentalni dokaz da se selektivnim
jezičnim usmjeravanjem može utjecati na spoj jezičnog planiranja i same govorne izvedbe.

• S postavkama EXPLAN teorije nije podudaran rezultat koji pokazuje veći broj netečnosti funkcionalnih riječi u starije djece koja mucaju u odnosu na mladu djecu koja mucaju. Ovaj je podatak u svojevrsnoj proturječju s rezultatom za stariju djecu koji po pokazuje da starija djeca koja mucaju imaju veći dobitak od usmjeravanja u SR uvjetu, a koji se iskazuje kraćim prosječnim trajanjem sadržajnih riječi.

Statistička obrada zavisne varijable trajanje tihih pauza upućuje na sljedeće zaključke:

• Trajanje pauza u prosjeku je kraće pri usmjeravanju sadržajnom riječju u odnosu prema usmjeravanju funkcionalnom riječju. Dobitkom u uvjetu usmjeravanja sadržajnom riječju (SR uvjetu) još se jednom potvrđuje da dobitak sadržajne riječi unaprijed znači svojevrsni dobitak u jezičnom planiranju i govornoj izvedbi, što se u slučaju tihih pauza vidi u skraćivanju njihova trajanja.

• Starija djeca koja mucaju imaju značajno kraće pauze u SR uvjetu usmjeravanja od mlađe djece koja mucaju. Ovo je još jedan pokazatelj kako starija djeca koja mucaju obuhvaćena ovim istraživanjem već pokazuju izvjesne poteškoće s usklađivanjem jezičnoga planiranja i motoričke izvedbe čiji je fokus upravo na izgovoru sadržajne riječi. To da su im upravo sadržajne riječi fokus poteškoća, pokazuju većim dobitkom u usmjeravanju.

Statistička obrada zavisne varijable vrijeme započinjanja izgovora upućuje na sljedeće zaključke:

• Pretpostavka H3. prema kojoj će djeca koja mucaju imati u obama uvjetima usmjeravanja, i u SR i u FR uvjetu, sporije vrijeme započinjanja izgovora (VZI) prve riječi u ciljanoj rečenici od djece koja ne mucaju, nije potvrđena

• Istraživanje je pokazalo kako obje skupine, i djeca koja mucaju (DKM) i djeca koja ne mucaju (DKNM) imaju prednost u započinjanju izgovora kod dobivanja plana unaprijed za sadržajnu riječ

U zaključku ovoga istraživanja ističe se da podatci potvrđuju da je i u hrvatskom jeziku potrebno kraće vrijeme za jezično planiranje nakon usmjeravanja sadržajnom riječju te da
zbog toga izostaje netečnost na obama tipovima riječi u iskazu, i funkcionalnim i sadržajnim, a da se nakon usmjerenja funkcionalnom riječju vrijeme za jezično planiranje ne skraćuje (kao što je i predviđeno EXPLAN teorijom). Ovo je značajan doprinos razumijevanju sraza jezičnoga planiranja i govorne izvedbe u nastanku i razvoju mucanja. EXPLAN teorija postavlja pretpostavku kako se govorne netečnosti pojavljuju upravo zbog vremenske nepodudarnosti jezičnoga planiranja i govorne izvedbe. Ovo je istraživanje potvrdilo navedenu pretpostavku što je doprinos boljem razumijevanju univerzalne naravi mucanja, bez obzira na značajke jezika u kojem se pojavljuje

Osim toga, ovo je istraživanje pokazalo da mlada djeca koja mucaju, pokazuju različitu distribuciju netečnosti u govoru u odnosu na stariju djecu koja mucaju. Isto tako, da je prijelaz simptoma zadržavanja (ponavljanja čitave funkcionalne riječi) u simptom napredovanja (ponavljanje i produljivanje slogova ili glasova sadržajne riječi), u hrvatskom jeziku moguće ranije nego u engleskom jeziku, što je doprinos otkrivanju specifičnosti razvoja mucanja u hrvatskom jeziku

**Ključne riječi:** EXPLAN teorija mucanja, sadržajne i funkcionalne riječi, jezično planiranje, govorna izvedba, leksičko usmjerenje, simptomi zadržavanja i napredovanja u mucanju
**BIOGRAPHY**

Ines Galić Jušić was born in 1961 in Šibenik, Croatia, where she finished high school. She graduated from the Faculty of Education and Rehabilitation Sciences with a degree in Speech Pathology in 1983. Since 1994 she has been the director of Logokor, a private speech therapy practice. In her 22 years at Logokor, she has worked on diagnostics and dyslexia therapy, specific language impairments, and stuttering in children and adults. From 1984 to 1994, she worked at the SUVAG clinic as an individual therapist for children with normal hearing and children with impaired hearing who have language and speech difficulties.


Her objectives in these educational programmes were to master the theoretical psychotherapeutic specializations and to gain an understanding of deep psychology as an aid in the realization of the goals of therapy in children and adults.

In 2007 she enrolled in the doctoral programme in Language Communication and Cognitive Neuroscience at the University of Zagreb. Her interests include language processing in children with dyslexia and stuttering.
SUPERVISOR BIOGRAPHIES

**Professor Vlasta Erdeljac** since 2000 holds the position of the Head of the Chair of General Linguistic at the Department of Linguistic at the Faculty of Humanities and Social Sciences, University of Zagreb.

Professor Erdeljac graduated at the Study of Linguistics and Phonetics and received her MA in 1989 on the subject *The Relative value of phonological distinctive features*. In 1996 she defended her doctoral thesis on the topic *A word from the definition to the recognition*.

She has been employed as an assistant, senior assistant and associate professor since 1985, and since 2013 as a professor at the Department of Linguistics, Faculty of Humanities and Social Sciences since 2013. She was the Head of the Department of Linguistics for two mandates, from 2000 to 2002, and from 2007 to 2009. She has been the Vice Dean for Teaching and Students at the Faculty of Humanities and Social Sciences since 2014.

In the course of her teaching career, she has articulated her scientific interest in general and theoretical linguistics, as well as psycholinguistics (language processing in production and perception) in a number of different courses/subjects: Introduction to General Linguistics, Phonological Description, Morphological Description, 20th Century Linguistics, Understanding of Language, Cognitive Approach to Language, Word Recognition, and Mental Lexicon.
**Professor Csaba Pléh** is a Hungarian psychologist and linguist. He was the founder and the Head of the Chair at the Department of Cognitive Science at the Budapest University of Technology and Economics.


Professor Pléh’s main research topics are the history of cognitive approaches in different domains (philosophy, psychology, biology, linguistics), the psychology of language including both language processing and language development. Lately, his specific interest has become the study of language development in impaired populations, especially in Williams syndrome and developmental language retardation.

As a member of the Hungarian Academy of Sciences, he works as deputy chair of the Session of Philosophy and History at the Academy, and also works in the governing boards of some grants and scholarships, like the Bolyai Grant and Magyary Grant.