STUDIES IN LANGUAGE AND MIND 4

SELECTED PAPERS FROM THE 8TH and 9TH WORKSHOP ON

PSYCHOLINGUISTIC, NEUROLINGUISTIC AND CLINICAL LINGUISTIC RESEARCH

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PREFACE

This volume, the fourth in the series *Studies in Language and Mind*, contains selected papers presented at the 8th and 9th Novi Sad workshop on *Psycholinguistic, neurolinguistic and clinical linguistic research*, held online in October 2020 and 2021. As in past editions and despite the global Covid-19 pandemic, the workshop gathered together an ever-increasing number of international senior and junior researchers seeking to understand language acquisition, processing, and loss. In 2020 and 2021, the program comprised 2 keynote talks by Professor Roelien Bastiaanse (2020) and Professor Carlo Semenza (2021) and 24 high-quality presentations of collaborative projects which included, for the first time, representatives from Europe, Asia, America and Australia. As a novelty, the 2021 edition also incorporated a poster session with 8 additional presentations. We are delighted to see that despite the impact of the Covid-19, the Novi Sad workshop on *Psycholinguistic, neurolinguistic and clinical linguistic research* continues to provide the research community with a meeting forum for the dissemination of state of the art research and for a fruitful exchange of ideas. Of especial relevance to us are the networking opportunities promoted by the friendly atmosphere, crucial for further developing multidisciplinary (experimental) research in linguistically non-impaired and impaired populations in the Slavic countries. No less important is it to once again highlight the enthusiasm of early career researchers (MA and PhD students) and younger students, who year after year embrace the event with eagerness and provide a powerful motivating force.

The current volume contains five chapters, thematically organized in two parts: Part I includes two processing studies of non-brain damaged adult participants, while Part II, which includes three chapters, focuses on communication disorders in children and adults. As in previous volumes, each of the manuscripts received two positive reviews by experienced experts in the field.

Part I: Processing studies

The opening chapter, *Can reading Chinese characters be independent of phonological encoding? A cross-linguistic priming lexical decision study on Chinese multilinguals* by Liying Yang, investigates crosslinguistic form and meaning priming effects in multilingual Mandarin Chinese - English - Norwegian speakers. A series of lexical decision tasks showed differences across language pairs. Priming effects were observed in meaning-related Chinese-Norwegian word pairs when primed by Chinese words. Priming effects for cognates and translations were found for Chinese-English word pairs independent of the priming language, whereas form priming effects were only found with English primes. Contrary to some previous studies, Chinese non-words were faster to identify than alphabetic non-words in all conditions. The author concludes that whereas phonological encoding may be avoided when reading Chinese, it is necessary for lexical retrieval in alphabetic languages.

Chapter II, *The nature of musical meaning and its bearing on the processing of lyrics* by Alice Karbanova, shows how previous evidence from musical semantics can advance our understanding of linguistic semantics and semantic cognition in general. The shared underlying processing mechanisms between music and language allow music to serve as a window to the identification of the nature of meaning representations and to how these are processed in the brain. Moreover, music and language are claimed to interact. Music is claimed to have an effect on the interpretation of lyrics.

Part II: Communication disorders

Part II opens with the chapter entitled *Social awareness and communication disorders,* in which Silvia Martínez-Ferreiro, Sofie Theilmann Kristensen and Kasper Boye discuss the general public self-reported awareness and actual knowledge of speech and language disorders. The results of a web-based closed questionnaire consisting of 42 questions about speech and language disorders, psychosocial aspects associated to speech and language disorders, and speech and language therapy, completed by 328 participants of diverse geographical origin, confirmed an asymmetry between self-reported awareness and knowledge low across the board, with highly educated respondents being most familiar with the different disorders and female respondents being most aware of the weight of psychosocial factors. The need to improve the efficiency of the transmission of information to the general public becomes more evident in the case of treatment, as a significant number of respondents are still unconvinced about the possible benefits of speech and language therapy.

Chapter IV deals with neurodevelopmental language disorders. In their paper entitled *Predictive language processing of children with autism spectrum disorder and children with developmental language disorder*, Georgia Andreou and Vasiliki Lymperopoulou critically review eight empirical studies on predictive language processing in children with ASD and DLD. The results show that children with DLD performed worse on predictive language processing tasks than children with ASD. Although delayed language development and poor oral communication abilities are claimed to be common to both groups, specific syntactic and semantic deficits in children with DLD are held responsible for the assymmetry.

Language disorders in adults are the matter of discussion in Chapter V. In their paper *The Morphosyntax Interface in patients with Alzheirmer's disease*, Silvia Curti and Emanuela Sanfelici investigate how morphologically complex words are formed in 20 Italian-speaking patients diagnosed with Alzheimer's Disease (AD), using a sentence completion task to detect whether conversion and affixation are impaired in this population and to determine whether word formation rules can be a useful marker in AD diagnosis. The authors report that both the low rate of accuracy and the selective application of morphological processes differentiate AD patients from neurologically age-matched healthy subjects and can thus be taken as markers in AD diagnosis. The results also have theoretical implications, contributing to the discussion of the potential nature of conversion as a form of affixation.

To finish, we would like to announce that the 10th Novi Sad workshop on *Psycholinguistic, neurolinguistic and clinical linguistic research* will be hosted by the Faculty of Philosophy, University of Novi Sad in April 2023. After this long period of physical distance, we hope to welcome in person all early-stage and consolidated scientists eager to share with us the results of their research and celebrate our first 10-year anniversary.

The Editors,
Novi Sad, September 2022

Part I: Processing studies

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CAN READING CHINESE CHARACTERS BE INDEPENDENT OF PHONOLOGICAL ENCODING? A CROSS-LINGUISTIC PRIMING LEXICAL DECISION STUDY ON CHINESE MULTILINGUALS

Abstract: The present study investigated form and meaning priming effects in native speakers of Mandarin Chinese with English as their second and Norwegian as the third language through a series of lexical decision tasks. The form and meaning influences across languages were tested through four categories: cognates (+meaning, +form), false friends (-meaning, +form), non-cognates (+meaning, -form) and unrelated (-meaning, -form). For Chinese-Norwegian word pairs, the priming effect was confirmed for meaning-related word pairs, but only when primed by Chinese words. Neither meaning nor form effects were demonstrated when primed by Norwegian words. For Chinese-English word pairs, priming effects for cognates and non-cognates were observed from both Chinese to English and the reverse direction, whereas form priming effect was only found when primed by English primes. Chinese non-words were faster to decide on than alphabetic language groups in all conditions, which contradicts the word superiority effect (Paap et al. 1982). It is possible that reading Chinese may be achieved without phonological encoding, which is necessary for lexical retrieval in alphabetic languages.

Key words: multilinguals, lexical decision, cross-linguistic priming, phonological encoding

1. Introduction

Learning to read typically involves a serial process, which requires mapping visually presented stimuli to corresponding sound and further matching the sound to representations in the semantic memory. In doing so, phonological awareness plays a key role in reading as the meaning of a new word will be accessible through the phonology-to-semantics link in the oral language system (e.g. Williams & Bever, 2010; Zhou & Marslen-Wilson, 2000; Tan, Hoosain & Siok, 1996). In alphabetic-phonemic languages, phonological activation is a relatively reliable means of word recognition due to the nature of the systematic mapping of sounds to symbols. This is particularly true for phonologically transparent languages, such as Italian and Finnish.

However, phonology in Chinese character reading is much weaker than that in alphabetic languages (Tan et al., 2005). Instead, other skills, such as (hand)writing can account for successful reading acquisition in Chinese. This proposal that orthographic awareness is more powerful than phonological awareness in predicting successful Chinese reading is also supported by Chung and colleagues (2011), as well as Siok and Fletcher (2001). This might be due to the fact that the underlying mechanism in Chinese acquisition is through visual processing of a character's configuration and discovery of orthographic structure (Luo, Chen, Deacon, Zhang, & Yin, 2013).

1.1 Reading Chinese Characters

A Chinese character, often written in squared shapes, is the basic unit in reading and in most cased, it corresponds to a morpheme. There are two kinds of characters: single and compound. The formation rules of Chinese characters can be classified as follows: imitative, indicative, ideo-compound, and ideo-phonetic. The first two rules applies to single characters and the latter two apply to compound characters. Specifically, imitative refers to the formation of written characters through the picture of real objects (e.g. *日rì* 'sun'). The indicative rule stands for the formation of symbols indicating the meaning (e.g. *上shàng* 'up'). Ideo-compound refers to the combination of two components giving a new character (e.g. *好hǎo* 'good' = *女nǚ* 'woman' + *子zǐ* 'child'), in which no orthographic unit represents the pronunciation. Ideo-phonetic refers to the composition of characters by combining one radical standing for the semantics and the other for phonetics (e.g. *村 cūn* 'village' = *木mù* 'wood' + *寸cùn* 'inch').

Compound Chinese characters are normally written in squares, each of the same size, composed of radicals with different stroke patterns. The radicals in Chinese are called 偏*piān*, 旁*páng*, 部*bù*, 首*shǒu*, standing for side, component, part, and head respectively, which indicates their spatial positions in a character (Chen, 1993). There are normally four positions for different radicals: left, right, top, and bottom. For a left-right structure character, the left-hand radical normally stands for the meaning of a character, also known as the semantic radical, while the right-hand indicates the pronunciation of a character, known as the phonetic radical. For a top-bottom structure, the top radical represents the meaning, whereas the bottom one indicates the pronunciation. The majority (about 81%) of Mandarin

Chinese characters are semantic-phonetic compounds, which consist of semantic radicals and phonetic radicals (Chen, Allport, & Marshall,1996). The semantic radicals are usually located at the left-hand side (the former example) or the top of the character, such as *雨yǔ* ‘rain’+*路lù* ‘road’ = *露lù* ‘dew’, which is used for identifying the semantic elements. The phonetic radicals, on the other hand, are usually located at the right-hand side or at the bottom of characters. However, the pronunciation of a Chinese character cannot always be achieved by phonetic radicals even though the same radical may appear at the same position of a character, for instance, *马mǎ* ‘horse’ in *妈mā* ‘mother’ and *冯féng* ‘surname’. As a result, the recognition of Chinese characters is not simply achieved by either the phonology or semantics of radicals, as these radicals are relatively unreliable cues in word recognition.

1.2 Priming studies on Chinese word recognition

Different paradigms have been used to investigate the phonological influence on lexical access of Chinese reading. For instance, lexical decision tasks under the priming paradigm were used to test the reaction times of Chinese characters that share phonological similarities. When primed by a homophonic stimulus, response time was faster in the lexical decision task compared to primes that share no phonology and semantics (Tan & Peng, 1991; Tan & Perfetti, 1998). This indicates that phonological information accelerates lexical activation in Chinese reading.

However, the findings on this topic are inconsistent (e.g. Zhou & Marslen-Wilson, 2000; Chen & Shu, 2001). For instance, under the same paradigm, compound words and single-character words were investigated in lexical decision and character decision, respectively (Zhou & Marslen-Wilson, 2000). By using both semantic and phonological primes, strong semantic priming effects were found, whereas phonological effects were absent. This, at least, suggested that phonological information is not always activated in reading Chinese.

In addition to lexical decision tasks within Chinese, the cross-linguistic priming version of lexical decision tasks was also adopted to explore the processing of Chinese words in contrast to alphabetic languages. For example, researchers (e.g. Jiang, 1999; Chen & Ng, 1989) tested Chinese-English bilinguals through the comparison between meaning-related word pairs (cognates) and unrelated word pairs (non-cognates), using lexical decision tasks. Generally, they found stronger priming effects for cognates than for non-cognates, and asymmetric priming effects between L1 and L2. However, they failed to differentiate phonological overlap between cognates and non-cognates, which may have influenced the results. The same effects (i.e. asymmetric effects) have also been found in another Chinese-English bilingual study (Chen, Zhou, Gao, & Dunlap, 2014). Such a cross-linguistic priming asymmetry can be explained by the revised hierarchical model that the conceptual representations shared with L2 words in L1-L2 priming are activated by L1, facilitating the recognition of L2 targets. However, this does not apply to L2-L1 priming until learners' L2 proficiency increases. Such an asymmetry can also be accounted for by the different scripts of the two languages. In other words, if two languages share similar scripts, such as English and German, the processing of L2 can benefit from that of L1 (Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009). However, Chinese and English have different scripts. The well-established L1 Chinese processing does not help the processing of L2 English. However, since Schoonbaert and associates (2009) focused on translation asymmetry effects, they did not test orthographic irregular targets to see if different scripts play a part in lexical processing between languages.

2. The present study

Previous literature (Chen & Ng, 1989; Jiang, 1999; Jiang & Foster, 2001; Chen et al., 2014) shows that larger facilitation is consistently found for translation equivalents than for semantically related words; priming effects from L1 to L2 are often stronger than the reversed direction (i.e. asymmetric priming effects). Priming effects were found for interlingual homographs, also known as false friends, in orthographically similar languages such as Dutch and English (Lemhöfer & Dijkstra, 2004), suggesting the importance of phonological encoding in alphabetic languages. Despite the phonological effects found in Chinese reading by using Chinese stimuli alone, however, it is still unknown whether such effects can be observed in orthographically dissimilar languages. In a pilot study of Norwegian-Chinese priming lexical decision (Yang & Johanson, 2019), neither form nor meaning effects were found from Norwegian to Chinese. It is, however, still unclear if the finding was due to the proficiency of the participants or particular to the experiment.

This study aims at further investigating form and meaning aspects of cognates, false friends, translations, and unrelated word pairs in contrast to the unprimed counterparts. This will be achieved by recording the reaction times collected from a series of cross-linguistic lexical decision tasks under the masked priming paradigm, in which different conditions will be compared, that is, +/- meaning and +/- form. The findings of this study will be interesting to establish whether form or meaning will be a reliable link for speakers from different orthographic language systems and how important phonology is in lexical access of Chinese characters.

To summarize, the hypotheses of the current study are the following:

1. Neither form nor meaning priming effects of Norwegian words and English words will be found for Chinese native speakers (which is the null hypothesis of the study).

2. Asymmetric effects will be expected in different language conditions (i.e. Chinese-Norwegian, Norwegian-Chinese, Chinese-English and English-Chinese), which has been supported by several studies (Chen & Ng, 1989; Jiang & Foster, 2001) on cross-linguistic translation priming.

3. Meaning-related word pairs will show stronger priming effects than form-related pairs when Chinese words are primed by either English or Norwegian since the Revised Hierarchy Model (Kroll & Stewart, 1994) suggested that lexical connections are stronger when bilinguals translate a word from L2 to L1.

4. Rejecting non-words of Chinese will be faster than either English or Norwegian due to participants' proficiency in both English and Norwegian. Namely, Chinese native speakers can tell the difference by the structure of characters visually, which may not involve phonological encoding. However, they have to encode and decode letter strings to discriminate if it is a word and their proficiency of English and Norwegian might play a role in making this decision.

5. Rejecting Chinese non-words will be faster than recognizing Chinese words if phonological information is not always activated in reading Chinese.

3. Method

3.1 Participants

The participants in this experiment were 20 Chinese speakers, 15 females, and 5 males, with a mean age of 31.44 years. All of them had a normal reading speed and a normal or corrected to normal eye-sight. They did not suffer from dyslexia and/or other reading disabilities. Chinese was their dominant language (L1), with English as their second language and Norwegian as the third. They had all lived in Norway for over four years. According to their self-reports, they all had taken the English Proficiency test (IELTS) with the overall mean score 6, which is equal to B2 level in CEFR, and passed the Norwegian proficiency test with B1 level. Fifteen participants reported English as the language that they used in their working or studying environment, while in their daily life they used Norwegian. The remaining 5 participants indicated both Norwegian and English as the language of their working or studying environment. They all had learned *bokmål* (preferred official written standard Norwegian) under English instructions after coming to Norway.

3.2 Materials

Altogether 80 word pairs were used in the experiment, of which 40 Norwegian-Chinese pairs and 40 English-Chinese pairs. Selected Chinese words were used as the primes in one condition and the targets in the other. This was the same for English and Norwegian. The frequency of the selected words was controlled. THU Open Chinese Lexicon was used to check the frequency for Chinese, the Word frequency data based on COCA for English, and Norwegian (Bok) Word Frequency for Norwegian. Since the aim of the experiment was to examine the relationship between form-related and meaning-related word pairs between Norwegian and Chinese, as well as English and Chinese, the word pairs were divided into four categories. Each of the categories consisted of 10 word pairs:

Cognates (+meaning, +form)
False friends (-meaning, +form)
Non-cognates (+meaning, -form)
Unrelated (-meaning, -form)

3.2.1 Cognates

Due to the typological differences between Chinese and Norwegian, as well as Chinese and English, no one-to-one cognate equivalents can be found between these languages. Therefore, the word pairs classified as cognates in this study are similar in sound and share the same meaning, although they are different in orthography. Besides, words considered cognates were only in Chinese-Norwegian and Chinese-English. For example, *karri* and*咖喱kā lí* were chosen as cognate pairs between Norwegian and Chinese in this experiment. *Muffin* and *马芬mǎ fēn* were considered English and Chinese cognates.

3.2.2 False friends

False friends, or sound-alike word pairs, in the current study refer to words with similar sounds which do not share the same orthography or meaning. For instance, *modig* in Norwegian means ‘brave’ whereas its sound-alike pair*目的mù dì* means ‘aim’ in Chinese. The English word *colour* and *可乐 kě lè* ‘Coca Cola’ in Chinese were chosen as false friends in English and Chinese.

3.2.3 Non-cognates

Words with a one-to-one semantic translation between Chinese and Norwegian as well as Chinese and English were selected as non-cognates to avoid confusion. For example, *银行yín háng* in Chinese can be translated as 'bank' in English, while the English word *bank* can mean '银行yín háng' and '岸àn' in Chinese. The former in Chinese means an organization that provides financial services, while the latter means the side of a river. These kinds of translation word pairs were excluded. In the Chinese-Norwegian condition, words such as *中心* and *senter* were selected, and in the Chinese-English condition, the one-to-one semantic correspondence, such as *能量* and *energy* were included.

3.2.4 Unrelated

Neither form nor meaning similarities can be found between the unrelated word pairs. In addition, this category of words shares no semantic relations in the two languages. An example of an unrelated word pair taken from the experiment is the Norwegian-Chinese word pair *navn* and *森林sēn lín*, meaning 'name' and 'forest', respectively, which share no resemblance in orthography or meaning. This criterion also applies to English-Chinese word pairs. For example, *wind* and *白色bái sè*, meaning 'white' were chosen as unrelated word pairs.

3.2.5 Chinese characters

In the experiment, all Chinese characters were in their simplified version. All Chinese stimuli were compound words, in which five of them were made up of three characters and the rest of two characters. None of the compounds were real words when the characters. were used in reverse order All of the Chinese stimuli had a corresponding meaning in the Modern Chinese Dictionary. The complexity of characters was based on the number of strokes, which is considered to be important in Chinese character processing (Peng & Wang, 1997; Kong, 2019). The Chinese words had an average of 15.35 strokes in the English-Chinese condition and 17.62 strokes in the Norwegian-Chinese condition. The length of an English word or a Norwegian word was calculated according to number of syllables. The English words consisted of 1.9 syllables on average and the Norwegian words of 1.82 syllables.

3.2.6 Non-words

To supplement 40 Norwegian-Chinese word pairs and 40 English-

Chinese word pairs, altogether 160 non-words were created, of which 40 for Norwegian, 40 for English and 80 for Chinese.

All Norwegian and English non-words, or more precisely pseudowords, were created following the basic syllabic structure of these two languages and were double-checked by university-level Norwegian and English native speakers to ensure the feasibility of those non-words. The length of the English and Norwegian non-words was also calculated based on the number of syllables, with an average of 2.45 syllables for English non-words and 2 syllables for Norwegian non-words.

Non-words in Chinese were created by a random combination of two or three pseudo-characters and/or non-characters, ensuring that no non-words have dictionary meanings or any agreed pronunciations. Five out of 80 non-words were made up of three pseudo-characters and/or non-characters, with an average of 15.61 strokes. The pseudo-characters (rules 1 and 2) and non-characters (rules 3 and 4) were created according to the following rules:

Rule 1: deleting the strokes (Kong, 2019)

尢 is from尤yóu 'especially', and 玨 is from琴qín 'a kind of instrument'

Rule 2: non-characters with correct stroke pattern positioning

忄国is from the radical忄 and国*guó* 'country'

Rule 3: the combination of two correct single characters

云云is a combination of two single characters云*yún* 'cloud'

Rule 4: illegal stroke pattern positioning

者纟 is from绪*xù* 'thread, mood'

4. Procedure

The experiment was conducted in a sound-attenuated phonetic lab. Participants were asked to judge whether the stimuli presented on the screen were real words or not by pressing the button on the response pad as quickly and accurately as possible. Before the test, the experimenter gave the instructions in Chinese, orally, in case participants had questions regarding the test. After that, a training session was presented.

The experiment was divided into three blocks: an introduction block, an experimental block, and an end block. In the introduction block, instructions on how to do the lexical decision task were provided in English. The experimental block followed the instruction block, within which conditions 1-4 (i.e. Chinese to Norwegian, Norwegian to Chinese, Chinese to English, English to Chinese) were included sequentially, each with an individual introduction preceding them. The end block informed the participants that that was the end of the experiment. The training was designed in the same way as the experiment (three blocks: an introduction, training, and an end block), but separate from the real experiment. A separate training session was designed to ensure all the participants were fully aware of the instructions and the whole process of the experiment.

Both the training and the experiment followed the priming sequence . Firstly, the fixation mark '*' was presented at the center of the computer screen for 100ms, followed by a forward mask made up of hash marks '########' for 75ms. It was then replaced by the prime in lower case letters for 50ms in the Norwegian-Chinese and English-Chinese conditions, which was followed by a backward mask identical to the forward one for 75ms. Finally, the target was visible for up to 1000ms or until a response was given. In the Chinese-Norwegian and Chinese-English condition, the Chinese stimuli were used as the prime, and the capitalized TARGET was presented at last.

Priming sequence for conditions 1-4:
* (100ms)
######## (75ms)
prime (50ms)
######## (75ms)
TARGET (1000ms)

The unprimed version, used as the baseline, was presented together with the primed version, differing only for the primes. The unprimed baseline showed an empty screen for 50ms. Thus, no lexical pre-activation of either competition or targets was possible.

Sequence for unprimed baseline in conditions 1-4:
* (100ms)
######## (75ms)
######## (75ms)
TARGET (1000ms)

All stimuli were presented in Kai font in black at the center of the picture against a white background. Based on Macintosh, Superlab 5.5 was used to design the testing program and record participants' reaction times and accuracy rates. The reaction times were collected via a response pad RB-530, which offers 1 millisecond reaction time resolution. The whole testing period lasted approximately 30 minutes.

5. Results

Data were collected by Cedrus Data Viewer and analyzed by using the ImerTest Package under R. Half of the participants (n=10) were presented with the Norwegian-Chinese and Chinese-Norwegian sequence to English-Chinese and Chinese-English, whereas the other half (n=10) were tested with the reverse sequence. Overall, 17 participants produced 76% of correct responses, of which fewer correct answers were produced from Chinese to either English or Norwegian. Specifically, the status of 59.93% of English words was correctly decided in theChinese-English sequence, as opposed to 95.81% of Chinese words in the English to Chinese sequence. In the Norwegian-Chinese group, the status of 52.87% of Norwegian words was decided coreclty, in contrast to 95.41% of correct responses made for Chinese targets. Three participants (3, 8, 10) were excluded from the analysis due to their less accurate rate. In particular, subject 3 chose more wrong alternatives (with an accuracy rate of 66.09%), whereas subjects 8 and 10 failed to respond (NR) in time (has a no response rate of 37.97% and 31.88%, respectively).

5.1 Reaction Times

Taking into account language differences and speakers' proficiency in these three languages, decisions for Chinese characters are always faster, whereas decisions for alphabetic scripts are slower (see Table 1). There is a meaning advantage, which results in translations and cognates being faster to decide after priming. However, false friends and unrelated items show longer reaction times. The results also revealed that participants tended to make more errors in the case of English (L2) and Norwegian (L3) targets than Chinese (L1) targets. Priming effects for meaning-related word pairs are more significant than either form-related or unrelated word pairs (see Table 2 below).

Condition	Mean RT for correct answers (ms)	Error rate (%)
English to Chinese	651.13	1.56
Norwegian to Chinese	661.43	1.16
Chinese to English	799.19	9.19
Chinese to Norwegian	802.82	12.66

Table 1. Mean reaction times for correct answers and error rate of each condition

Condition	Mean RT (ms) primed	Mean RT (ms) unprimed	Priming effects (ms)
Form-related	694.97	705.81	+10.84
Meaning-related	687.49	708.94	+21.45
Unrelated	698.39	707.33	+8.94

Table 2. Priming effects for form and meaning-related word pairs in contrast to unrelated word pairs

5.2 Chinese and Norwegian

Conditions 1 and 2 tested form and meaning relations between Chinese and Norwegian word pairs. The ANOVA test of repeated measures of reaction time revealed no significant priming effects for either form [F (1, 23.43)=0.03, p=0.87] or meaning relations [F (1, 24.92)=0.03, p=0.86] when primed by Norwegian words (see Figure 1 and Figure 2, respectively). For the reverse direction, from Chinese primes to Norwegian targets, the priming effects were confirmed for both form [F (1,27.8)=8.56, p=0.0068] and meaning-related word pairs [F (1, 25.7)=7.44, p=0.011]. Priming effects can be found for meaning-related words between Chinese and Norwegian (see Figure 3 and Figure 4).

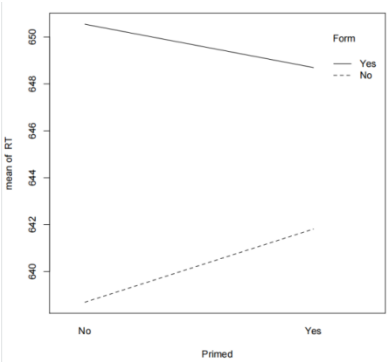


Figure 1: Form priming from Norwegian to Chinese

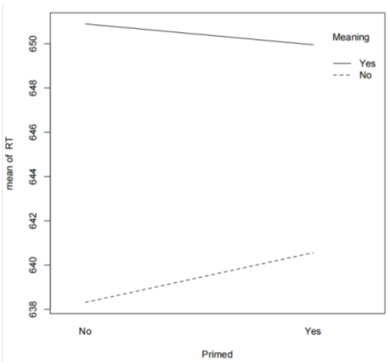


Figure 2: Meaning priming from Norwegian to Chinese

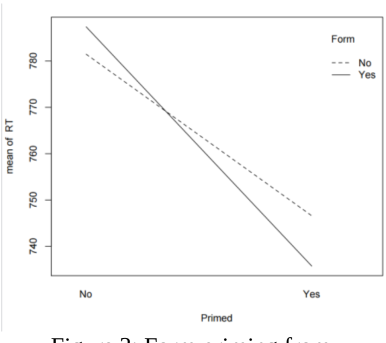


Figure 3: Form priming from Chinese to Norwegian

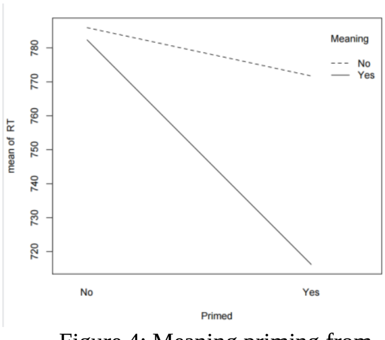


Figure 4: Meaning priming from Chinese to Norwegian

These results are in line with previous findings on Chinese and English bilinguals, which showthat priming effects can be found from the stronger language to the weaker (e.g. Jiang, 1999; Chen & Ng, 1989; Gollan, Forster & Frost, 1997). The mental representations for these two languages may be linked through a translation as Norwegian is the third language of the participants and they are less proficient in it than in their native Chinese and even less proficient than in their second language, English.

5.3 Chinese and English

For Chinese-English word pairs, only correct answers were considered for the analysis of reaction times. For tests from English primes to Chinese targets, priming effects for both form [F (1,17.5)=5.65, p=0.029] and meaning-related word pairs [F (1,19.5)=5.23, p=0.033] were found (see Figures 5 and 6). When primed from Chinese to English, a significant priming effect was found for meaning-related words (i.e. translations and cognates) [F(1,65.6)=9.3, p=0.0033] (see Figure 8), whereas no priming effects were confirmed for form-related counterparts (i.e. false friends and unrelated items) [F(1,71.63)=1.52, p=0.22] (see Figure 7). Although there was a slight decrease (20ms) in reaction times for primed and unprimed conditions, this might be due to cognate primes also sharing corresponding meanings with the targets.

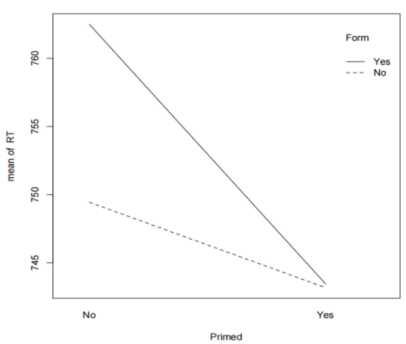


Figure 5: Form priming from English to Chinese

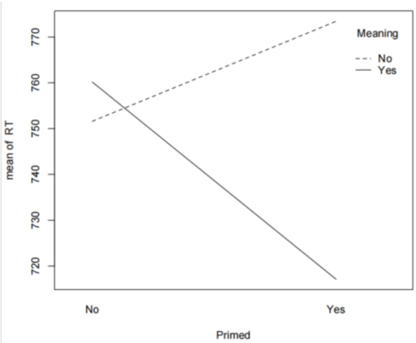
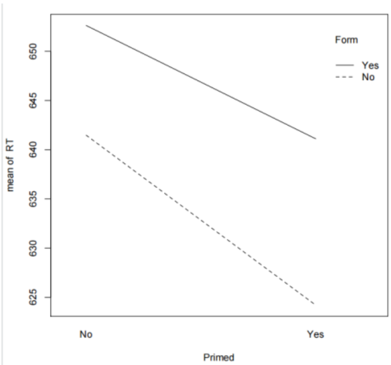


Figure 6: Meaning priming from English to Chinese



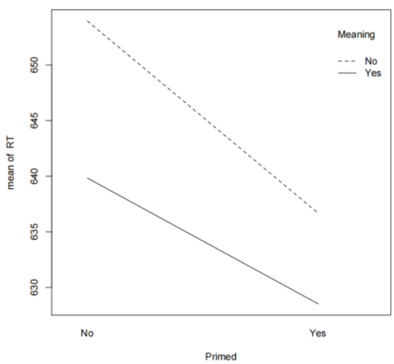


Figure 7: Form priming from Chinese to English

Figure 8: Meaning priming from Chinese to English

These results are in agreement with previous findings on Chinese and English bilinguals, which suggests that meaning is a reliable link for L1 and L2 in the participants' mental lexicon (Zhao et al., 2011). Besides, language proficiency plays a part in lexical retrieval. When a speaker becomes more proficient in one language, the form relations will be more salient. In this study, the participants' use of English is more frequent and more proficient than their Norwegian. As a result, when primed from English, priming effects can be found for form-related word pairs.

5.4 Non-words

Chinese non-words are significantly faster (see Table 2 below for detailed information) to decide in contrast to an alphabetic string of letters. However, as shown in Table 3, compared with the number of Chinese signs classified as non-words (with an accuracy rate of 94.06% from English to Chinese and 96.12% from Norwegian to Chinese, respectively), the number of the correctly recognized alphabetic strings of letters (with the accuracy rate 36% for English and only 29.81% for Norwegian, respectively) demonstrated difficulties for participants in making decisions.

Condition	Mean RT (ms)	Percentage of correct decisions
Chinese to English	830.51	36%
Chinese to Norwegian	825.23	29.81%
English to Chinese	612.56	94.06%
Norwegian to Chinese	627.17	96.12%

Table 3 The number of items correctly recognized as non-words and respective RT in each condition

6. General Discussion

6.1 Meaning

The findings of this study show an advantage for meaning-related words for L1-L2 (Chinese to English), L2-L1 (English to Chinese), and L1-L3 (Chinese to Norwegian) lexical decision tasks. Faster reaction times were found for L1 targets when primed by either L2 or L3 cognates. Although cognates in this study did not show orthographic closeness, the meaning-related words (i.e. cognates and translations) were recognized faster than the unrelated counterparts (i.e. form-related and unrelated words) in these three conditions. The results of the Chinese and English conditions in this study are consistent with previous findings between Chinese and English, i.e. with the claim that translation facilitates lexical decision tasks (e.g. Chen & Ng, 1989; Jiang & Forster, 2001) and in agreement with the Revised Hierarchical Model (Kroll & Stewart, 1994) in that meaning is the link for the bilinguals' mental lexicon of two languages. As for Chinese and Norwegian (L1-L3), the current results at least support the hypothesis that priming effects regarding meaning-related words can be found from the stronger language to the weaker one.

However, condition 1 (Norwegian-Chinese L3-L1 condition) shows neither meaning nor form priming effects as opposed to the English-Chinese condition. This is probably because the users' experience of Norwegian is more limited than that of English. In other words, the participants' Norwegian is less proficient than their English. As proposed by Zhao and Li (2010), bilinguals' mental representations of two languages are highly associated with their language learning history. Their simulation suggested that the onset time of learning a new language is highly correlated with the structure of mental representations. In other words, words from a new language were distributed in small chunks depending on the meaning similarity between the new language and the well-organized L1. In the current study, all the participants started learning Norwegian at a relatively late age (at 22.18 years old on average) in contrast to their acquisition of English (at 11.11 years old on average) and are still in the process of becoming more proficient.

6.2 Form

In contrast to meaning-related words, form-related counterparts did not show significant priming effects across languages. The only observed effects from L2 English to L1 Chinese might result from cognates which share not only form but also meaning relations between targets and primes. Besides, the priming effects may be the result of the bi-directional phonological awareness between Chinese and English. In other words, such awareness to segment speech sounds into syllables and phonemes is predictive between the interaction of these two languages (e.g. Chung et al., 2013; Chow, 2014; Yang et al., 2017).

The only significant form priming effects were found in the English-Chinese condition. This suggests that phonological information of Chinese words can be activated during English word reading. This result was also supported by ERP studies on Chinese-English bilinguals (Wu & Thierry, 2010). One possible explanation might be that, on average, participants have learned English since their secondary school and used their second language for over 10 years, and they all learned Norwegian under English instructions.

It is probably their relatively higher proficiency in English and the higher frequency of English words encountered that makes the English primes in the current study more accessible.

Besides, different approaches in learning English and Norwegian might account for such an effect. Specifically, the participants in this study learned to read English letters after being exposed to their sounds via IPA (International Phonetic Alphabet). To put it another way, they had learned English phonemes by IPA before mapping graphemes to phonemes. However, all of them learned Norwegian under English instructions by directly mapping the Norwegian graphemes to corresponding phonemes through the imitation of sounds rather than another systematic representation of sounds. However, whether the form priming effects found in this direction but not from Norwegian to Chinese are due to the proficiency of the participants or the learning process of English or even the mechanism of the experiment needs further research.

6.3 Non-words

The most surprising and interesting results in this study come from the response times and accuracy rate for non-words. Neither English nor Norwegian witnessed a high accuracy rate and shorter response time in rejecting non-words, whereas rejecting non-words of characters was much easier and less demanding, with a mean RT of 619.87 ms to reject Chinese non-words, as opposed to 830.51 ms to reject English non-words and 825.23 ms to reject Norwegian ones. Besides, rejecting Chinese non-words in this study can be faster than recognizing Chinese words (i.e. 619.87 ms in contrast to 656.28 ms). This contradicts the Word Superiority Effects (Paap et. al, 1982) which suggests that, in alphabetic languages, words are always faster to recognize than non-words. This may be because non-words in alphabetic languages do not have a grapheme-to-phoneme correspondence in the mental lexicon, increasing the processing rate. This result may also provide evidence that phonological encoding may not always play a role in discriminating Chinese pseudo-characters and/or non-characters. This is because recognizing non-words made up of pseudo-characters and non-characters is less time-consuming since it does not require analytical processing such as phonological encoding.

To account for the observed facts about longer RT for alphabetic letter strings, phonological neighborhood density could explain why Chinese participants responded to alphabetic non-words less accurately and more slowly. Coltheart et al. (1977) define phonological neighborhood density as the number of phonologically similar words in the lexicon and claim that it most often comes about by changing, adding, deleting, or substituting a single letter in a given word. For example, the word '*hit*' has more neighbors (e.g. sit, it, split) than the word '*calculate*'. Neighbors are items that are highly confusable with the target word, in the sense that they share a large number of features with the target. Words with more neighbors are said to be in dense neighborhoods, whereas words with fewer neighbors are in sparse neighborhoods. Phonological neighborhood density may have different influence on different languages. For example, Russian adults can recognize words with dense neighborhoods faster than words with sparse neighborhoods (Arutiunian & Lopukhina, 2020). The same pattern has been found for Spanish-speaking adults (e.g. Sadat et al., 2014; Vitevitch & Stamer, 2006). However, for English, words with dense neighborhoods are recognized more slowly than words with sparse neighborhoods (Luce & Pisoni, 1998). The English and Norwegian non-words, or more precisely pseudo-words, created in this study all followed the word-formation rules by substituting, changing a single sound or some letters. The pronounceable pseudo-words increased the competition among other possible targets, making them difficult to discriminate from the original words for non-native speakers. Therefore, rejecting the pseudo-words in alphabetic languages might be more time-consuming (e.g. more than 1000ms needed).

Regarding Chinese words, semantic-phonetic compound characters account for approximately 72% of the whole character inventory. Of these characters, 27% of radicals have fixed positions and 43% of radicals can appear in more than one position (Shu et al., 2003). Orthographic awareness requires learners of Chinese to be aware of the radical positions (Peng, Li, & Yang, 1997; Taft et al., 1999; Wang, Perfetti & Liu, 2005). In this study, at the character level, 90% of non-words were composed of non-characters with radicals in an illegal position, making it possible for native speakers to observe the irregularity of the made-up characters and leading to a quick response before processing the non-words as a whole. This is in line with the finding that orthographic form information can be processed quickly and accurately, even preceding the whole character processing (Liu et al., 2010).

Also, fast reaction times in rejecting non-characters may provide evidence that recognizing Chinese characters does not always require phonological information at least for highly proficient speakers. In other words, the recognition of radical combination may not spread the activation (Dell, 1986) of phonological information regarding pseudo-words in the mental lexicon as the illegal position of the radicals makes pseudo-characters unpronounceable.

At the word level, processing Chinese words is more holistic compared to character processing (Liu et al., 2010). It is reasonable to assume that rejecting non-words in Chinese may involve the process of holistic visual recognition as well. Since no corresponding meaning of the non-words can be found in the mental lexicon, there are no conflicts for non-words to be processed and thus rejecting non-words of Chinese in this study is less time-consuming.

Various additional experiments could be done. The first one would be to see whether the form priming effects found in the English-to-Chinese direction but not the reverse one is due to the proficiency of the participants or the learning process of English. It would also be interesting to see the interaction between English and Norwegian by conducting corresponding lexical decision tasks. This could make a comparison between the observed more proficient English and less proficient Norwegian and help determine if proficiency plays a part in triggering priming effects. It would also show whether one's L2 can be transferred to L3 learning.

7. Conclusion

Most previous studies on cross-linguistic priming effects between Chinese and English have focused on translation equivalents or semantically related word pairs. Despite the limitations, however, in addition to the meaning influence, the present study also investigated how forms affect the mental process of word recognition of multilinguals (i.e. Chinese native speakers with English as their second and Norwegian as the third language) by using interlingual homograph pairs across languages. A series of lexical decision tasks under the masked priming paradigm was conducted to reveal a robust meaning priming effect across language groups, which is consistent with what has been expected in hypothesis 3. Both cognates and translations were faster to decide than false friends and unrelated word pairs, suggesting that meaning is a reliable link for words from typologically different languages to be connected in the mental lexicon of a multilingual.

The significant short reaction times on rejecting non-words of characters in contrast to the longer time of discriminating alphabetic non-words may indicate the different route of recognizing logographic signs and the alphabetic string of letters. Specifically, the recognition of alphabetic letters requires less orthographic awareness than logographic Chinese does. The strategy used in discriminating non-words of characters may not be transferrable to rejecting alphabetic non-words. Besides, recognition of non-words made up of pseudo-characters and non-characters may support that phonological information does not always play a role in Chinese recognition. Possibly, reading Chinese is different from listening to Chinese. The former may involve a less linguistic but more aesthetic approach. It would be possible to use auditory stimuli in a similar experiment to find out more details about multilingual processing of Chinese in reading and listening.

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THE NATURE OF MUSICAL MEANING AND ITS BEARING ON THE PROCESSING OF LYRICS

Abstract: Similarities between language and music have in past decades attracted scholars from various disciplines as music has proven a valuable tool for research of human cognition. Given the shared underlying mechanisms, music may also help identify the nature of meaning representations and the way in which they are processed in the brain. Song, a ubiquitous human behavior, represents the most natural setting for comparison of linguistic and musical semantics, and therefore lies at the heart of this paper. In an interdisciplinary approach, this paper underscores the parallels between linguistic and musical meaning. Drawing on evidence from cognitive neurosciences, it also calls attention to the possible ways in which music might influence the interpretation of lyrics in a song by highlighting their overlapping processing mechanisms. The purpose of this review is to summarise evidence on musical semantics and to show how it can advance our understanding of linguistic semantics and semantic cognition in general.

Key words: cognitive semantics, musical semantics, mental representation, song interpretation, brain overlap

1. Introduction

Music, just like language, represents a uniquely human and universal feature that challenges almost all of the components of human cognition, representing one of the most prominent tools to explore the human cognitive processes. Its uniquely human nature also precludes comparative inter-species research, which is common practice in the exploration of different cognitive faculties (as for instance memory, Allen & Fortin, 2013). Music is highly relevant for linguistic research, given its shared features with language, and its study may result in a better understanding of the cognitive processes subtending both. Both share several basic mechanisms and perform remarkably similar interpretive feats (Patel, 2008). There is copious evidence for the intricate relationship of syntax processing in language and music, yet a considerable lack of studies focusing on semantic processing (Koelsch, 2006). Linguistic semantics seems to be rather challenging to address experimentally and research on the neural basis of music might therefore provide better knowledge of the organisational principles of language, as overlapping brain areas for the processing of both musical and language meaning have been suggested (Steinbeis & Koelsch, 2008). This paper attempts to add to the knowledge of semantic processing by bridging evidence from cognitive sciences and neurolinguistics on the one hand, and pragmatics and musicology on the other. In an essentially multidisciplinary approach, we investigate whether language and music compete for processing resources during the perception and interpretation of song, possibly the most natural (however largely understudied) setting to compare music and language combined.

This paper proposes evidence that music influences semantic cognition and provides contextual cues that modulate the resulting interpretation of the incoming information. It conveys contextual meaning by virtue of which discourse representation is formed. Research on the music-language interface can advance our understanding of the neural representation of semantics in general and might ultimately enhance our understanding of the meaning of ‘meaning’ (Fitch & Gingras, 2011). Here we sketch a panorama of current views on meaning and mental representation drawing on theories of various allegiances, and we argue that the study of music might ultimately advance our knowledge of how and what representations the semantic system uses, how they emerge and are manipulated (Schön & Morillon, 2019).

2. The Nature of Meaning

The spurt of interest of scientists coming from various disciplines towards the research of common grounds of music and language processing is symptomatic of its importance in the current development of cognitive sciences. Research on the music-language interface could help us decipher the organisation of meaning in the brain and point out the overlapping representations, thus elucidating unanswered questions about the ways humans derive meaning from the external world and the mechanisms serving meaning allocation,amely, whether the latter relies on cerebral resources specific to language or it rather borrows from other domains. It has been suggested that research on music can help us investigate the nature of the cognitive processes allocating meaning since specific aspects of musical form may result from constraints imposed by the vertebrate nervous system (Fitch, 2006).

The word ‘meaning’ is being used here in its broadest semiotic sense whereby meaning exists when perception of an object or event brings something to mind other than the object or event itself (Nattiez, 1976). Patel

(2008) also claims that language should not be taken as a model of significance in general and the current evidence seems to argue against any view of sense-making in which linguistic information is treated differently than nonlinguistic information (Kutas & Federmeier, 2011).

While music and language might share resources for rather more general types of processing (i.e. integrating new information into any type of unfolding representation (Slevc et al., 2009)), on another account they draw on shared conceptual networks and are subserved by an aspecific cognitive module of conceptual processing, where overlapping representations guarantee an overlapping lexical access to linguistic and musical concepts (Daltrozzo & Schön, 2009). Music lacks arbitrary semantic reference but is not utterly devoid of referential power although the specificity of semantic concepts activated by music is much lower and more idiosyncratic than of concepts activated by language (Patel, 2008). Although the referential function appears to be restricted in music and its mode of signifying is rather metaphoric, this does not mean that music is devoid of meaning (Locatelli & Delpy, 2009). Unlike language, which denotes specific semantic concepts, music picks out concepts at a coarser grain and the representations it conveys are relatively vague (Koelsch, 2011).

The psychological reality of music-semantic processing is reflected in event-related potential (ERP) components. Several different classes of meaning (see Koelsch et al., 2004) are mediated by different cognitive processes and reflected in different ERPs. The N400 ERP component that is thought to reflect the processing of extra-musical meaning has been found during priming experiments where the target words (concrete or abstract noun) followed semantically mismatched versus matched musical excerpts (Koelsch et al., 2004). The same effect as with linguistic priming has been obtained in the same study, with both conditions (music and language) activating similar brain regions, namely the posterior portion of the middle temporal gyrus (MTG) and Brodmann areas (BA) 21 and 37. The amplitude and latency were equal for both linguistic and musical conditions. The existence of N400 for a mismatched word following a musical prime has been interpreted as indicative of the capacity of music to convey a semantic concept and to influence lexical semantic processing. Besides the N400, another important component has been found that is thought to reflect intra-musical meaning emerging from the cognitive interpretation of intrinsic relations between musical sounds in a sequence, that is, the N5 (Koelsch, 2011). This ERP component is supposed to reflect general principles of meaning emerging from structural relations which are the same as for poetry and visual arts, for example. This finding supports the idea that intra-musical phenomena can give rise to extra-musical meaning, since meaning is emerging from harmonic integration due to the construction of a structural model. As a matter of fact, it seems that semantic aspects of music arise from the formal ones and therefore depend on the structuring of the material (Dürr, 2004). Indeed, structure seems to be the key feature leading to semantic processing and making sense of music (Steinbeis & Koelsch, 2008). However, meaning in general requires establishing relationships between successive events and processing of the structural aspects of sequential information (Koelsch & Schröger, 200). At the same time, the structure of a linguistic utterance can also give rise to certain semantic expectations, as for instance the membership of a certain word into a word class. Every word has a category that carries more information than the word on its own and the rules that govern it are what is meaningful. Parts of speech contain higher-level semantic information, a fact suggesting that there is a meaning to function. For a mental representation of meaning to be established, syntactic and conceptual information must be combined effectively and quickly. For instance, Kuperberg et al. (2003) compared the effects of syntactic and conceptual anomalies in sentences and showed that largely overlapping widespread networks are involved in processing both of these types of anomalies. Pragmatic and morphosyntactic information seem to be processed in parallel but with different time courses.

Also, the N400 ERP component traditionally viewed as a semantic processing signature is elicited by an impressive range of stimulus types, including written, spoken, and signed words, drawings, faces, objects, actions, sounds etc. (Kutas & Federmeier, 2011). It also reflects the process of semantic integration of the critical word with the working context, and therefore results from combinatorial processes, rather than simple lexical-level processes (Lau et al., 2008). Consequently, it is plausible that semantics is shared between grammar and extra-linguistic representations, and the semantic processing relies on a distributed network with different hubs. Indeed Kutas & Federmeier (2011) conceive of the N400 in a broader sense as an electrophysiological marker of processing in a distributed semantic memory system. It purportedly indexes something fundamental about the processing of meaning and could therefore be viewed as a signature of the mechanism allowing humans to perceive something as meaningful, to ascribe meaning to something. There is therefore a theoretical possibility that there might be a component of meaning that is of syntactic nature. Syntax obviously provides important sources of information for constraining conceptual composition (Binder, 2016). This would represent one convergent feature with processing of musical meaning which relies for the major part on the syntactic and logical structural sequences.

One of the important features of musical meaning is the fact that listeners acquire sensitivity to the statistical distributions of tones over time and can infer some structural relations on this basis. From the disembodied vantage point, meaning of any word can be defined combinatorially by relating it to other words with which it typically occurs, by extracting and systematising information from texts or discourse, a process corresponding to Hebbian neuronal correlation learning algorithms (Pulvermüller, 2013). Since words that co-occur frequently are subsequently bound together into sequences, the combinatorial information mapped by the network is both syntactic and semantic in nature. Piantadosi (2021) defines structure-sensitivity as one of the central features of thought, whereby meaning of a representation can only be defined by the role it plays in an interconnected system of knowledge and cannot be studied in isolation. The meaning of one expression is given by its linguistic role within the structure of the whole language system, whereby the reference is not viewed as central. Similarly, the meaning of one musical motive can only be apprehended within the whole of the knowledge about music that we acquire through experience and learning of statistical co-occurrences of certain acoustic structures and their patterning. The meaning of any given entity is defined by its relationships and its position within a certain structure. Meaning in this sense is emergent, because it is not specified by any explicit feature of the design of the symbolic system. As maintained by Binder (2016), conceptual representations are not looked up in memory but rather dynamically created and highly context-dependent. Quite in the same sense, given that "semantic memory states are continuously changing, the meaning of a given stimulus, defined as the configuration of neural activity that is bound together in response to that stimulus, will be somewhat different across people, time, contexts, and processing circumstances" (Kutas & Federmeier, 2011: 641). Doumas et al. (2008) also posit an integrated theory of the origins of complex mental representations emphasising that thinking is constrained by the relational roles entities play. Relational thinking is therefore viewed as a cornerstone of human perception and cognition, underlying the ability to understand and produce language as well as art. It is also of moment for the truth-conditional semantics of music (Schlenker, 2021). Musical meaning can be true of a large set of diverse situations as long as the musical events, instantiated in the musical structure, preserve the specific ordering of world events in terms of energy and proximity among those events. Music reconstructs the structure of events undergone by its 'virtual sources' with a full hierarchy of more or less important sub-events reflected in the musical structure (Schlenker, 2017). Understanding of music relies precisely on such analogies between structures of music and structures of dynamic processes in the world (Zbikowski, 2017). By the basic cognitive capacity of analogy, structural similarities between disparate domains are drawn into correlation. We will come back to the analogical mappings between domains in more detail when discussing the specific ways in which music influences perception of words.

According to Piantadosi (2021), the cognitive sciences have to face the fact that we do not know what mental representations are like. There are indeed many theories of mental representations. For instance, Binder (2016) asserts that semantic cognition operates with supra-modal, highly conjunctive conceptual representations in high-level convergence zones which receive input from various modalities. He proposes a “hierarchical model of knowledge representation in which modal systems provide a mechanism for concept acquisition and serve to ground individual concepts in external reality, whereas broadly conjunctive, supra-modal representations play an equally important role in concept association and situation knowledge” (Binder, 2016: 1096). In this model, concepts are viewed as generalisations derived from sensory, motor, and affective experiences whereby emotions and perceptions play a far-reaching role in concept retrieval. To stress the combinatorial function of mental representations, Binder coins a new term, ‘cross-modal conjunctive representations’ (CCRs), which arise through neurobiological convergences of information coming from different input sources and can be activated by any kind of low-level input. The degree to which this input is preserved at higher levels of representation depends on its salience. All nodes of the semantic network (which is identified in Binder et al., 2009) are multimodal convergence areas manipulating CCRs. Interestingly enough, we can spot parallels between Relevance Theory (Wilson & Sperber, 2006), which deals with salient stimulus features on a pragmatic level, and Binder’s theory of CCRs, which aspires to account for the actual implementation of conceptual processing in the brain. Binder insists on CCRs not being theoretical constructs but rather on their being instantiated as distributed neural ensembles or networks. Convergent points can be also spotted with the model of conceptual priming accounting for interactions between conceptual processing of music and language proposed by Schön et al. (2010), where features of sounds (such as timbre or energy) can trigger activation of a semantic concept in the lexicon. They argue that a-modal concept representations might be the link between concepts evoked by sounds and concepts evoked by words. As a matter of fact, many kinds of features, including emotional valence, contribute to semantic analysis (Kutas & Federmeier, 2011). Koelsch et al. (2004) further advance that it is possible that semantic concepts as mental representations are stored without the help of language, and are therefore activated by music as well as by words. Accordingly, musical information would activate conceptual representations *per se* rather than their covert verbalisation (Koelsch, 2011). Language is inadequate to specify the particular synthesis of associations and correlations triggered by a musical event (Schotanus, 2020). But it is also not an absolute prerequisite of human thought since severely aphasic individuals are capable of complex mental operations (Fedorenko & Varley 2016), and a meaning does not necessarily need to be verbalised. From both phylogenetic and ontogenetic points of view, nonverbal modelling represents a primary and language represents a secondary modelling system (Sebeok, 2001). There are always components of a speaker's meaning that words do not encode (Wilson & Sperber, 2006). Conceptual representations abstract away from modality-specific attributes and are generalised (Patterson et al., 2007), which means that any feature may automatically spread to a whole range of concepts. In Binder's model various meaning-laden stimulus types ultimately converge on shared or at least partially overlapping conceptual representations. Concepts arise from generalisations from all our senses whereby the resulting representations include abstract and specific features. Semantic hubs integrate features from different modalities and are activated across modalities, and the processing of meaning therefore seems to depend on distributed neural systems. Distributed neural ensembles in the hubs of the conceptual network "are literally equivalent to CCRs, each of which can activate a set of associated CCRs" (Binder, 2016: 1100). At the same time Kutas et al. (2010) underscore the fact that the N400 data point to a distributed, multimodal and bihemispheric comprehension system that is simultaneously open to linguistic and nonlinguistic influences, which often interact. This suggests again a predictive, flexible and context-dependent comprehending.

Music involves multiple levels of syntax, and much of its meaning relies on how these levels are coordinated (Zbikowski, 2007). As Fitch & Gingras (2011) put it, there is no need to draw a clear line between 'semantics' and purely structural 'syntax' in music. Musical meaning seems to be extremely multifaceted, but meaning in general is usually multidimensional. It emerges from sign qualities, structural context, idiosyncratic responses, different personal associations, cultural background and so on. It has been suggested that all these dimensions form the whole of a meaning which might therefore be distributed over a multitude of brain areas. Semantic representations seem not to be confined to some meaning-specific brain regions but appear rather distributed in a systematic way throughout the entire brain (González et al., 2006; Huth et al., 2016). Meaningful representations evoked by music were generally thought of as hopelessly idiosyncratic, but it has been proven that the narratives induced by listening to instrumental music contain constant features in individuals sharing the same culture (Margulis et al., 2022). Musical meaning is assumed to be available as part of one's innate psychological makeup and what has to be learned through exposure are only the factors that differentiate one musical idiom from another (Jackendoff, 1991).

Furthermore, musical structures form a scene on which the described situation takes place (Dürr, 2004). The question remains whether the imagined narrative induced by instrumental accompaniment can be strong enough to influence the meaning conveyed by lyrics, and song is for that reason an ideal tool to explore the robustness of the music-meaning effect.

3. Influence of Music on Linguistic Processing in a Song

Although a full overlap is unlikely, since music conveys different kinds of concepts than language, not necessarily requiring verbalisation, it has been suggested that music, despite being an autonomous, innately constrained function, is made up of multiple modules, some of which end up overlapping with other functions - such as language (Peretz, 2006). Evidence from non-fluent aphasics impaired in recognition of spoken words while retaining spared recognition of music also suggests the functional independence of music and speech at some levels (Peretz & Zatorre, 2005). Likewise, studies with amusic patients show that language and music are processed in, to some extent, separate modules (Peretz, 1993; Peretz & Zatorre, 2005). However, more recent research has revealed that amusia is not a music-specific disorder, given that tone-language speakers exhibit impaired performance on lexical tone perception, linguistic and emotional prosody processing, phonological processing, and speech imitation (Liu et al., 2015). The study of Liu et al. (2015) has shown that the patients also showed impaired judgment of semantic acceptability of sentences during speech comprehension. It seems therefore that the relationship between the modules is more intricate than traditionally believed.

Furthermore, there is evidence for interference effects of music at a higher level of linguistic processing, suggesting that there may exist some kind of overlap between the two domains (Poulin-Charronnat et al., 2005). Given this overlap, transfer effects are likely to occur and the next section is going to discuss the specific ways music might influence the meaning of lyrics.

To be able to look at the mutual influencing of linguistic and musical elements in a particular case of song, it is necessary to define what the meaningful units are. Yet finding such comparable units has proven particularly delicate. What the semantic primitive in music amounts to is not clear and remains arbitrary in the available literature. Jackendoff (1991) defines it as an unconscious construction of abstract musical structure, of which the events of the musical surface are the only audible part. Frey et al. (2009) talk rather of Temporal Semiotic Units, which are segments conveying meaning through their dynamic organisation in time, categorised based on their morphological and semantic description and other characteristics such as energy, intensity, tension and so on. The most common way to define meaningful units is as a set of sounds and the relations between them composing a motif, theme or sentence. Having said that, some argue that the units may be even smaller, one second of music being able to convey concepts (Daltrozzo & Schön, 2009).

According to the Musical Foregrounding Hypothesis (Schotanus, 2020), music seems to influence the processing of song lyrics in two seemingly opposing ways. It seems to hinder and facilitate it at the same time. The accompaniment as well as the melody in the voice can increase listener’s perceptiveness towards the verbal message, for example by raising arousal and attention. It might highlight important words or add supportive prosodic information and reinforce its semantic meaning, and at the same time improve language processing by increasing the aesthetic valence or by inducing emotion that has bearing on the interpretation of words. Patel (2008) agrees that musical context influences the perceived affective valence of lyrics and views song as a kind of ‘word painting, whereby the meaning of words is complemented by the use of tonal patterns that iconically reflect some aspect of word meaning. The underlying harmonic syntax can complement the meaning by articulating points of tension and resolution, stability and instability, as well as openness and closure.

By adding meaning to selected points in the lyrics, music can steer the understanding towards one particular interpretative pathway while diverting from concurrent ones (Schotanus, 2020). On the other hand, one possible way to impede the processing is by distracting attention from the words. Poulin-Charronnat et al. (2005) stress that the role of music resides in capturing the listener’s attention during the unfolding of a musical piece. It modifies allocation of attentional resources necessary for linguistic computation. Music would therefore draw attention first, and then linguistic analysis would take place. On top of that, sad music has been shown to engage the listener in mind-wandering and by that means to disrupt ongoing task performance by disengaging attention from perception (Taruffi et al., 2017).

Temporal unfolding of both music and language raises expectations and their synchronisation or misalignment may alienate the structure locally, affecting the perceived meaning and perceived emotional content of specific words (Schotanus, 2020). Expectations play an important role in the process of creating formal meaning, producing a sense of logical connectedness, progress and direction whereby tension and resolution mediate a sense of semantic meaning (Koelsch & Schröger, 2008). Sudden changes of harmony or any kind of unforeseen structural breaks followed by intriguing new structure may bring about transient increases in arousal which receive *ad hoc* semantic interpretation by the perceiver (Koelsch & Fritz, 2007). Music can therefore affect the physiological bodily processes, as measured in the cardiac pulse, respiration depth and skin conductance, mainly due to the activation of the autonomic sympathetic nervous system. These effects on arousal and mood constitute an important component of the meaning of music (Fitch, 2006). Koelsch et al. (2005) develop by pointing out that any emotional activity is always related to bodily reactions whose perception or awareness conveys a sense of meaning.

Musical features may also interfere with the linguistic computation of lyrics exactly as prosodic cues in spoken language do. Through music, certain points in the lyrics, probably carefully chosen by the author, might be endowed with affective prosodic cues, which in spoken language elicit sensational processes in a perceiver, bearing resemblance to those occurring in the producer (Koelsch, 2011). Such prosodic cues, in a way the musical components of a linguistic utterance, allow us to understand the overall message even if it is produced in a foreign language which we do not speak (Dürr, 2004). This emotional part of the information, that is much more inter-individually shared, enables the communication and is to a certain extent independent of the codes each individual language uses.

Patel (2008) further advances that people are good in judging the affective qualities of voice, independent of lexical meaning, and thus, speech could function as a mental basis on which an emotional quality is assigned to a musical piece. This would occur on the grounds of overlapping acoustic cues used to convey basic emotions in speech and music. Brown (2000) regards musical meaning as being fundamentally constrained by the emotion the given musical unit is carrying. By the same token Steinbeis & Koelsch (2008) used an affective priming paradigm to investigate the semantic processing of emotional stimuli, confirming that emotional expression in music is one way by which meaning can be conveyed through music. However, Koelsch et al. (2004), among others, have examined the neural correlates of extra-musical meaning while at the same time controlling for emotional expression, finding that meaningful representations were activated by music independent of emotion. Furthermore, Painter & Koelsch (2011) have ruled out emotion as a cause of meaning conveyed by a sound because there was no systematic difference in affective value between their stimulus pairs. Koelsch & Schröger (2008) also underscore that musical meaning is not constrained by the emotional aspects since the character of the N400 does not change depending on whether the target word has an emotional content or not. This provides evidence for the capacity of music to convey meaning *sui generis* and although there seems to be a strong emotional component to musical meaning, it would be erroneous to reduce its meaning to emotion.

An alternative cue for ascribing meaning to music is the resemblance of musical patterns to movements of people in different emotional states or metaphorical relation between structure and emotion based on universal facial expressions or psycho-physical cues. Music becomes meaningful by virtue of imitating the specific cues of certain mood-like gestures or prosody and thus influencing the perception of lyrics. Patel (2008) stresses that listeners are good at decoding basic emotions from the sound of a voice, even when the words spoken are emotionally neutral or semantically unintelligible (as in foreign language) and suggests that songs may employ intensified versions of the affective cues used in speech.

This effect might possibly be explained by Piantadosi's (2021) theory of mental representations, which posits a universal mental language by virtue of which structures isomorphic to the world are created in the mind. Crucially then, by extracting regularities and abstract rules, the mind generalises over inputs. Such mechanism would explain how music can model the meaning of one's speech, gestures and postures by creating isomorphic correspondences, and why there seems to be an overlap in the acoustic cues used to convey basic emotions in speech and music. If the mind abstracts away from the particularities of each input stream and generalises, it might very well treat those cues in a similar way. Thanks to generalisations, emotion perception modules will not recognise the difference between vocal expressions and other acoustic expressions and therefore react in the same manner as long as certain cues are present in the stimulus. Music performance indeed seems to use largely the same emotion-specific patterns of acoustic cues as does vocal expression (Juslin & Laukka, 2003). The underlying processes would also account for Patel's (2008) hypothesis that many instruments are processed by the brain as expressive voices. Their perception purportedly engages emotion perception modules in the brain, because they contain enough speech-like acoustic features to trigger them. The brain has developed mechanisms sensitive to the perception of human voice that are most probably located in the superior temporal gyri and sulci (Grandjean, 2021). There is a special cerebral mechanism underlying the capacity of this system to process and generate emotional information comprising universals, as well as unique traits for each individual language. An important function of emotional prosody is purportedly to capture attention. When the brain detects emotional information, it attends to the stimulus, independently of any voluntary focus.

However, such generalisations surpass the purely acoustic level, human mind being capable of correlating structural elements of musical sounds with physical gestures of any kind of dynamic processes by virtue of analogical connections based on abstract similarity judgement (Zbikowski, 2017). The source events, on which the musical structure is mapped, do not need to have a sonic component.

As demonstrated, music seems to both alienate and accentuate lyrics, but unless the hindrance becomes too pronounced, accompaniment enhances speech (Schotanus, 2020). Its role is to promote interpretations beyond the literal meaning of specific words or phrases, as well as the resulting general interpretation. Foregrounded elements are usually perceived as more striking and having more importance and appear to be the major contributing factors to the overall interpretation. Musical accompaniment exerts influence upon the text by pointing out, highlighting, and altering certain aspects of the text through a careful choice of expressive means (Dürr, 2004). At the same time, putting a text into music means intensifying the utterance with the aim to communicate more content, and reflects the composer's interpretation of the text as a whole (Zbikowski, 2017). The accompaniment usually tries to follow the prevailing mood of the passage but is able in individual cases to intensify or question the meaning of the text. Even from the union of incongruous text and accompanying music a rich meaning emerges by virtue of conceptual blending (Hsu & Su, 2014), an important meaning-making process that is going to be discussed in greater detail below. The function of musical accompaniment would therefore be to interpret the text, to reveal its hidden aspects, to bring about unexpected meanings and guide the listener in its interpretation. The melody is supposed to translate what remains hidden in the language and counterbalance its shortcomings (Brogniez & Piret, 2005).

Music is generally considered an auditory stimulus, but it has been suggested that perceptual and cognitive representation of music can involve non-auditory (e.g. kinaesthetic) information (Hubbart, 2019). Moreover, music might be able to induce an image of a virtual environment through the sense of motion, as well as of fictional movements and gestures in the aforementioned environment and bring about the sense of external objects moving in relation to the self. This effect might evoke mental imagery of nonmusical phenomena and give rise to scene representations by engendering narrative thoughts (Patel, 2008). In the case of a song, these abstract mental representations of the movement may be contrasting to the text, which might have an overriding effect on the interpretation. The body arguably has a role in human reasoning (Johnson, 1990), as perceptual interactions and motor programs give coherence and structure to our experience. Johnson (1990) underscores the creative faculty of the mind to form novel representations endowed with novel meaning by assembling inputs from various sources, among others namely the body. Therefore, linguistically specified word meanings are typically adjusted in the course of pragmatic interpretation, using available contextual information and *ad hoc*, occasion-specific concepts are constructed under the influence of a wide range of cognitive and contextual factors.

Some even grant music a superior power to express certain sensations, despite the fact that they cannot be translated into words, and consider language as hopelessly limited by its attachment to signification (Locatelli & Delpy, 2009). The inherent vagueness of musical expression represents its very advantage. As Koelsch (2011) puts it, sensations, such as sensori-interoceptive information, action tendencies, or background-feelings must be reconfigured into words in order to be conceptually grasped and communicated between individuals. Whether these verbalised sensations are shared between individuals is nevertheless dubious even if the exact same wording is used to refer to these sensations. Music, on the other hand, mediates sensations in their pre-linguistic mode of existence, and thus it might be much more in accordance with their real essence on the inter-individual level. Such meaning is therefore conveyed prior to its reconfiguration into words. Furthermore, as Fitch & Gingras (2011) affirm, even for language the scientific understanding of meaning remains elusive. We can come near to the meaning of a lexeme but it is illusory to think we can define it once and for all because it depends essentially on the discourse and genre (Cusimano, 2015). On top of that, most languages have a cluster of procedural items (e.g. affective intonation and mood indicators) which are associated with mechanisms for emotion and mind reading (Wilson & Sperber, 2006). Humans arguably possess cognitive faculties to attribute mental states to others in a social interaction based on what they hear. In order to identify the speaker’s meaning, the addressee must enrich the decoded explicit meaning by complementing it at the implicit level. Processing of both explicit and implicit contextual information is carried out in parallel and sense-making is a matter of mutually adjusting tentative hypotheses about explicit content, context and cognitive effects (Wilson & Sperber, 2006). The context participates fundamentally in the content of a word and the need to approach song perception on an interdisciplinary level is therefore urgent.

4. Song and Pragmatics

The purely semantic content is not the only way an utterance conveys its meaning. It is essentially constrained by elements external to the propositional content. Not only do speech and music possess similar acoustic properties coding emotional expression, they also both derive their meaning from the context and discourse.

Understanding of song is a complex hermeneutic undertake. The cognitive relationship between lyrics and tune in song is currently under debate and the central issue is whether they are represented as separate components or processed in integration (Sammler et al., 2010). It seems intuitive that music influences the understanding of lyrics; it has nevertheless proven extremely challenging to address this question experimentally. To tackle the problem, one of the possible roads seems to be approaching the interpretation of lyrics as a message, or an act of communication that is constantly influenced by the external factors, musical accompaniment in this case.

A distinction is often made between semantics and pragmatics, which has led to the construction of a two-step model of linguistic processing, whereby listeners initially compute a local, context-independent meaning of a phrase, based on low-level lexical information, and only subsequently relate it to the context. On this account, local semantics could not be initially overruled by global contextual factors. This view has nevertheless proven problematic. Context seems to shape word processing from its earliest stages and evidence mounts attesting to the prevalent role of sentence and discourse-based context information in shaping language comprehension (Kutas & Federmeier, 2011). Even speaker's identity is taken into account as early as 200–300 ms after the beginning of a spoken word, and is processed by the same early interpretation mechanism that constructs sentence meaning (Berkum et al., 2008). This suggests that pragmatic information is integrated very rapidly. According to these findings, language comprehension does not involve an initially context-free semantic analysis, and sentence interpretation seems to amount to an intrinsically contextualised social activity. Nieuwland & van Berkum (2006) propose a one-step model of interpretation where words are immediately mapped onto the widest interpretative domain available, with no initial computation of local, context-free meaning followed by contextual reappraisal. By this mechanism, a song would be immediately perceived as one semantic whole with all its parts influencing the resulting interpretation. Kutas & Federmeier (2011) claim furthermore that message-level constraints arguably have the power to override lexical associations. It seems, therefore, that the meaning of an utterance cannot be studied independently of its broader context. Since language is just one part of communication (Semino & Culpeper, 2002), one can think of musical accompaniment in song as an additional contextual information. Furthermore, the fact that music might express ideas in a more compelling, although less specific manner than language (Limb, 2006), might make it an efficient tool to specify song lyrics which very often are of equivocal nature.

Arguably, language users are accustomed to adding contextual information to utterances and to recovering the intended meaning based on contextual information and inferencing (Patel, 2008). Meaning is derived from discourse, an operation that involves assuming unstated information, and drawing inferences about what was said. Similarly meaning of a musical piece amounts to inferences it licenses about some music-external reality or its ‘virtual sources’ (Schlenker, 2017). It seems that there is no airtight division between the linguistic semantics and pragmatics which is indicative of mutual influences of both domains (Nieuwland & Van Berkum, 2006). It has been suggested that similar cognitive principles are at play in organising the flow of meaning in both language and music. Cross (2011) insists on the participatory nature of musical meaning, of which he conceives as a mode of human communication that is homologous with aspects of linguistic interaction, because it is organised around multiple interactional goals beyond the transmission and reception of factual information.

Decoding of speaker’s meaning during the comprehension of speech acts involves Theory-of-Mind and social cognition brain areas (Hellbernd & Sammler, 2016). Patel (2008) argues that music can be meaningful on the pragmatic level and can provide contextual information to semantic structure. This appears to be corroborated by the fact that, just like during the decoding of communicative meaning in speech acts, Theory-of-Mind as well as social cognition networks get engaged while listening to music (Koelsch, 2011). It is believed that the message conveyed by music includes intentions and that deciphering such intentions and the attribution of mental states is one of the components of musical meaning. Thus, there seems to be a social-intentional dimension of musical meaning. Kutas & Federmeier (2011) observe that N400 data provide strong evidence that gestures and body movements are analysed and used semantically in real time, influencing ongoing language comprehension almost immediately and in a manner functionally indistinguishable from linguistic inputs. Establishing discourse coherence by recovering its implicit structure is central to language understanding. And just like speakers are accustomed to adding contextual information, music listeners use contextual cues such as the parallelisms with prosodic and gestural cues, in order to forge structural relations within a sequence, thus creating a semantic reference. In this sense, meaning of an utterance seems to be derived from discourse by assuming unstated information, and drawing inferences about what was said (Patel, 2008). This seems to be the case of music as well. It is likely that the same basic cognitive processes underlie making sense of event sequences in both domains.

Utterance meaning is a vehicle for conveying the speaker’s meaning, which has to be inferred from behaviour together with contextual information. Crucially, context covers mentally represented information of any type such as beliefs, goals, intentions, and so on. Salient information is selected during comprehension from a range of potential contexts available to the perceiver (Wilson & Sperber, 2006). A salient element is defined as the one that achieves greater cognitive effect. Contextual cues provided by the musical part might also be assimilated with the meaning of lyrics by virtue of conceptual blending which enables the invention of new concepts. By blending elements coming from different input sources, new dynamic mental patterns are assembled. Mixing and matching out ways of understanding seem to come naturally to humans, who possess the capacity to acquire and express new concepts and ideas. Our ability to compose new meanings does not seem to be limited to language. The capacity of putting together disparate facts indeed appears to be a general cognitive faculty of compositionality, which is a property of general intelligence (Everett, 2021). Language only verbalises a minuscule part of its potential combinations. According to Hopper (2019), the primary purpose of a sign is not to signal pre-established meanings, but to link together all the different aspects of the act of communication. This seems to contrast with the traditional view that assumes a fixed system of signs based on a pre-determined relationship between a form and a meaning. On the contrary, in Hopper's view the active role of listener in the act of perception comes to the foreground.

Different frameworks make different predictions about the evolution of language. But if we assume that meaning is constrained by a need for successful communication, and take into account the suggestion that music has preceded language as a means of communication (Darwin, 1871; Fitch, 2006), we might find that music itself can in fact be conceived of as a means of communication. As stated by Brown (2000), music and language evolved from a common ancestor, so called *musilanguage*, hence they both have strong underlying biological similarities and therefore overlapping mechanisms. Thus, these two domains differ more in emphasis than in kind and are represented along a spectrum instead of occupying two discrete, but partly overlapping universes.

5. Overlapping Brain Mechanisms

Research on syntax has shown that language and music draw on a common pool of limited resources and areas known to be involved in language processing. Superior temporal gyrus (STG) is involved in melodic processing and superior temporal sulcus (STS) more specifically in the melody contour analysis (Thaut & Hodges, 2019). The whole of the superior temporal lobe is implicated in perception of melodic intervals (Klein & Zatorre, 2015) and categorical perception of major and minor chords (Klein & Zatorre, 2011). It has been argued that Broca's area computes domain-general 'syntactic' processing (Schön & Morillon, 2019), and there is also evidence for music-syntactic processing in this region (Maess et al., 2001).

Moreover, BA 44, the inferior frontal gyrus as well as the anterior portion of STG are involved in establishing syntactic relationships by evaluating the harmonic relationship between incoming tonal information and a preceding harmonic sequence (Koelsch, 2011). Koelsch et al. (2005) have shown interference of linguistic and musical syntactic incongruities showing that processes underlying the initial structural build-up (LAN and ERAN) compete for similar neural resources. As for semantic processing, Koelsch (2011) suggests that posterior temporal cortical regions might store conceptual features rather than only lexical representations *per se*, which would explain why these regions can be activated by musical concepts. It has also been pointed out that semiotic relations of musical events seem to be processed by the brain in a similar way as corresponding relations in the case of concepts coded by linguistic constructions, a fact indicating shared neural networks involved in common processing of language and music (Reich, 2011).

Distributed views of semantic system with hubs underlying high-level integrative processes would account for the fact that features of the acoustic surface of music can activate linguistic concepts, regardless of where the hubs binding semantic representations are located (AG: Binder et al., 2009; aTL: Patterson et al., 2007; vmPFC: Pylkkänen et al., 2009). The semantic system embedded in the human brain purportedly corresponds in large measure to the network of parietal, temporal, and prefrontal heteromodal association areas, where input from multiple modalities is balanced and highly convergent (Binder et al., 2016). The expansion of these regions in the human relative to the nonhuman primate brain may explain uniquely human capacities to use language productively, plan, solve problems, and create cultural and technological artefacts, all of which depend on the fluid and efficient retrieval and manipulation of semantic knowledge.

It seems that musical meaning is at least partly processed by the same mechanisms as meaning in language (Koelsch, 2011). However, an important caveat to bear in mind is that similarity of activation does not entail similarity of the underlying processes, or that the recruited areas are critical to performing a given task (Peretz & Zatorre, 2005). By the same token there is both behavioural (Bonnel et al., 2001) and neurological evidence (Besson et al., 1998) in support of the independence of the linguistic and melodic components within a song. In the study of Sammler et al. (2010), the left mid-STS showed an interaction of the adaptation effects for lyrics and tunes, suggesting an integrated processing of the two components at prelexical, phonemic processing level. Lyrics and tunes seem to be processed at varying degrees of integration and separation, through the consecutive processing levels following a gradient from more to less integrated along the posterior-anterior axis of the left STS and the left PrCG (cingulate gyrus). The question of overlapping mechanisms is fairly intricate and Schön & Morillon (2019) discourage from thinking about language and music as a whole, but rather in terms of precisely defined elementary operations. Some of these might be overlapping and some might be subserved by specific circuits. Music is not a unitary cognitive module since different components of 'the music faculty' may have different evolutionary histories (Fitch, 2006). To be fully examined, every complex behaviour needs to be broken down into independent components and most importantly it appears that the degree of integration or separation of the two domains depends on the specific cognitive processes targeted by an experimental task (Sammler et al., 2010). Undoubtedly, one of the biggest research challenges on the music-language interface field is to draw further analogies at higher levels and to find comparable units by reducing both domains to more elementary functions.

6. Concluding Remarks

González et al. (2006) unravel the way in which words and their meanings are represented and processed in the brain as one of the central issues in cognitive neurosciences. Seeking for meaning representations in other domains can surely contribute to this crucial query, in that it can help to decipher its actual organisation in the brain and to point out the overlapping representations with words, supposedly processed by distributed neural assemblies with cortical topographies reflecting their meaning or aspects of their reference.

On one hand, musical meaning seems to be understood in terms of physiological changes that listening triggers by inducing emotions, as well as with reference to engendered impressions of movement through space. On the other hand, it seems to rely on learned probabilistic statistics of pattern sequences creating expectations that are subsequently experienced as meaningful. It would therefore be the sense of logical structure, maybe comparable to linguistic syntax, that bestows on music the referential power. It has been shown that music is not semantically deficient relative to language, yet it encourages a complementary mode of interpretation which might be precisely the major source of its appeal.

An array of experimental studies has been brought together showing clearly the ever-growing interest of researchers coming from diverse domains who all see the research on music-language interface as a unique opportunity to better understand human cognitive capacities and organisation of the human brain. It has been shown that the processing of musical and linguistic meaning likely relies on shared as well as specific mechanisms. Yet the precise extent of domain specificity in language and music still remains elusive. To fully grasp their organisation there is a great need for an interdisciplinary approach. Since both domains are uniquely human, a synergic research approach can strongly contribute to the knowledge of each separate domain and their integration.

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Part II: Communication disorders

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SOCIAL AWARENESS AND COMMUNICATION DISORDERS*

Abstract: How much does the general public know about speech and language disorders, their symptoms, the possible remediation, and their real impact on everyday life? This article aims to assess general public knowledge of speech and language disorders, in an attempt to identify key factors that can predict awareness level. To do so, a web-based closed questionnaire was created consisting of 42 questions classified in 4 thematic blocks (I. *Speech and language disorders*, II. *Specific language disorders*, III. *Psychosocial aspects associated to speech and language disorders*, and IV. *Speech and language therapy*). The results of 328 participants confirmed that awareness of both speech and language disorders is still rather low across the board, with highly educated respondents as the most familiar with the different disorders and female respondents as the more aware of the weight of psychosocial factors. The importance of increasing awareness is made especially evident by our results for issues related to treatment. Although the majority of respondents recognize that a deeper knowledge of symptoms is critical for the amelioration of the patients' situation and the treatment of speech and language

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disorders, they are dubious about the possible benefits of speech and language therapy.

Key words: awareness, speech disorders, language disorders, psychosocial factors, therapy, predictors

1. Introduction

Many disorders can affect our communicative capacities. However, worldwide incidence and prevalence estimates of communication disorders are difficult to determine due to methodological differences, scattered results, and variability across groups. According to the National Institute on Deafness and other Communication Disorders (NIDCD, 2022), in the US alone, 1.4% of children have a voice disorder (e.g., spasmodic dysphonia), 5% have a speech disorder (mostly speech-sound disorders and stuttering), and 3.3% have a language disorder. Among the adults, 4% were reported to have a voice disorder, whereas 0.3% have aphasia. These deficits, which can range from mild distortions in the production of specific speech sounds to the inability to produce or comprehend one's native language, persisted for a week or longer (Black et al., 2015; Hoffman et al., 2015). McCormack and colleagues' (2007) report on Australian children serves to illustrate the wide range of variability across studies and regions, with percentages of voice disorders as low as 0.1% and percentages of speech and language production deficits as high as 25.2%. Despite the wide spectrum of clinical cases included under the umbrella of speech and language/communication disorders and the impact they have on quality of life (Cruice, 2001), up to this date, most people have very little knowledge about the disorders, their symptoms, the possible remediation, and their long term impact, as shown by Code (2000) for aphasia.

Different organizations have implemented initiatives to facilitate access to comprehensible information and compensate for this lack of knowledge. Some examples in the US are the American Speech-Language-Hearing Association (ASHA), with campaigns such as *Better Hearing and Speech Month* (BHSM), and the National Aphasia Association (NAA), with the *Aphasia Awareness month*. These organizations, among many other national and private groups across the globe (e.g., the Indian Speech, Language and Hearing Association's *Speech and hearing awareness campaign*), seek to inform the public about communication disorders, treatments, and current research that can improve quality of life. The ability of these campaigns to significantly influence the general public is still to be demonstrated. Taking aphasia as an example, as part of the *2018 Aphasia Awareness Challenge*, the NAA reported that 84.5% of the population had never heard about aphasia, and less than 9% could correctly identify aphasia as an acquired language disorder. Of the 15.5% who reported being aware of aphasia, up to 34.7% had direct experience with the disorder, either as persons with aphasia or as relevant others of people with aphasia (NAA, 2018), thus reducing even more the percentage of the public aware of the condition when not driven by personal circumstances.

Different surveys have attempted to capture the general public's degree of awareness of communication disorders and speech and language therapy. In what follows, we provide an integrative overview of those, focusing on 3 major aspects: 1) increased awareness over time, 2) predictors of awareness level, and 3) the relationship between awareness and knowledge.

Already in the 80's, Breadner et al. (1987) gave an account of public awareness of speech and language disorders, comparing the results of 252 Canadian respondents from the general public with those obtained in a previous study using the same methodology (Husband, 1980; n. of respondents: 264). The questionnaire aimed at determining familiarity with speech and language therapy, communication disorders, and the role of therapists. The authors showed that not only was public awareness very limited but, as indicated by the lack of significant differences for communication disorders, there was also no improvement in comparison to earlier results. Most respondents failed to identify a variety of pathologies included in the communication spectrum (e.g., cleft lip and palate, language delay), the user groups (infants vs. adults), or the role of speech and language pathologists (SLPs), including how to obtain their services. An effect was found for gender, education, and profession, with highly educated females working in the field of health and education showing higher awareness and accuracy rates.

Similar results were found by Mahmoud and collaborators (2014) in a study conducted in Amman using an Arabic adaptation of Husband's (1980) and Breadner et al.'s (1987) questionnaire. The study of 1203 participants showed low levels of awareness and knowledge of SLPs and speech-language disorders among non-specialists, with the only exception of stuttering (69% of respondents were aware of the need for an SLP to treat the disorder). Similar to Breadner et al. (1987), gender, education, and professional background were found to have an effect, with female and highly educated informants in the sector of health and education again demonstrating higher awareness and knowledge rates, especially with respect to accessing information through readings.

Studies of stuttering, a speech disorder with a prevalence of 5% (Mansson, 2000), also offer the possibility to evaluate similarities across countries. Public awareness and knowledge of stuttering were measured in

Belgium (Van Borsel et al., 1999; 1362 informants), China (Xing Ming et al., 2001; 1968 informants), Brazil (de Britto Pereira et al., 2008; 606 informants), and Japan (Iimura et al., 2018; 303 informants) using the same materials. Although most participants reported a certain degree of familiarity with stuttering across countries, differences according to gender, age, and educational level similar to those reported in Breadner et al. (1987) showed when aspects such as prevalence, onset, cause, or treatment (among others) were evaluated. In addition to previously reported factors, cultural background was found to have an effect.

Less evidence is available for awareness of language disorders, with the only exception of aphasia. Truelsen and Krarup (2010) examined the awareness of major stroke risk factors and symptoms in 811 representative Danish participants aged 40+ years. With very few exceptions (e.g., hypertension, identified by 72.3% of the informants), most major risk factors and symptoms were almost unknown to the general population. However, speech disturbances were identified by 78.4% of the informants as a common symptom, with women again generally better informed than men. In a later study comparing knowledge of Parkinson’s disease (PD), stroke, and aphasia among the general public (200 informants) and health professionals (100 informants) of New Zealand, McCann and collaborators (2012) found limited self-declared awareness and knowledge about aphasia. Whereas awareness means reached 11% for the general public and 68% for health professionals, the percentages decreased for knowledge (1.5% general public, 21% health professionals). Figures were poorer than for PD and stroke, and, as in the case of Canada (Breadner et al., 1987), no improvement was found with respect to an earlier international study with the same methodology conducted with 978 individuals in England, the US, and Australia, 10 years earlier (Simmons-Mackie et al., 2002).

Focusing on aphasia, some recent international studies showed that, although awareness is nowadays improving, basic knowledge of aphasia is not (Code et al., 2016; Hill et al., 2019; Code, 2020). Code et al. (2016) included results from 3483 respondents from 6 different countries in Europe and the Americas. Overall, 37.1% of the participants reported having heard about aphasia (ranging from 16% in the case of Slovenian respondents to 60% in Croatia), with young females being more aware. However, actual knowledge was found to be lower (9.2% on average), ranging from 1.0% in Argentina to 13.9% in Norway, thus confirming that in addition to important differences across countries, there is clear dissociation between awareness and actual knowledge (see also Code, 2020 and references cited therein).

This article aims to evaluate general public awareness and knowledge of different speech disorders and language disorders to identify key factors that can predict awareness level. Based on previous results, we hypothesize a slight increase of awareness with respect to early studies, although not necessarily followed by an increase of actual knowledge. Factors such as age, gender, and educational level are predicted to have a significant impact on the results, with highly educated young females being expected to be better informed.

2. Methods

2.1. Participants

A total of 328 informants (76.8% female, n = 252) participated in the study, using a web-based, closed questionnaire available in English and Danish. Potential participants were recruited by university students using snowball sampling via e-mail, social media, and standard distribution lists. Information about the purpose of the study, the nature of the questions, and data treatment were included in the call for participation. All respondents were volunteers and gave their explicit consent to participate online, after re-reading the instructions and before proceeding to the questionnaire. To guarantee anonymity, no identifying data (names, IDs, contact details, IPs) were collected.

Informants from Europe, Africa, Australia, the Americas, and Asia were recruited. However, most respondents were European citizens (88.7%, n = 291). Different age groups were represented, with a predominance of informants in the 20-29 years old group (72%, n = 236), followed by participants between 30-39 years old (17.1%, n = 56). At the time of the interview, 56.7% of the respondents had higher education (n = 186), 19.2% had secondary school education (n = 63), and 24.1% had primary school education (n = 79). As amny as 59.8% of the respondents were students (n = 196), 32.9% were employed (n = 108) and 7.3% were either retired or unemployed (n = 24) (see Appendix 1.A for further background information).

In order to obtain a deeper insight into the population, participants were asked about their personal experience with both speech and language disorders. Out of the 328 respondents, 4.6% (n = 15) declared experiencing a speech or a language disorder. Speech sound disorders (n = 5) and stuttering (n = 4) were the most common responses. When asked if they knew one or more persons with speech and/or language disorders, 53.7% of the informants (n = 176) replied positively. Stuttering (31.71%; n = 104) and speech sound disorders (4.27%, n = 14) were the most frequently reported speech disorders. Dyslexia (12.5%, n = 41) and aphasia (6.1%, n = 20) were the most common answers within the group of language disorders (see Appendix 1.B).

2.2. Design

A self-developed questionnaire consisting of 42 questions was designed as part of a course project by the Master's students of the Department of Linguistics of the University of Copenhagen in 2017. Inspired by previous studies, questions sought the most accurate image of self-reported awareness and actual knowledge of speech and language disorders and their treatment (see Appendix 1 for the full set of questions). Quantitative and qualitative responses were elicited by means of yes/no questions, multiple choice questions (including Likert scales), and open questions. All questions were marked as obligatory to minimize missing data, although *don't know* responses were possible in certain forced choice and all open questions.

In addition to the background information sections, the questionnaire covered 4 main thematic blocks. The first block, *Speech and language deficits*, included 13 questions about speech disorders and language disorders, intended to evaluate the ability of the participants to distinguish them. Block II, *Specific Language Disorders,* consisted of 7 questions about aphasia, dyslexia, and Alzheimer's disease, and was aimed at assessing the degree of the participants' knowledge about these disorders. Block III, *Psychosocial aspects associated with speech and language disorders,* included 6 questions focusing on psychosocial aspects related to speech and language disorders such as their impact on everyday activities, quality of life, and stigmatization. Finally, block IV, *Speech and Language Therapy*, included 7 questions about the specific linguistic aspects susceptible to disruption and the benefits of language therapy.

2.3. Data analysis

Due to space limitations and for the sake of clarity, only the data relevant to our aim are reported in this article. Responses are reported by block. Subjective questions portraying perceived awareness and objective working knowledge questions are contrasted in order to control for a positive bias effect on the self-assessment and to measure the effectivity of awareness raising campaigns. Quantitative results were analyzed using IBM SPSS Statistics 24.0. Since the individual scores were not normally distributed, with a majority of European female respondents in the age group of 20-29 years old, non-parametric tests were used. Friedman and Wilcoxon signed-rank tests were run for within-group comparisons. Spearman's rank-order correlations were also calculated to determine the relationship between variables. Only significant differences are reported.

3. Results

3.1. Block I: Speech and language deficits (Appendix 1.C)

Block I groups together questions aimed at distinguishing perceived awareness and actual knowledge of communication disorders in general. Responses include familiarity reports, information sources and specific differences between speech and language disorders (e.g. syndromes and symptoms, and anatomical substratum). We only analyzed answers to 10 of the 13 questions within this block (9 multiple choice questions and 1 open-ended question). The results show a generalized low degree of self-reported familiarity with communication disorders. Only 6.7% (n = 22) of the informants declared a high degree of familiarity with speech disorders (vs. 11%, n = 36, who declared not being at all familiar). For language disorders, 8.2% (n = 27) claimed to be very familiar, and 33.5% (n = 110) declared no familiarity at all. Significant differences between speech and language disorders (Z = -4.798, $p < .001$) indicate that the general public is generally more aware of the existence of speech disorders. This is more visible in the case of people with a high educational level. Although weakly, higher education was found to correlate with awareness of speech (but not language) disorders ($r_s(328) = .124$, $p = .025$).

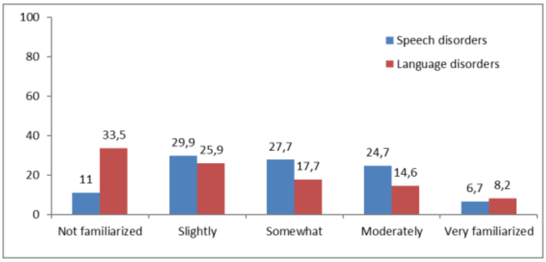


Figure 1: Familiarity with communication disorders

Differences were also found in the amount and the sources of information respondents had been exposed to, with access to speech disorders through audiovisual media and written sources (including online and physical informative and scientific materials) more frequently acknowledged than access to language disorders (Z = -2.872, $p = .004$; see Figure 2). Whereas 42.1% of the informants reported not having either heard or read about the latter, 29.9% confirmed having both heard and read about speech disorders. As in the case of familiarity, a weak correlation restricted to speech disorders was found between confirmed access to information and higher education ($r_s(328) = .112$, $p = .042$).

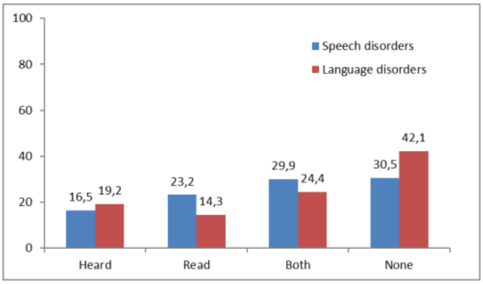
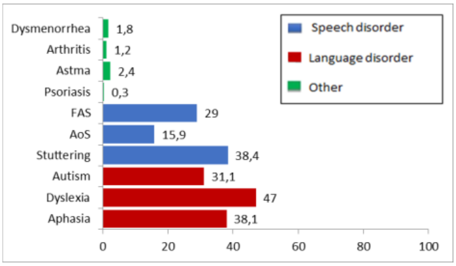
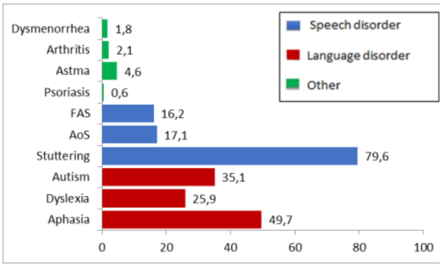


Figure 2: Have you seen, heard, or read about speech and language disorders?

Significant differences between speech disorders and language disorders were further attested when the participants were asked to name and classify specific syndromes (or descriptions of symptoms). Whereas 10.1% of the respondents (n =33) declared themselves unable to name any specific speech disorder, the percentage rose to 40.5% (n = 133) in the case of language disorders (Z = -8.639, $p < .001$). For those who completed the task, stuttering stood out as the most widely mentioned speech disorder (63.7% of the responses, n = 209), followed by speech sound disorders (18%, n = 59). However, language disorders such as aphasia were also frequently incorrectly identified as speech disorders (11.6%, n = 38). This indicates that the distinction between speech and language deficits is unclear to a significant subset of the population even when they declare themselves familiar with these deficits. Variability in the responses was also observed for language disorders, with aphasia as the most widely recalled disorder within this group (27.4% responses, n = 90), followed by dyslexia (15.9%, n = 52). Stuttering was the most frequently misidentified disorder included in the language group (2.1%, n = 7). The complete list of responses is included in Appendix 2.

Contrary to the previous question, Figures 3 and 4 illustrate the percentage of responses when respondents are confronted with a closed list of disorders. Although respondents correctly classify aphasia and foreign accent syndrome (FAS) as a language and a speech disorder, respectively, more often than not (Aphasia Z = -3.167, $p = .002$; FAS Z = -4.041, $p < .001$), the opposite pattern is observed for dyslexia, often incorrectly considered a speech disorder (Z = -5.129, $p < .001$), and for stuttering, incorrectly identified as a language disorder (Z = -8.421, $p < .001$) in contradiction with the responses to the previous question.



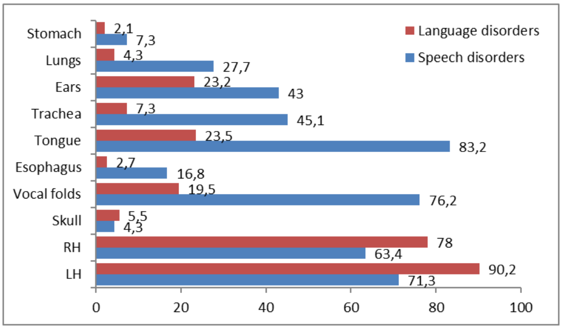


FAS: foreign accent syndrome, AoS: apraxia of speech

Figure 3: Selection of speech disorders. Figure 4: Selection of language disorders.

Inconsistencies were also found when identification results were correlated with familiarity. Individuals who declared themselves familiarized with language disorders were better at identifying aphasia, dyslexia, and autism as syndromes belonging to the group of language deficits and at identifying stuttering as a speech disorder. However, although weak, unexpected positive correlations were also found for apraxia of speech (AoS) and its incorrect classification as a language disorder ($r_s(328) = .275$, $p < .001$) and aphasia as a speech disorder ($r_s(328) = .225$, $p < .001$). Familiarity with speech disorders did not guarantee the correct categorization of syndromes. On the contrary, the only correlation found was an unexpected weak negative correlation for FAS and its correct classification as a speech disorder ($r_s(328) = -.141$, $p = .011$). Statistical results are summarized in Appendix 3.

Regarding knowledge about the physical substratum involved in communication disorders, participants were asked to select as many correct responses as relevant from a list of 10 body parts (see Figure 5). Significant differences were found in the number of affirmative responses across different anatomical structures in the case of speech disorders ($\chi^2(9) = 1070.137$, $p < .001$) and in the case of language disorders ($\chi^2(9) = 1637.202$, $p < .001$). The vocal folds and the tongue were the most frequently selected responses in the category of speech disorders (76.2% and 83.2%, respectively). The left and the right hemisphere were the most common responses in the category of language disorders (90.2% and 78%, respectively).



RH: Right hemisphere, LH: Left hemisphere

Figure 5: Physical substratum of speech and language

Additionally, the left and the right hemisphere were considered to be involved in language production significantly more often than in speech production (see Table 1), whereas the vocal folds, the esophagus, the tongue, the trachea, the ears, the lungs, and the stomach were claimed to participate in speech production significantly more often than in language production. Nevertheless, more than 20% of the respondents identified structures such as the ears or the tongue as involved in language production.

Structure	*Wilcoxon signed-rank test*
Left hemisphere	Z = -6.765, p < .001
Right hemisphere	Z = -5.737, p < .001
Vocal folds	Z = -13.286, p < .001
Oesophagus	Z = -6.147, p < .001
Tongue	Z = -13.723, p < .001
Trachea	Z = -10.960, p < .001
Ears	Z = -6.369, p < .001
Lungs	Z = -8.663, p < .001
Stomach	Z = -3.545, p < .001

Table 1: Physical substratum – Speech vs. language production

Weak correlations were found between self-reported familiarity with language disorders and the correct identification of the supporting anatomy. Informants who were familiarized with this group of disorders were aware of the relationship between the respiratory, phonatory, and articulatory systems and speech production. Specific results are summarized in Table 2.

Structure & Participation	*Spearman's correlations*
RH: speech	$r_s(328) = -.147$, $p = .007$
Vocal folds: speech	$r_s(328) = .131$, $p = .018$
Oesophagus: speech	$r_s(328) = .139$, $p = .012$
Tongue: speech	$r_s(328) = .125$, $p = .024$
Trachea: speech	$r_s(328) = .149$, $p = .007$
Ears: speech	$r_s(328) = .144$, $p = .009$
Lungs: speech	$r_s(328) = .288$, $p < .001$
Vocal folds: language	$r_s(328) = -.148$, $p = .007$
Tongue: language	$r_s(328) = -.117$, $p = .033$

RH: right hemisphere

Table 2: Correlation between familiarity with language deficits and correct identification of physical substratum

3.2. Block II: Specific language disorders (Appendix 1.D)

Block II focuses on language disorders alone and further explores the relationship between awareness and working knowledge of three specific conditions: two primary language disorders (aphasia and dyslexia), and one secondary language disorder (language deficits in Alzheimer's disease). We analyzed answers to all 7 questions in block II (4 yes/no questions and 3 multiple choice questions). Informants were asked about their degree of familiarity with these specific disorders and requested to select their possible etiology out of a list of 7 potential causes: no obvious reason, genetic factors, stroke, degenerative processes, psychological factors, traumatic brain injury, and/or developmental disorders. Significant differences were found as for the number of respondents who declared to have heard about the 3 conditions ($\chi^2(2) = 148.788$, $p < .001$).

Alzheimer's disease (AD) was the most commonly identified disorder. 99.4% (n = 326) of the informants declared having heard about it. Among the causes, 89.6% (n = 294) of the respondents selected degenerative factors and genetic factors (63.7%; n = 209) as the potential causes of AD (see Figure 6). Participants were also asked about the possibility of dementia affecting language. The vast majority of the respondents (90.9%, n = 298) replied positively. A total of 84.8% (n = 278) participants also reported having heard about dyslexia and pointed towards genetic (58.8%, n = 193) and developmental factors (49.4%, n = 162) as the most common causes. Only 64% (n = 210) of the informants had heard about aphasia. Strokes and TBIs were correctly identified as the most plausible etiologies by the majority of the informants who had heard about it (stroke: 58.2%, n = 191; TBI: 56.1%, n = 184).

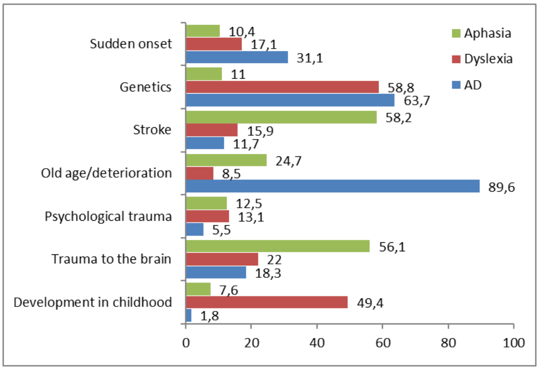


Figure 6: Etiology of aphasia, dyslexia, and AD

Reported familiarity with language disorders moderately correlates with positive identification of stroke and TBI as the most common causes of aphasia., There is also a correlation, although weak, between familiarity and correct identification of developmental disorders and genetic factors as the causes of dyslexia. AD was identified across the board independently of whether the informants were familiar with it or not. There are also weak correlations among awareness and knowledge across language disorders. Participants who claimed having heard about aphasia were found to be well informed about dyslexia and its main causes (developmental and genetic disorders). Likewise, participants who reported having heard about dyslexia were likely to be familiar with aphasia and its etiology. Interestingly, no correlations were found in the case of AD. Awareness seems to be only superficial and detached from knowledge of communication disorders in general. Significant results are summarized in Appendix 4.

3.3. Block III: Psychosocial aspects associated with speech and language disorders (Appendix 1.E)

The results of 4 out of the 6 questions in block III, including 2 yes/no questions and 2 multiple choice questions, show that speech and language disorders are perceived to have a major impact on quality of life (QoL). Overall, 78.4% (n = 257) of the informants reported a severe degree of loss of QoL in the event of both speech and language disorders (moderate impact: 19.2%, n = 63; mild impact: 2.4%, n = 8). Female participants were more likely to acknowledge a severe loss of quality of life ($r_s(328) = .115$, $p = .037$). Awareness of the impact of speech and language disorders on QoL was also found to weakly correlate with specific knowledge about aphasia and AD. As expected, participants who had heard about these language disorders were more likely to acknowledge their devastating impact (aphasia: $r_s(328) = .182$, $p = .001$; AD: $r_s(328) = .164$, $p = .003$).

Although people with speech and language disorders are still perceived as socially stigmatized (yes: 79.9%, n = 262; no: 5.5%, n = 18; DK: 14.6%, n = 48), most respondents differentiate these disorders from a decrease in intelligence quotient (IQ). Overall, 81.1% (n = 266) disagree or strongly disagree when asked if people with communication deficits have lower intelligence, and an additional 8.2% (n = 27) partially disagree with this statement. Only 3% of the participants (n = 10) declared to agree or strongly agree. Education was again found to have an effect. A weak negative correlation was found between stigmatization and education ($r_s(328) = -.207$, $p < .001$), with participants with higher education more susceptible to react against stigmatization. This is extremely important given that 91.8% (n = 301) of the participants declared that factors such as fear and anger can worsen the symptoms in the event of speech and language disorders and that only 3% (n = 10) saw these factors as immaterial.

3.4. Block IV: Speech and language therapy (Appendix 1.F)

The questions in block IV aim at capturing the perceived importance and the knowledge of the different linguistic and psychosocial factors susceptible to being treated in the event of speech and language disorders. Out of the 7 questions included in this block, only 6 (3 yes/no and 3 multiple choice questions) were analyzed. The results show that informants know that various aspects of language and/or speech may be impaired (together or in isolation): articulation (94.8%, n = 311), intonation (86.3%, n = 283), vocabulary (87.8%, n = 288), grammar (84.1%, n = 276), reading (86.3%, n = 283), and writing (82.6%, n = 271). People with knowledge of language disorders differ from people who are only aware of speech disorders with respect to their knowledge about the linguistic aspects that may be compromised, with the former being the better informed group. Moreover, participants who are more aware of the aspects of language that can be impaired are also more aware of the impact of language disorders on QoL. One exception seems to be vocabulary loss; this was acknowledged by all respondents. The results of Spearman’s tests are summarized in Appendix 5.

Regarding speech and language therapy, participants were inquired as to the importance of the treatment of physical and psychological factors. Treatment of physical factors is only reported to be very important by 42.4% (n = 139) of the respondents and moderately important by 33.8% (n = 80). This stands in opposition to the treatment of psychological or emotional factors (very important: 64.3%, n = 211, moderately important: 25%, n = 39) (see Figure 7). The comparison yielded significant differences in the distribution of responses across factors, with psychological factors taken to be of crucial importance in the therapeutic approach to communication deficits (Z = -3.051, p = .002).

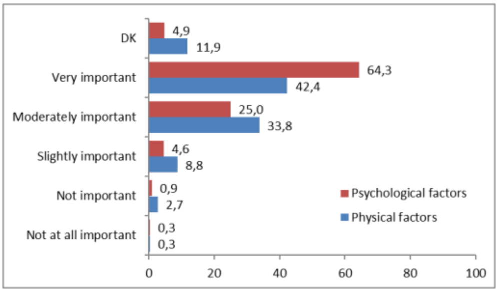


Figure 7: Importance of treatment of physical and emotional factors

A weak correlation was also found between emotional factors and gender. Female participants were more likely to acknowledge the importance of emotional factors ($r_s(328) = .123$, p = .025). Emotional factors were also found to correlate with decreased QoL. Informants who acknowledged a decrease in QoL tended to highlight the importance of addressing emotional factors ($r_s(328) = .189$, p = .001). No differences were found for physical factors and gender or quality of life; however, there is a weak negative effect with respect to education, the lower the educational level, the higher the weight given to physical factors ($r_s(328) = -.125$, p = .024).

It is noteworthy that 80.5% of the informants (n = 264) believe that speech and language therapy may not be beneficial. Interestingly, participants who reported that speech and language disorders do not affect articulation, intonation, grammar, vocabulary, reading, and writing significantly were more likely to accept the curability of these disorders ($r_s(328) =.112$, p = .042). Additionally, most of the participants (85.7%, n = 281) were unaware of the divergence in the potential benefits of rehabilitation across different speech and language disorders.

Finally, 97.6% (n = 320) of the respondents agree that there is a need for an increase of awareness, especially those who acknowledge the impact of speech and language disorders on QoL and on linguistic processes such as articulation, grammar, vocabulary, and reading (see Appendix 6 for a summary of the statistical results).

4. Discussion

This article had a double aim: a) to assess general public knowledge of different speech and language disorders in the search for a potential increase in awareness and knowledge of speech and language disorders, and b) to identify key predictors of both aspects. However, the study presents limitations associated with the lack of balance across groups of respondents. This is attributable to the sampling method (snowball sampling) and the requirements to complete the questionnaire, which included access to a computer with internet connection and working knowledge of English or Danish. Given that the vast majority of participants fall into the category of European young adults (20 to 39 years old), our results are not generalizable to other age groups or geographical areas, an issue to be addressed by future studies.

Overall, the results of our questionnaire further support previous studies showing that despite international efforts, awareness and degree of knowledge levels are still low among the general public (11% of the respondents reported not being at all familiar with speech disorders, and 33.5% were not at all familiar with language disorders). More importantly, similar to the results of Code et al. (2016), Hill et al. (2019), and Code (2020) for aphasia, our results fail to show a consistent correlation between awareness and knowledge, as clearly illustrated by the results for AD.

Despite the limitations, the results also confirm the influence of education (Breadner et al., 1987; Van Borsel et al., 1999; Xing Ming et al., 2001; de Britto Pereira et al., 2008; Mahmoud et al., 2014; Iimura et al., 2018). Educational level has been found to correlate with a higher degree of familiarity with speech (although not language) disorders and with more access to audiovisual and written information. Very importantly, although most informants told apart speech and language disorders from general intelligence deficits, educational level was also found to correlate with decreased stigmatization.

In line with Truelsen and Krarup (2010), speech disorders, especially stuttering and speech sound disorders, are generally more known to the public than language disorders. Moreover, those familiarized with language disorders tend to be better informed, as indicated by the results of the identification of syndromes and the physical substratum responsible for speech and language. However, even individuals who declared themselves familiar with speech and language disorders have problems distinguishing both groups. Among language disorders, aphasia and dyslexia are the most widely recognized syndromes.

Psychosocial factors involved in speech and language disorders are attributed a major role in QoL and the potential for recovery. Increased awareness, including deeper knowledge of symptoms and treatment programs, is seen as critical for the amelioration of the patients' situation and for access to the appropriate therapeutic intervention (in line with Truelsen & Krarup, 2010). Psychosocial factors are especially acknowledged by female respondents, who showed increased awareness of the loss of QoL and the weight of emotional factors associated with speech and language deficits compared to their male counterparts. However, contrary to other studies (e.g., Breadner et al. 1987; Truelsen & Krarup, 2010; Code et al., 2016), gender differences were restricted to these factors.

Our findings emphasize the need for raising awareness and sharing knowledge about speech and language disorders. Especially alarming is the common belief that speech and language therapy may not have beneficial effects on the recovery from speech and language disorders. Although general awareness is increasing, the results cast doubt on the permeability of the dissemination campaigns across different sectors of the population, especially among those with lower educational levels, and their contribution to the increase of actual knowledge. When seeking for potential causes of the reduced access to relevant information, lack of terminological consensus has been taken as a possible source of confound (Kahmi, 2004; Bishop, 2014). Different classification systems, such as the International Classification of Disorders (ICD-10; World Health Organization, 2004) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), attempt to capture all this variability and account for all speech and language disorders in an orderly manner. However, the content of these (and similar) highly specialized manuals is inaccessible to the general public, which could explain the consistent relationship found across high levels of education and awareness rates.

Declaration of interest statement

The authors report no potential conflict of interest.

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Appendix 1: Awareness questionnaire

Nº of Participants: 328 – Total Nº of Questions: 42

A. Background (Nº of questions: 5)

Gender	%	Total
Female	76.8%	252
Male	22.6%	74
Not Specified	0.6%	2
Age	%	Total
<20	0.3%	1
20-29	72.0%	236
30-39	17.1%	56
40-49	3.7%	12
50-59	3.0%	10
60-69	1.8%	6
70-79	1.5%	5
>80	0.6%	2
Education	%	Total
University	56.7%	186
Secondary studies	19.2%	63
Primary studies	24.1%	79
Professional background	%	Total
Students	59.8%	196
Employees	32.9%	108
Unemployed	5.5%	18
Retired	1.8%	6
Nationality	%	Total
Europe	88.7%	291
America	7.3%	24
Asia	3.4%	11
Africa	0.3%	1
Oceania	0.3%	1

B. Experience with speech & language disorders (Nº of questions: 4)

Do you have any speech and/or language disorder? If yes, which one?	Yes: 4.6% (n = 15)
Speech disorders	Speech sound disorders (n = 5) Stuttering (n = 4)
Language disorders	Dyslexia (n = 3) Autism (n = 1) Aphasia (n = 1)
Don't know responses	1 response
Do you know anybody with a speech and/or language disorder? If yes, which one(s)?	Yes: 53.7% (n = 176)
Speech disorders	Stuttering (n = 104) Speech sound disorders (n = 14) AoS (n = 3) Dysarthria (n = 2) Speech motor problems (n = 2) FAS (n = 2) Tourette syndrome (n = 1) Mutism (n = 1) Parkinson (n = 1) Dysrhythmia (n = 1)
Language disorders	Dyslexia (n = 41) Aphasia (n = 20) Autism, Down, Asperger (n = 9) Cerebral palsy (n = 3) Language delay (n = 2) Alzheimer disease (n = 1)
Other	Underspecified speech & language disorders (n = 3) Asthma (n = 2)

*AoA = Apraxia of Speech; FAS = Foreign accent syndrome

C. Speech disorders vs. Language disorders (Nº of questions: 13)

1. How familiar are you with speech disorders?

a. Not familiar b. Slightly familiar c. Somewhat familiar
d. Moderately familiar e. Very familiar

2. Have you seen, heard, or read about speech disorders?

a. Yes, I have seen or heard about it (Tv, Radio, Talk)
b. Yes, I have read about it (Journal article, Book, Brochure)
c. Both of the above d. None

3. How familiar are you with language disorders?

a. Not familiar b. Slightly familiar c. Somewhat familiar
d. Moderately familiar e. Very familiar

Have you seen, heard or read about speech disorders?

a. Yes, I have seen or heard about it (Tv, Radio, Talk)
b. Yes, I have read about it (Journal article, Book, Brochure)
c. Both of the above d. None

Can you give an example(s) of speech disorders?

4. Which of the following would you classify as a speech disorder(s) or as conditions that can cause speech disorders? (Check all relevant boxes)

a. Stuttering b. Aphasia c. Autism d. Arthritis
e. Apraxia d. Psoriasis e. Asthma f. FAS
g. Dysmenorrhea h. Dyslexia

Can you give an example(s) of language disorders?

5. Which of the following would you classify as a language disorder(s) or as conditions that can cause language disorders? (Check all relevant boxes)

a. Stuttering b. Aphasia c. Autism d. Arthritis
e. Apraxia d. Psoriasis e. Asthma f. FAS
g. Dysmenorrhea h. Dyslexia

6. Which population group(s) can suffer from speech disorders? (Check all relevant boxes)

a. Children (-13) b. Teenagers (14-19) c. Young adults (20-39)
d. Mature adults (40-59) e. Elderly (60+)

7. Which of the following organs/part of organs do you think are involved in speech disorders? (Check all relevant boxes)

a. Lungs b. Right side of the brain c. Skull d. Vocal folds
e. Esophagus f. Stomach g. Left side of the brain
h. Ears i. Tongue j. Trachea

8. Which population group(s) can suffer from language disorders? (Check all relevant boxes)

a. Children (-13) b. Teenagers (14-19) c. Young adults (20-39)
d. Mature adults (40-59) e. Elderly (60+)

9. Which of the following organs/part of organs do you think are involved in language disorders? (Check all relevant boxes)

a. Lungs	b. Right side of the brain	c. Skull	d. Vocal folds
e. Esophagus	f. Stomach	g. Left side of the brain	
h. Ears	i. Tongue	j. Trachea	

10. Do you think it is possible to suffer from more than one speech and/or language disturbance?

a. Yes	b. No

D. Specific language disorders (Nº of questions 7)

1. Have you heard about aphasia?

a. Yes b. No

2. If yes, what do you think may cause aphasia? (Check all relevant boxes)

a. Development in childhood b. Trauma to the brain c. Psychological trauma
d. Old age/deterioration e. Stroke f. Genetics
g. Sudden onset with no apparent reason

3. Have you heard about dyslexia?

a. Yes b. No

4. If yes, what do you think may cause dyslexia? (Check all relevant boxes)

a. Development in childhood b. Trauma to the brain c. Psychological trauma
d. Old age/deterioration e. Stroke f. Genetics
g. Sudden onset with no apparent reason

5. Have you heard of Alzheimer's disease?

a. Yes b. No

6. If yes, what do you think may cause Alzheimer's disease? (Check all relevant boxes)

a. Development in childhood b. Trauma to the brain c. Psychological trauma
d. Old age/deterioration e. Stroke f. Genetics
g. Sudden onset with no apparent reason

7. Do you think dementia can affect language?

a. Yes b. No c. I don't know

E. Psychosocial factors (Nº of questions: 6)

1. Do you think speech and language disorders can affect quality of life?

a. Severely b. Moderately c. Mildly d. Not at all

2. What do you think would affect the quality of life the most for a person having a disorder?

a. Not being able to produce language (sufficiently)
b. Not being able to understand language (sufficiently)
c. Both of the above d. I don't know

3. What do you think can be difficult for people with speech and language disorders?

a. Keeping a job b. Formal presentations c. Social life
d. Being taken seriously in a conversation e. Using public transport
f. Going to school g. Finding a place to live h. Shopping

4. Do you think people with speech and language disorders are socially stigmatized?

a. Yes b. No c. I don't know

5. To what extent do you agree with the following statement: People with speech and language disorders have lower intelligence?

a. I completely agree b. I agree c. I partially agree
d. I neither agree nor disagree e. I partially disagree f. I disagree
g. I completely disagree

6. Do you think factors like fear and anger can affect language?

a. Yes b. No c. I don't know

F. Speech and language therapy (Nº of questions: 7).

1. Do you think all speech and language disorders are curable?

a. Yes b. No

2. Which of the following do you think can be affected by speech and language disorders? (Check all relevant boxes)

a. Articulation b. Reading c. Vocabulary d. Grammar
e. Intonation f. Writing g. All of the above h. None of the above

3. How important is it to take physical factors into consideration in speech and language treatment?

a. Very important b. Moderately important c. Slightly important
d. Not really important e. Not at all important f. I don't know

4. How important is it to take psychological factors into consideration in speech and language treatment?

a. Very important b. Moderately important c. Slightly important
d. Not really important e. Not at all important f. I don't know

5. Do you think that everyone benefits equally from treatment of speech and language disorders?

a. Yes b. No

6. Do you think that awareness about speech and language disorders can improve the situation for people suffering these disorders?

a. Yes b. No

7. Where would you seek help in the event of a speech or language disorder?

Appendix 2: Speech and Language disorders

Table 1. Open questions C.5 & C.7: Can you give an example(s) of speech/language disorders?

	Speech disorders	*Language disorders*
Stuttering	63.7%	2.1%
Sp. sound disorders	18%	1.8%
Dysarthria	3.4%	0.3%
AoS	3.4%	0.3%
Cluttering	1.5%	0%
Tics & Tourette	1.5%	0.3%
Other sp. disorders	3.7%	0%
Aphasia	11.6%	27.4%
Anomia	0.9%	1.5%
Dyslexia	0.6%	15.9%
SLI	0.3%	3.4%
Delayed lge. develop.	0%	0.9%
Autism	0%	1.8%
Other lge. disorders	0%	5.2%

Sp.: speech, Lge.: language, AoS: Apraxia of Speech, SLI: Specific language impairment.

Appendix 3: Familiarity & Categorization

Table 2. Correlation between familiarity with speech and language disorders and correct categorization of given syndromes

Familiarity	Syndrome & Categorization	Spearman's correlations
Speech disorders	FAS: speech	$r_s(328) = -.141$, $p = .011$
Language disorders	Aphasia: lge.	$r_s(328) = .344$, $p < .001$
	Dyslexia: lge.	$r_s(328) = .275$, $p < .001$
	Autism: lge.	$r_s(328) = .115$, $p = .038$
	Stuttering: lge.	$r_s(328) = -.324$, $p < .001$
	AoS: lge.	$r_s(328) = .275$, $p < .001$
	Aphasia: speech	$r_s(328) = .225$, $p < .001$
	Stuttering: speech	$r_s(328) = .212$, p < .001

FAS: Foreign Accent Syndrome; AoS: Apraxia of Speech

Appendix 4: Familiarity with & Knowledge of language disorders and their causes

Table 3: Correlation between familiarity with language deficits and correct identification of deficits and potential causes

Disorder	*Disorder/Cause*	*Spearman's correlations*
Aphasia	Aphasia after stroke	$r_s(328) = .401$, $p < .001$
	Aphasia after TBI	$r_s(328) = .419$, $p < .001$
	Dyslexia	$r_s(328) = .230$, $p < .001$
	Dyslexia after developmental disorders	$r_s(328) = .212$, $p < .001$
	Dyslexia after genetic factors	$r_s(328) = .232$, $p < .001$
Dyslexia	Dyslexia after developmental disorders	$r_s(328) = .170$, $p = .002$
	Dyslexia after genetic factors	$r_s(328) = .184$, $p = .001$
	Aphasia after stroke	$r_s(328) = .208$, $p < .001$
	Aphasia after TBI	$r_s(328) = .274$, $p < .001$

Appendix 5: Familiarity, QoL & Linguistic disruptions

Table 4: Correlation between familiarity with language disorders and QoL and correct identification of linguistic aspects susceptible to impairment.

	Linguistic Aspects	*Spearman's correlations*
Familiarity with language disorders	Articulation	$r_s(328) = .145$, $p = .009$
	Intonation	$r_s(328) = .189$, $p = .001$
	Grammar	$r_s(328) = .249$, $p < .001$
	Vocabulary	$r_s(328) = .266$, $p < .001$
	Reading	$r_s(328) = .150$, $p = .006$
	Writing	$r_s(328) = .206$, $p < .001$
Decreased quality of life	Articulation	$r_s(328) = .217$, $p < .001$
	Intonation	$r_s(328) = .224$, $p < .001$
	Grammar	$r_s(328) = .165$, $p = .003$
	Reading	$r_s(328) = .186$, $p = .001$
	Writing	$r_s(328) = .218$, $p < .001$

Appendix 6: Increased Awareness and knowledge

Table 5: Correlation between need for increased awareness and knowledge of consequence of speech and language disorders

	Affected level	*Spearman's correlations*
Increased Awareness	QoL	$r_s(328) = .161$, $p = .003$
	Articulation	$r_s(328) = .141$, $p = .010$
	Grammar	$r_s(328) = .148$, $p = .007$
	Vocabulary	$r_s(328) = .183$, $p = .001$
	Reading	$r_s(328) = .109$, $p = .048$

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PREDICTIVE LANGUAGE PROCESSING OF CHILDREN WITH AUTISM SPECTRUM DISORDER AND CHILDREN WITH DEVELOPMENTAL LANGUAGE DISORDER

Abstract: Predictive language processing is a crucial ability that contributes to the real-time sentence comprehension and concerns the ability of the interlocutor to predict the upcoming word based on the semantical characteristics of the utterance. Especially, it concerns the ability of using verb information to predict the following words, while the interlocutors do not wait to hear the whole utterance in order to understand its meaning. Predictive language processing is associated with lexical development and enhances the individuals to conduct a conversation. Children with Autism Spectrum Disorder and children with Developmental Language Disorder have a delay in language development and their oral communication abilities are poor. The purpose of this paper was to critically review empirical literature on predictive language processing in children with Autism Spectrum Disorder (ASD) in comparison with children with Developmental Language Disorder (DLD). Eight studies that met the established inclusion criteria were identified and reviewed. The findings of the present paper pin down the similarities and the differences between children with ASD and children with DLD in predictive language processing. Children with DLD performed worse on predictive language processing tasks than children with ASD. The weaker performance of children with DLD in comparison to children with ASD is likely to be due to their syntactic and semantic deficits. The knowledge of how children of both groups process language stimuli benefits the scientific and educational communities.

Key words: Predictive Language Processing, Developmental Language Disorder, Autism Spectrum Disorder, conversational skills

1. Introduction

Language processing is complex, given that a discussion an individual has to combine conceptual and linguistic information while integrating his/her general knowledge into a specific situation (Andreu, Sanz-Torrent & Rodríguez-Ferreiro, 2016). Accordingly, sentence comprehension is based on the ability to rapidly integrate different types of linguistic and non-linguistic stimuli (Zhou et al., 2018).

Nevertheless, the language processing of capable speakers is fast and efficient, as they are able to “think ahead”, generating assumptions regarding likely upcoming linguistic stimuli and process them (Federmeier, 2007), on account of predictive language processing, that is the ability of speakers to predict the upcoming input (Huettig & Janse, 2016). More specifically, speakers can anticipate the upcoming words of a sentence based on the semantic characteristics of the utterance or on the contextual constraints. Speakers do not wait to hear the whole phrase in order to understand its meaning, but they are able to predict the following words based on the characteristics of previous words (Pickering & Garrod, 2013; Verhagen et al., 2018). For example, the interlocutors can predict that the following noun will concern a vehicle, upon hearing the phrase “I drive ...”. Previous studies have found that children are able to generate predictions about the upcoming words by the age of 2 (Borovsky, Elman & Fernald, 2012; Mani & Hueting, 2012), utilizing the semantic features of verbs and thus their language development is gradually enhanced (McGregor et al., 2013; Vulchanova et al., 2019).

The ability for predictive language processing is related with conversational skills and contributes to the comprehension of sentences and to the accurate conduct of a discussion without much effort on the part of the individual (Curcic, Andringa & Kuiken, 2019; Verhagen et al., 2018). Therefore, it seems that predictive language processing is a crucial component of language comprehension and especially in understanding sentences in real time (Brothers, Swaab & Traxler, 2017).

Language skills affect predictive language processing and consequently the daily communication of individuals. Production skills (Mani & Hueting, 2012) and vocabulary knowledge (Andreu, Sanz-Torrent, & Trueswell, 2012; Borovsky et al., 2012; Crandall et al., 2019) play an important role in successful predictive language processing. A high level of vocabulary and especially verb knowledge provides both semantic and syntactic information, as verbs contribute to the relation between events and objects and therefore verb knowledge is crucial for the formation of sentences (Crandall et al., 2019). More specifically, low explicit producers may be impaired in generating thematic arguments to semantically constraining verbs in order to conduct predictions (Mani & Hueting 2012). The semantics of a word constrains what listeners expect and can lead them to process the sentence quickly by making a correct prediction during a conversation. Verbs contain lexical biases that are strong constraints on the categories of the words that complement them, as well as on the semantics, since the arguments of each verb must satisfy certain features (Andreu et al., 2016). However, some verbs do not provide any clues to identify the object. For example, the verb 'eat' is characterized as a biasing verb as it suggests to the listener that the word that follows will be something edible. On the other hand, the verbs 'move' and 'see' are characterized as neutral verbs, as these verbs do not contain any biasing constraints (Bavin et al., 2015).

While predictive language processing is associated with language development, the ability for predictive language processing in children diagnosed with disorders that cause language deficits, such as DLD and ASD, is an interesting issue. A comparison between the language development of these populations may be needed, as a lot of similarities are observed on their linguistic profile concerning deficits in phonology, vocabulary, semantics and morphosyntax (Kjelgaard & Tager-Flusberg, 2001; Ramírez-Santana et al., 2019), as well as in pragmatic language (Osman et al., 2011; Simmons et al., 2014). These similarities led to the hypothesis that the two disorders might be related and share a common etiology (Bishop, 2010; Norbury & Bishop, 2003) or that DLD may be co-morbid with a subgroup of ASD (Roberts, Rice & Tager-Flusberg, 2004). In addition, studies in ASD children in comparison to DLD children support the assumption of a common phenotype between the two disorders (McGregor et al., 2012). However, other studies show qualitative differences in language development in both structural language skills and communicative language between children with ASD and children with DLD (Geurts & Embrechts, 2008; Loucas et al., 2008).

DLD and ASD are two disorders that have a significant impact on all domains of language development (Williams, Botting & Boucher, 2008) although the current study focuses on the deficits children with DLD and children with ASD exhibit in their oral production and their spoken sentence comprehension. Real-time sentence comprehension is an under-investigated area of language comprehension in children with ASD and DLD. In addition, although the ability to produce predictions during online conversation is a crucial ability for the social life of individuals with ASD and DLD, there is very little research regarding predictive language processing in these two populations, while there is no research comparing DLD and ASD in this domain. The present review aims to fill this gap by comparing the predictive language processing of these populations, more specifically, by critically reviewing empirical literature on predictive language processing in children with Autism Spectrum Disorder (ASD) and children with Developmental Language Disorder (DLD) and comparing their competence. Given that both populations have language and social difficulties, the study of predictive language processing would provide crucial information for the language processing and the conversational skills of the two disorders that could be used to create interventions in order to improve their conversational skills.

1.2 Language in Developmental Language Disorder

Developmental Language Disorder (DLD) is a neurodevelopmental language disorder (Sengottuvel & Rao, 2015) that causes a severe language deficit in the absence of a clear biological or neurological cause (Bishop et al., 2016). In the past, the term Specific Language Impairment (SLI) was mainly used. However, in recent research this term was replaced by the term Developmental Language Disorder, which is more inclusive than the previous term (Bishop et al., 2016).

Children with DLD face a whole range of difficulties in language development, as they present considerable heterogeneity of their strengths and difficulties in language (Bishop et al., 2016; Ryder, Leinonen & Schulz, 2008).

They present deficits in syntax, as they struggle to understand and produce syntactically complex sentences (Loucas et al., 2008; McGregor et al., 2012). The syntactic awareness of children with DLD is often weak resulting in difficulties in anticipatory processing. Furthermore, they use relatively immature processing strategies to enhance sentence comprehension (Jones & Westermann, 2021). These strategies are successfully used by younger typically developing children in understanding simple sentences, but are inadequate in understanding long and complex sentences (Ndiaye & Camaco, 2021). In addition, they present a delay in making sentence grammaticality decisions and identifying the target terms during sentence processing (Ndiaye & Camaco, 2021).

Morphology is also impaired in children with DLD as they exhibit deficits mainly in inflectional morphology (Leonard, 1998) and in passive voice (Jones & Westermann, 2021). They often incorrectly produce or completely omit the tense and agreement (T/A) morphemes (Deevy & Leonard, 2018). There is also a delayed vocabulary development, as they face deficits in encoding verb semantic representations, in verb learning and in argument structure. More specifically, they produce fewer argument types, argument structure types and verb alternation than their TD peers, while omissions of obligatory arguments are also observed in their language production (Andreu et al., 2012). Moreover, they show a delay in understanding and using verbs and functional morphology (Leonard et al., 1997), while they are able to learn nouns more easily than verbs (Alt, Plante, & Creusere, 2004).

Impairments in non-word repetition (Lalioti et al., 2016) and in verbal short-term memory (Girbau & Schwartz, 2007) are also observed in individuals with DLD. This population also experiences difficulties in working memory and in processing speed or processing capacity (Jones & Westermann, 2021). More specifically, children with DLD present a reduced ability to produce knowledge and to process information rapidly (Leonard, 1998) and when sentences are of high linguistic complexity, children with DLD face difficulty in processing them (Leonard, 1998).

Successful sentence processing is affected by these impairments and as a result the oral production of individuals with DLD is impaired. More specifically, children with DLD have poor conversational skills and they present deficits in initiating speech (Osman et al., 2011). Furthermore, they present difficulties in finding the key point in a conversation, while simultaneously they are weaker than their TD peers in using verbal context and contextual information in order to understand an utterance (Osman et al., 2011; Ryder & Leinonen, 2014). Moreover, as the speed and/or the capacity of cognitive processing of children with DLD is poor, in listening tasks, they face difficulties in making grammaticality judgements and in recognizing the key words of the sentence (Jones & Westermann, 2021).

1.3 Language in Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by deficits in communication and social interaction, and restricted and repetitive patterns of behavior (American Psychiatric Association, 2013). The symptoms and the severity vary among children with ASD depending on their age and the pace of their development (Tager-Flusberg, Paul & Lord, 2005; Williams et al., 2008).

Children with ASD present a delay in their language development, and they have difficulty in communicating, even though they want to communicate with the people around them (Baixauli-Fortea et al., 2019), as they present deficits in understanding speech during everyday conversations, while they also have difficulty in expressive speech (Tager-Flusberg et al., 2005). Children with ASD often use stereotyped language and exhibit deficits in nonverbal communication (Baixauli-Fortea et al., 2019).

It is worth mentioning that word comprehension is more delayed than production. Although many children with ASD acquire a rich vocabulary, they are not able to properly use this knowledge to communicate, as they use words with too specific or abnormal meaning and they cannot understand and use metaphorical language (Tager-Flusberg et al., 2005).

Individuals with ASD also have difficulties in receptive language as they have impairments in language comprehension skills affecting sentence comprehension during real-time conversations. In terms of conversational skills, individuals with ASD are impaired in identifying the topic of the conversation their interlocutor started and in responding appropriately. Moreover, they are not able to find the cues of the conversation and to answer based on the knowledge of their interlocutor or based on what their interlocutor would expect in terms of the amount and the content of information they provide (Tager-Flusberg et al., 2005). In addition, Bavin et al. (2015) pointed out that children with ASD need more time than TD children to process language input. As a result, they miss information, as they delay to interpret the meanings of their interlocutor's utterances and their communication is prevented. Additionally, they rarely initiate communication and they use non-verbal elements of the language less often in comparison to their TD peers (Adams et al., 2012).

However, according to Venker et al. (2018), existing receptive language skills are related to predictive language processing in a semantically constrained context in children with ASD. More specifically, they are able to use verb information in order to understand a sentence when semantically restrictive verbs are used. In addition, they are able to process within-sentence information, as they do have the ability to use linguistic context in order to understand ambiguous words. Rabagliati et al. (2014) also pointed out that children with ASD, like their TD peers, use the context to resolve lexical ambiguities in a sentence. Studying the use of prosodic cues in real-time sentence comprehension in children with ASD, Diehl et al. (2015) found that children with ASD can resolve syntactic ambiguities using prosodic cues as well as their TD peers when they do not need to revise their initial interpretation. Similar findings were observed in the study of Hahn et al. (2015), who concluded that children with ASD are sensitive in context, like their TD peers.

2. Method

2.1. Systematic Review

For the present review, studies that met the following criteria were selected: (1) studies published in English in peer-reviewed journals, (2) studies that included children and adolescents who had either a diagnosis of Autism Spectrum Disorder or a diagnosis of Developmental Language Disorder, aged 2,5 to 17 years, (3) studies that examined predictive language processing and the use of context during online conversation, (4) studies in which children with either DLD or ASD were compared with children of typical development, in the absence of studies comparing this ability between the two clinical populations. Doctoral dissertations and theses were excluded from the review. Inclusion criteria are listed in Table 1, while Table 2 lists the studies included in this review.

INCLUSION CRITERIA		
	Criteria	
	Diagnosis	*Age*
Participants	Autism Spectrum Disorder Developmental Language Disorder Typical development (control group)	2,5-17 years
Evaluation	Predictive Language Processing	
Language of paper	English	
Publishing	Academic journals, excluding doctoral dissertations	
Published date	2008-2021	

Table 1. Inclusion criteria

SURVEYS INCLUDED					
Author	***Year***	***Participants***		***Language of participants***	***Method***
		Age	***Number and population***		
van Alphen, Brouwer, Davids, Dijkstra & Fikkert	2021	2;5-4;5	21 DLD 31 TD	Dutch	visual world paradigm
Deevy & Leonard	2018	3;3-5;11	15 DLD 15 TD	American English	looking-while-listening (LWL) paradigm
Andreu, Sanz-Torrent, & Trueswell	2013	3;3-8;2	25 DLD 50 TD	Spanish	visual world paradigm
Andreu, Sanz-Torrent & Rodríguez-Ferreiro	2016	3;3-8;2	25 DLD 50TD	Spanish	visual world paradigm
Bavin, Kidd, Prendergast & Baker	2016	5-9	47 ASD 56 TD	English	eye-tracking measure
Brennan, Lajiness-O'Neill, Bowyer, Kovelman & Hale	2019	8-12	16 ASD 16 TD	English	Magnetography (MEG)
Brock, Norbury, Einav & Nation	2008	12;5-17;5	24 ASD 24 TD	English	eye-tracking measure
Zhou, Zhan & Ma	2018	4-5	26 ASD 49 TD	Mandarin	visual world paradigm

Table 2. Studies included in the review

2.2 Purpose and search procedure

A total of 3 databases were searched: NCBI/PubMed, Researchgate and Google Scholar. In all databases, the following terms were inserted into the Keyword field: “Autism Spectrum Disorder AND predictive language processing”, “Autism Spectrum Disorder AND anticipatory language processing”, “Autism Spectrum Disorder AND anticipatory language comprehension” “Developmental Language Disorder AND predictive language processing", “Developmental Language Disorder AND anticipatory language processing”, “Developmental Language Disorder AND anticipatory language comprehension” “Specific Language Impairment AND predictive language processing", “Specific Language Impairment AND anticipatory language processing”. In the first place, studies were selected based on their title and then they were evaluated based on their abstract. All studies that mentioned the above keywords in the abstract, in the title or in the list of keywords were studied.

3. Review outcomes

Fourteen studies were initially selected to be included in the review. They were evaluated by the authors and finally 8 studies that met the established inclusion criteria were identified and reviewed.

As there are no studies comparing predictive language processing of children with DLD and children with ASD, the present review attempts to compare the two clinical populations based on the comparison made in the existing literature between children of typical development and children of each population separately.

3.1. Predictive language processing in DLD

Four studies that examined predictive language processing in children with DLD were included in the review (Andreu et al., 2013; Andreu et al., 2016; Deevy & Leonard, 2018; van Alphen et al., 2021).

Predictive language processing in children with DLD was investigated in all four studies using the eye-tracking method. The researchers designed eye-tracking experiments in which the participants listened to a phrase, while they were looking at an image depicting two or four objects, only one of which was correct. Predictive language processing was assessed by the eye-movements of the participants andby measuring the time they looked at the correct object (Andreu et al., 2013; Andreu et al., 2016; Deevy & Leonard, 2018; van Alphen et al., 2021).

Children with DLD exhibited weaker ability in sentence processing, as they made fewer predictions than their TD peers. More specifically, investigating the online word prediction of 3-year-old children with DLD as compared to children of typical development, van Alphen et al. (2021) found that the DLD group showed fewer anticipatory looks to the target noun than the TD children.

Similar findings are presented in the study of Deevy & Leonard (2018), who investigated whether children with DLD are sensitive to tense/agreement information on fronted auxiliaries during real-time comprehension of questions. They presented questions such as “Is this a nice little boy running?”, while two pictures were displayed on the screen; the target and a distractor. The target and the distractor featured the same action but different agents, always differing in number (plural, singular; e.g., one boy running, two dogs running). Their results revealed that children with DLD did not exhibit anticipatory looking based on the number information (plural, singular) contained in the fronted auxiliary, while TD children did. Children with DLD showed deficits in acquiring tense/agreement forms, but also in understanding the relation between subject-verb sequences and the information included in the questions.

The study of Andreu et al. (2013) included adults, 5-year-old children with DLD, and an age-matched and an MLU-matched control group. They conducted three eye-tracking experiments using sentences such as “The woman opens quickly the door” in the presence of four objects; the target-object (the door) and three distractors that were not related to the sentence (pencil, cat, elephant). The results showed that children with DLD were able to use the semantic information of the verbs in order to anticipate the following word. However, as in the previous studies, anticipatory looks to the target of children with DLD were significantly lower than those of age-matched TD children and adults, but quite similar to those of the MLU-matched group.

In contrast to the preceding studies, Andreu et al. (2016) found that children with DLD do have the ability to select the appropriate information from a verb in order to anticipate upcoming information, as they anticipated upcoming arguments and adjuncts rapidly, as did their TD peers. The researchers examined whether children with DLD use verbs to predict arguments (themes, goals, and instruments) and adjuncts (locatives). In their study, a group of adults and two control groups (age-matched and MLU-matched) were also recruited. They presented 24 sentences while four objects were displayed on the screen. For example, in order to examine the prediction of the theme argument, they included sentences such as “The girl slowly eats the cake with the spoon”, while four pictures were displayed (Target: cake; Competitor: spoon, Distractors: hat, dinosaur). To examine the prediction of source/goal they presented verbs of motion that require a a postverbal source or goal arguments of the event to be expressed. More specifically, they presented sentences such as “The man slowly enters the house with the suitcase” (T: house; C: suitcase; D: moon, tractor). For the prediction of the instrument argument, they included verbs of action that require an instrument (e.g., The woman skis down the mountain fast with the sled). Finally, in order to examine the locative, intransitive verbs and locatives (adjuncts) that had strong semantic relationships among each other were selected (e.g., The girl always sleeps in bed with a teddy bear). The sentences used in the study were simple and had canonical word order, as the main goal was to investigate whether children with DLD have poor verb semantic representations or not. Thus, the high performance of children with DLD in the task, in contrast to the previous studies, is likely to be due to the simple sentences the researchers used.

Regarding the time of looking, Andreu et al. (2013) observed that children with DLD showed a developmental delay regarding their eye movements, the proportion of which to target referents was lower than those of the age-matched group, but similar to those of the MLU-matched group. This finding is in line with the study of van Alphen et al. (2021), who also found that children with DLD were slower than the TD group in anticipating the target picture upon hearing the verb.

3.2. Predictive language processing in ASD

Predictive language processing in children with ASD was examined in four studies. Three of the studies used visual-world eye-tracking (Bavin et al., 2016; Brock et al., 2008; Zhou, Zhan & Ma, 2018) and one study collected MEG data (Brennan et al., 2019).

In contrast to children with DLD, who exhibited weak predictive language processing, children with ASD were found to have the ability to produce predictions, as their TD peers. More specifically, the study of Bavin et al. (2016) investigated the use of lexical and referential information of 5- to 9-year-old children with ASD during online sentence comprehension. The researchers used phrases that included bias and neutral verbs and expected and unexpected conditions. According to the results, similarities in sentence processing were observed between the two groups. However, children with ASD were slower than TD children. Both groups of children presented a higher proportion of looking at the target in the biasing verbs, than in neutral verbs. Therefore, children with ASD have the ability to use their linguistic knowledge to make correct predictions when a sentence contains highly constraining linguistic information (e.g., biasing verbs).

These findings are in line with the findings of Zhou et al. (2018), who found that 5-year-old Mandarin-speaking children with ASD exhibited similar performance to their TD peers, as the children with ASD used verb information in order to anticipate the upcoming linguistic input. In addition, all the participants exhibited a higher proportion of looking at the target, when hearing a ‘bias’ verb than when hearing a ‘neutral’ verb. However, a difference between children with ASD and their TD peers was observed in their eye gaze patterns, with the ASD group exhibiting increased looks to the target area in the ‘bias’ condition than in the ‘neutral’ condition.

By recording their eye-movements, Brock et al. (2008) investigated whether children with ASD are able to process ambiguous linguistic information in context during spoken sentences and reported similar findings. More specifically, they examined whether the sentence context affects the predictions of participants, while they were looking at four images, among which one word was phonologically similar to the target word. The participants were looking at a display, where four objects were depicted, while hearing spoken sentences. Two conditions were created: a target-present condition and a target-absent condition. In the first condition each display consisted of one target-object (e.g., hamster), one phonological competitor (e.g., hammer) and two unrelated distractors. In the target-absent condition there was one phonological competitor and three unrelated distractors, while the target-word was absent. The phonological competitor was semantically incongruous with the verb. The authors found that the ASD group exhibited similar performance to the TD group, as both groups used context while processing sentences. Interestingly, participants with weak language abilities from both groups were not affected by the context to anticipate the target object.

Relying on different research method than the previous studies, Brennan et al. (2019) concluded that children with ASD are able to use predictions in a similar way as typically developingchildren, as the researchers failed to find evidence supporting a distinction in predictive mechanisms in ASD and TD children. In contrast to thestudies described above, the study of Brennan et al. (2019) utilized computational psycholinguistic models of sentence prediction to characterize Magnetoencephalographic (MEG) neural signals in order to clarify potential mechanistic differences in comprehension, as eye-tracking methods cannot investigate differences in the mechanisms the participants used during predictive language processing. More specifically, the researchers collected neural signals from the participants, while the participants were listening to an audiobook story and measured the effect of unexpected words.

4. Discussion

The present review attempted to investigate the language processing of children and adolescents with a diagnosis of DLD or a diagnosis of ASD during real-time language use. More specifically, we examined studies reporting on the predictive language processing of either of these two populations and we compared their performance in tasks concerning this ability. In the absence of studies comparing predictive language processing directly between the two clinical groups, we included studies which compared either children with ASD or DLD with TD children and we attempted to draw conclusions based on their comparison to the TD group.

Previous research has revealed that typically developing children are able to utilize linguistic cues in order to generate predictions and consequently to achieve high sentence comprehension (Borovsky et al., 2012; Federmeier, 2007; Gambi, Pickering & Rabagliati, 2016; Mani & Hueting, 2012). Our findings revealed that both children with DLD and children with ASD do have the ability to use semantic information from the context in order to generate predictions, especially when language stimuli contain highly constraining semantic information. However, it seems that children with DLD are slightly weaker than children with ASD in producing predictions during online comprehension.

Specifically, children with DLD exhibit a delay in generating predictions and a lower proportion of looking at the target compared to their TD peers and children with ASD. Children with DLD present a developmental delay, as they exhibit similar performance to that of younger TD children. It is also observed that when children with DLD are given verbs that provide less syntactic and semantic information, they need more time to process them than typically developing children (Andreu et al., 2013) and children with ASD, who did not show a delay in corresponding studies (Brennan et al., 2019; Brock et al., 2008; Venker et al., 2018; Zhou et al., 2018). This is in line with the study of Pijnacker et al. (2017), who found that the language processing of children with DLD is slow when the restrictions of the verb are less determined. The researchers showed that the slow processing of children with DLD might be caused by deficiencies in semantic integration of multiple words in a sentence. Alt et al. (2004) also concluded that children with DLD exhibit deficiencies in recognizing semantic features and that their verb representations may not be fully determinate. In general, in the whole vocabulary of young children, there are more nouns than verbs, as nouns are acquired earlier than verbs, probably due to the fact that nouns refer to specific objects or concepts (Arunachalam, Syrett & Chen, 2016; Naigles & Tek, 2017). Deficits in syntactic representations (Sanz-Torrent et al., 2008; van der Lely, 1994) and low verb lexicons are likely to cause a delay in verb learning of children with DLD. In addition, Miller et al. (2001) suggested that children with DLD exhibit slow online language processing and impairments in working memory that may have a negative impact on their ability to conduct predictions during online conversations.

Importantly, in contrast to other studies, the study of Andreu et al. (2016) proved the capacity of children with DLD to use verb semantics during online prediction without a delay, highlighting the range of language differences between children with a diagnosis of DLD. Th findings may be due to the differences in the degree of complexity of sentences between the studies as well as the vocabulary used in each study. Van Alphen et al. (2021) suggest that more complex sentences and the use of unfamiliar words require a higher level of semantic integration processing. Accordingly, as put forward by Ndiaye & Camaco (2021), children with DLD exhibit difficulties processing complex sentences.

As opposed to children with DLD, children with ASD tend to exhibit similar performance with TD children and, more specifically, the mechanism for sentence comprehension children with ASD use during real-time language use is similar to the mechanism of TD children. As a result, the relationship between language development and the ability for predictive language processing of children with ASD is not different from that of children with typical development. Children with ASD are able to use semantic information of verbs in speech to predict the nouns that follow as well as their TD peers and even at the same time as them (Bavin et al., 2016; Zhou et al., 2018). This finding is in line with the study of Hahn et al. (2015), who found that children with ASD are able to integrate information into a sentence. This fact shows that the semantic framework positively influences language processing in children with ASD. Other studies pointed out that the semantic framework helps them to incrementally process sentences and use the structural and semantic characteristics of the sentences (Luyster & Lord, 2009; Venker et al., 2018).

Nevertheless, the slower processing children with ASD exhibit compared to their TD peers when constraining semantic information is absent indicates a general slowing in the processing for children with ASD when the context does not provide any semantic clues to confirm predictions (Bavin et al., 2016). Another explanation for this difference may lie inthe difference in the cognitive control of visual attention between ASD children and TD children, as individuals with ASD have been shown to present deficits in the cognitive control of visual attention (DiCriscio et al., 2016; Zhou et al., 2018).

The weaker ability of children with DLD in comparison to children with ASD on predictive language processing could be a distinct marker between the two populations, but further research is needed to clarify the mechanisms children of both groups use during real time language processing.

In general, it was observed that children with poor language skills (and especially weak expressive language skills) tend to be weak in conducting predictions, a finding that emphasizes the importance of language development in the capacity of real-time sentence comprehension (van Alphen et al., 2021). Research has shown the crucial role of vocabulary and structure in anticipatory incremental sentence interpretation and therefore low vocabulary and structure knowledge have a negative impact on predictive language processing and consequently on real-time sentence comprehension (Borovsky et al., 2012; Gambi et al., 2016; Mani & Hueting, 2012).

The present review attempted to investigate the ability of making predictions during real-time language use, as well as the language processing of children with ASD and children with DLD. Examining the findings of the aforementioned studies, we can draw important conclusions regarding the way children of both clinical groups process language, and consequently come up with practical methods to communicate with children with ASD and DLD. For example, using simple sentences and slow rate in talking may help ASD and DLD children to successfully process language input. Also, interventions should focus on strengthening the vocabulary and knowledge of structures. Research on the ability of children with DLD and children with ASD to predict the upcoming linguistic stimuli is crucial, as prediction is likely to be the basis for a smooth social interaction and may be used as an efficient tool for learning (Gambi et al., 2016).

However, since language difficulties affect the performance on tasks regarding predictive language processing, the fact that children with ASD were matched in terms of language skills with TD children (control groups) should be considered as a limitation of this review. This means that the language difficulties children with ASD experienced were not as severe as those of children with DLD. At the same time, recent research highlights that a subgroup of ASD experiences severe language difficulties and therefore this subgroup exhibits more similarities with DLD (Georgiou and Spanoudis, 2021). Moreover, the studies included have been conducted in different languages. Every language has a different structure, and the differences in terms of sentence and vocabulary complexity affect the performance of participants (Loucas et al., 2008; van Alphen et al., 2021).

Further research should be carried out including children with ASD and DLD, so that a direct comparison could be made. A subgroup of individuals with ASD who show linguistic similarities to individuals with DLD should also be included in order to investigate the similarities and the differences between the two populations in language processing and in generating predictions during real-time language use.

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THE MORPHOSYNTAX INTERFACE IN PATIENTS WITH ALZHEIMER’S DISEASE

Abstract. This paper investigates the morphological competence of Italian-speaking patients diagnosed with Alzheimer’s Disease (AD). More specifically, we test whether and how AD patients can apply the morphological operations involved in complex word formation, i.e., conversion and affixation. The aims are twofold: (i) to detect whether morphological operations are impaired in this population and (ii) to determine whether word formation rules can be a useful marker in AD diagnosis. Previous studies on AD have reported that patients are impaired in various linguistic domains, but little is known about whether and how morphology is affected. This study reports the results of a picture-supported sentence completion task administered to 20 AD patients (MMSE score 0-24) and 20 neurologically age-matched healthy subjects. We found that AD patients’ performance differed from that of neurologically age-matched healthy participants in both the rate of accuracy and the morphological processes exploited to create complex words. While AD patients apply both conversion and affixation, the former operation was selectively applied to create complex verbs derived from nouns and the latter was applied to compose complex nouns from verbs. We conclude that both the low rate of accuracy and the selective application of the two morphological processes distinguish AD patients from neurologically age-matched healthy subjects and can thus be taken as markers in AD diagnosis. From a theoretical viewpoint, our results may suggest that conversion is a form of affixation, as proposed in various studies, e.g., Bauer (2008).

Key words. Alzheimer’s Disease, Derivational Morphology, Conversion, Affixation

1. Introduction

Alzheimer's Disease (henceforth, AD) is the most common cause of dementia in the elderly, as it currently affects over 30 million people worldwide (Villain & Dubois, 2019; among others). It is a neurodegenerative disease characterized by a gradual loss of cognitive functions (Ghezzi, 2018), which is mainly manifested in a memory system deficit, among additional neuropsychological disturbances (Devanand et al., 1997; Budson, 2011; Duong et al., 2017; among others). Not only memory but also linguistic abilities are compromised in AD (Auriacombe et al., 2006; Reilly et al., 2011; Cummings, 2020). AD patients' linguistic competence will be the focus of this paper.

Various linguistic domains have been found to undergo deterioration with AD. For instance, phonological processes seem to be impaired in AD patients. Some studies have claimed that phonological processing is compromised from very early on (Biassou et al., 1995; Croot et al., 2000; a.o.).[1] In spoken-words recognition, AD patients exhibit lexical discrimination difficulties with frequent phonological confusions (i.e., *doll* instead of *dog*), especially when faced with words having a great number of phonological neighbors (Eustache et al., 1995). Further studies have reported speech errors with different production tasks, i.e., sentence repetition, naming, connected speech. AD patients produced more pseudoword errors (*popped* < *plopped*), word initial errors and phonemic substitutions than the normal controls and phonological paraphasias were their systematic error (Biassou et al., 1995; Croot et al., 2000). Another linguistic domain in which AD patients are reported to be impaired is semantic processing. As demonstrated by neuroimaging, cerebral regions in charge of semantic processing are affected early in the progression of AD (Zahn et al., 2006). Evaluation in word-association and naming tasks is taken as evidence for a semantic memory deficit in AD. Indeed, patients showed dissimilar impairments in semantic category fluency (i.e., name as many animals as possible in 60 seconds) relative to letter-naming fluency (i.e., name as many words beginning with the letter "F" as possible in 60 seconds) (Adlam et al., 2006). Not only did AD patients exhibit reduced semantic priming effects in word-stem fragment completion (i.e., cat⟶d-?) (Passafiume et al., 2006), but they also exhibited reduced word frequency effects in free association (i.e., bride⟶?) (Gollan et al., 2006). Moreover, corrupt semantic knowledge is shown in nonverbal tasks, such as describing the appropriate function of a common object (Chainay et al., 2006) and sorting pictures into the

[1] According to other authors, phonological processing is not compromised until a very late stage of AD (Bayles & Tomoeda, 1983; among others).

appropriate category (Aronoff et al., 2006). In the early stages of the disease, AD patients exhibit difficulties in naming tasks (Nicholas et al., 1985; Reilly et al., 2011; among others). Indeed, AD subjects are generally described as presenting anomia. They might show difficulties in retrieving the names of people and places (Oppenheim, 1994), they may substitute generic terms for more specific ones (Kempler et al., 1995) and coordinate naming errors (*dog* for *cat*), as well as taxonomic naming errors (*animal* for *cat*) (Reilly et al., 2011). There is also some evidence that patients with AD may have more difficulty naming verbs than nouns, especially those denoting manufactured artifacts and natural kinds (Gonnerman et al., 1997; Whatmough et al., 2003; Beber et al., 2015). Nonetheless, also the opposite pattern has been detected, with verbs being named more easily and correctly than nouns (Bowles et al., 1987; Robinson et al., 1999; Ivanova et al., 2013). Another problematic domain for AD patients is syntax. In particular, AD patients experience difficulties in sentence comprehension, as clearly revealed by various studies adopting different experimental tasks, e.g., sentence-picture matching (Waters et al., 1995; Caloi, 2017), enactment (Emery, 1983), or the Token Test (Tomoeda et al., 1990). Finally, discourse processing is another domain affected in AD. Common manifestations in the AD patients' discourse are repetition of content, poor organization of the discourse and several circumlocutions. All these characteristics result in a speech that has frequently been described as fluent but empty (Tomoeda & Bayles, 1993).

Despite this quite dense literature on AD patients' linguistic abilities, little is known about the morphological domain in this population. We are aware of only one study addressing inflection in AD population, Ullman et al., (1997). AD patients were tested on the formation of English past tense verbs. The authors reported a better performance on the inflection of English regular verbs, like *listen* > *listened*, than on the inflection with irregular forms, *go* > *went*. These results support a dual-route model of complex word processing and retrieval of complex words (see Ellis and Young, 1988; Ullman et al., 1997). According to this model, words are accessed in some cases from the mental lexicon as whole-units (as in the case of irregular verbs), while in other cases as decomposed smaller units, i.e., in terms of their composing morphemes (as in the case of regular verbs). If patients have problems in lexical retrieval, words listed in the mental lexicon, e.g., irregular verbs, cannot be retrieved. Conversely, morphemes and word formation rules are separated from word knowledge. Thus, words created online applying word formation rules, e.g., regular verbs, are the only option available when the retrieval of a stored word fails.

The present study adds to this line of research and investigates how Italian AD speakers deal with morphologically complex words created via derivation, i.e., conversion and affixation.

The paper is structured as follows: in Section 2 we summarize the characteristics of affixation and conversion in Italian. Section 3 illustrates our experiment, i.e., the demographic information of the participants, the experimental design, the coding, and the results. Section 4 discusses the results and concludes the paper.

2. Word formation

With the term word formation, we refer to the process which results in the creation of new lexemes (Haspelmath, 2002; Bauer, 2008). New lexemes can be formed via two morphological processes, namely, compounding and derivation. In this paper we focus on the latter process. Derivation is defined as the morphological operation that creates new lexemes, either by changing the syntactic category (part of speech) of a base or by adding substantial, non-grammatical meaning to a free or bound base, or both (Lieber, 2017).[2]

Derivation may be accomplished by various formal morphological means, including affixation (English: *employ* > *employ-ment*), reduplication (Samoan: *solo* 'wipe dry' > *solosolo* 'handkerchief'), internal modification of bases (Arabic: from the root *ktb* > *katab* 'wrote' *kattab* 'caused to write'), and subtraction (Tohono O'Odham: *hi:m* 'walked' with imperfective aspect > *hi:* 'walked with perfective aspect).[3]

We focus on affixation, which is the process of creating new words by adding an affix to the base (Bauer, 2004). Most often, affixation involves (i) prefixation, namely the attachment of a prefix to the base, like *un-* and *happy*, which gives *unhappy*, or (ii) suffixation, the attachment of a suffix to a base, like *organize* and *-ation*, which gives *organization*. The process of affixation obeys the so-called word-formation rules (henceforth WFRs), which specify which bound morphemes can be attached to a free morpheme in order to form a new complex word (Plag, 2003). In other words, the rule must contain information about the phonology of the affix, what kind of affix it is (prefix or suffix), its semantics, and the possible base morpheme the affix can merge with.

In addition to these means, derivation may be accomplished via conversion, namely a non-concatenative operation. With conversion, no lexical material is added to the base in order to change its categorial status, as in *to kick* vs. *the kick* 'the instance of kicking', with the possible exception of the specific word-class inflectional morphemes, as in Italian (Plag, 2003). According to Plag (2003), conversion is theoretically a slippery concept for

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[2] For a discussion on the differences between derivation and compounding, we refer the reader to Haspelmath (2002) and Lieber (2017).

[3] All language examples are taken from Lieber (2017).

two reasons: (i) its theoretical status and (ii) the directionality of the process. As for (i), while it is uncontroversial that conversion is a derivational process, debate has centered on whether conversion is a form of derivation distinct from affixation. According to some studies, conversion is affixation but in this case the affix is a zero morpheme (Bauer & Valera, 2005; Valera 2014). Items that have undergone conversion are predicted to display the same properties as items derived by overt affixation such as determination of a clearly circumscribed semantic category (e.g., instrument) or inflectional class (e.g., masculine, feminine). However, other studies have noticed that items undergone conversion do not seem to behave as overt affixes do, rather they instantiate several semantic categories or fall into multiple inflectional classes (Lieber, 2017). As a consequence, other scholars have proposed that conversion implies something different from affixation, either a simple relisting of items in the mental lexicon or a listing of category-less items in the lexicon (see Lieber, 2017 and references therein). In addition, conversion faces the problem of directionality (ii): it is not obvious how to identify the base of the morphological process. Plag (2003) provides four criteria to determine the direction of conversion: (a) the history of words may suggest which one is first attested; (b) the semantic complexity of the supposed base and derived forms; (c) the formal properties of the two items and (d) the frequency of the two items (see Plag, 2003 for a detailed clarification). In this paper we followed the four criteria to determine the directionality of conversion in designing our experimental items.

We now focus on affixation and conversion in Italian, limiting our discussion to the categories tested in our experiment, namely nouns derived from verbs (Section 2.1) and verbs derived from nouns (Section 2.2). Finally, we discuss the two morphological operations with respect to the linguistic principles they obey (Section 2.3).

2.1. Word formation in Italian: new nouns from verbs

Nominal expressions derived from verbal items are labeled deverbal nominals (henceforth DVNs). DVNs can be created by both affixation and conversion in Italian. In (1), we illustrate DVNs which are created by merging the base verbal morpheme with a nominalizing suffix. In (2) we illustrate DVNs formed by conversion.

1) a. *spazz-ino* 'sweeper', from *spazzare* 'to sweep'
b. *frulla-tore* 'mixer', from *frullare* 'to mix'
c. *dormi-torio* 'dorm', from *dormire* 'to sleep'
d. *ammira-zione* 'admiration', from *ammirare* 'to admire'

2) a. *aiutante* ‘helper’, present participle of *aiutare* ‘to help’
b. *stampante* ‘printer’, present participle of *stampare* ‘to print’
c. *incrocio* ‘intersection’, present/bare stem of *incrociare* ‘to intersect’
d. *ricerca* ‘research’, present/bare stem of *ricercare* ‘to search/research’

As shown in (1), Italian exhibits a conspicuous number of suffixes to create DVNs (Grossmann & Rainer, 2004). For instance, instrument nouns are generally formed with agentive suffixes, such as *-ino/ina* as in (1a), -*tore/-trice*, as in *aspira-tore* ‘aspirator’ from *aspirare* ‘to draw/suck’ and *lava-trice* ‘washing machine’ from *lavare* ‘to wash’, and *-toio/-torio,* as in *annaffia-toio* ‘watering can’ from *annaffiare* ‘to water’. In addition, the literature reports that Italian possesses about 30 suffixes to derive action nominals (Grossmann & Rainer, 2004). Among them, the most productive suffixes are *-(z)ione, -mento* and *-tura* (Plag, 2003; Grossmann & Rainer, 2004). We briefly discuss their properties since they are the suffixes used in our experimental design.

To create action nominals, the suffix *-(z)ione,* with its allomorphs -*sione, -ione, -gione*, is usually added to a verbal stem, as in *crea-zione* ‘creation’ from *creare* ‘to create’. However, in other cases the suffix is merged with a bound morpheme which is the past participle form of the verbal base and not its bare stem, as in *conclus-ione* ‘conclusion’ from *concluso* ‘concluded’ past participle of *concludere* ‘to conclude’. The suffix -(z)*ione* seems to be the preferable or the unique suffix to be attached to monosyllabic verbal stems (*sta-zione* ‘station’ from *stare* ‘to stay’), morphologically derived verbal bases (*de-composi-zione* ‘decomposition’ from *de-comporre* ‘to decompose’ from *comporre* ‘to compose’), and verbal bases derived via conversion from a noun (*progetta-zione* ‘planning’ from *progettare* ‘to plan’ from *progetto* ‘plan’). Action nominals derived with the suffix –-(z)ione exhibit a wide semantics. While they generally mean “the act of V”, according to Gaeta (2004: 316) they can also denote (i) the result of a process, denoting either a concrete or an abstract object, (ii) the resulting state reached by the predicate, (iii) the object/instrument used to perform the dynamic situation described by the base verb, (iv) the location where the event takes place or where the action is carried out, (v) the manner in which the event is performed and (vi) the temporal slot in which the event takes place.

The suffix *-mento* derives DNVs by attaching to the imperative forms (Thornton, 1990). It is the suffix usually merged with polysyllabic verbs (*addestra-mento* ‘training’ from *addrestrare* ‘to train’) and parasynthetic verbs (*inceneri-mento* ‘incineration’ from *in-cener-ire* ‘to incinerate’). As for its semantics, the suffix *-mento* mainly means “the act of V” but it can also have other interpretations, such as (i) the expression of the external argument of the verb, (ii) the instrument used to perform the action, (iii) the location where the event takes place. Interestingly, action nominals may be created from the same verbal base with both the *-mento* and the *-(z)ione* suffixes. While in some cases the meaning of the two action nominals may overlap, as in *aggrega-zione/aggrega-mento* 'aggregation' from *aggregare* 'to aggregate', in others they clearly differ as in *tratta-mento* 'treatment' and *tratta-zione* 'discussion' from *trattare* 'to treat/discuss'. Indeed, after having compared the behavior of the suffixes *-mento* and *-zione,* Gaeta (2004) concluded that both suffixes allow the same number and types of readings, but to different extents, with the suffix *-mento* presenting less polysemy than *-zione*.

The suffix *-tura* attaches to various verbal bases: (i) verbal stems as in *apri-tura* 'willowing' from *aprire* 'open', (ii) past participle forms as in *let-tura* 'reading' from *leggere* 'to read', and (iii) verbal bare stems as in *proced-ura* 'procedure' from *procedere* 'to proceed'. The suffix is preferably employed with polysyllabic verbs and derived verbs with aspectual suffixes, as in *sceneggia-tura* 'script' from *scen-eggi-are* 'to dramatize'. The suffix *-tura* is generally employed to derive DNVs denoting technical activities belonging to specific fields, such as agriculture (*potatura* 'pruning' from *potare* 'to prune') and manufacturing (*legatura* 'bookbinding' from *legare* 'to bind'). Moreover, the suffix *-tura* can also designate "the result of V", which can be abstract or concrete, a location or an instrument.

In addition to affixation, complex nominals can also be derived via conversion. Italian has many different patterns of conversion to create DVNs (Rainer, 2016). Note that, differently from English, conversion in Italian requires the presence of the inflectional morpheme of the new grammatical class. The first pattern, which applies most frequently, consists in the conversion of the present stem of the verbal base and the addition of the *-o* morpheme to the stem. This operation is very common for the predicates belonging to the first conjugation like *acquist-o* 'purchase' from *acquist-are* 'to purchase'. Such DVNs may present a variety of readings (Gaeta, 2004). Indeed, they may designate the result of the verbal action, like *accordo* 'agreement' from *accordar(si)* 'to agree', the instrument or means used to perform an action, like *cambio* 'changeover' from *cambiare* 'to change', the place where the action takes place, *arrivo* 'arrival' from *arrivare* 'to arrive', the concrete result of the action, like *strappo* 'tear' from *strappare* 'to tear'. The second pattern consists in the conversion of the present stem of the verbal base but, in this case, the derived nominal ends in *-a*, such as *ricerca* 'research' from *ricercare* 'to search'. The third pattern is represented by conversion from non-finite verbal forms. Italian applies conversion from present participle stems to generally form *nomina agentis,* such as *manifestante* 'protester' from *manifest-ante* 'prostesting' and *nomina instrumenti*, like *stampante* 'printer' from *stamp-ante* 'printing' (Grossmann & Rainer, 2004 for further information). Another subcase is represented by conversion from the past participle stem, which is generally used to designate *nomina actionis*, like *mangiata* 'meal' from *mangi-ata* 'eaten', interpreted as individual or instantiated events. DVNs created via conversion of past participle stems cannot denote the action or the process as such, rather they isolate a specific portion of the action with a specific end point (Gaeta, 2004). Finally, DVNs can be formed also from athematic verbal stems. These forms can be considered lexicalized since their eventive interpretation is no longer available, as illustrated by the example *scritta* 'the concrete result of writing' from *scrivere* 'to write'.

2.2 Word formation in Italian: new verbs from nouns

Verbs created from nouns are called denominal verbs (henceforth, DNVs). As previously seen for DVNs, DNVs are formed through the application of affixation and conversion.

DNVs can be created via affixation, adding to the nominal base the suffixes *-eggi-*, *-ific-* and *-izz-* as in (3), thereby producing predicates of the first conjugation. DNVs can also be created via conversion, as in (4).

3) a. *fiamm-eggi-are* 'to flame' from *fiamma* 'flame'
b. *nid-ific-are* 'to nest/nidify' from *nido* 'nest'
c. *vapor-izz-are* 'to vaporize' from *vapore* 'steam'

4) a. *puzz-are* 'to stink' from *puzza* 'stink'
b. *regal-are* 'to gift' from *regalo* 'gift'
c. *fiocc-are* 'to snow' from *fiocco* 'snowflake'

As for DNVs formed via affixation, various studies have shown that the three most frequent suffixes, *-eggi-*, *-ific-* and *-izz-*, display different distributions. The suffix *-eggi-* is particularly productive in forming verbs belonging to the informal registers, more generally to form intransitive verbs. Verbs derived with the suffix *-eggi-* correspond to 47% of DNVs produced by applying affixation. However, when we look at the new formations after the '50s, the actual productivity of this suffix seems rather low (Grossmann & Rainer, 2004). The suffix *-ific-* is restricted to high-level and technical registers, especially the ones concerning the technical-scientific domain. It generally forms transitive verbs and represents 8% of all suffixed DNVs. The suffix *-izz-* is productive across various registers and is used to form both intransitive and transitive verbs. It represented 40% of

DNVs produced through suffixation before 1950 and 73% of the novel formations nowadays: it therefore qualifies as the most productive suffix to create DNVs.

DNVs created by means of suffixation can designate a variety of functions which may be culturally and socially dependent. Indeed, to interpret the complex verb, the encyclopedic knowledge of the speaker and the listener is extremely relevant (Aronoff, 1980). Generally, the base nominal expression is not inflected, it can refer to one or more entities of the same class and it can have a metaphoric reading, as in *corn-ific-are* 'to betray' from *corna* 'horns'. Finally, derived complex verbs may present a more generic meaning with respect to corresponding analytic constructions and they often develop a secondary meaning as in *bors-eggi-are* 'to pickpocket' from *borsa* 'bag'.

Turning to DNVs derived via conversion, the literature agrees in claiming that conversion is the most frequent operation to create verbs in Italian: more than half of all derived verbs in Italian are conversions, mostly from a nominal base (Rainer, 2016). The great majority of complex verbs derived via conversion belongs to the first conjugation, while only a small residual portion belongs to the third conjugation (thematic vowel -*i*-), which constitutes a no longer productive pattern nowadays. DNVs created by converting a nominal base into a verb can be classified into several types according to the relation that the incorporated N entertains with the event. We provide some examples. The nominal base can denote the result of the event, agentive or non-agentive, described by the complex verb, as in *puzz-are* 'to stink' from *puzza* 'stink'. The complex derived predicate has thus the meaning of "to do/produce/build N". The nominal base can also correspond to the localized object, an entity that is approached/warded off from X or that is put over/removed from X, as in *profum-are* 'to perfume' from *profumo* 'fragrance'. Thus, the derived verb can be paraphrased as "to put/strew with/provide with/give N". In addition, the nominal base can also designate an entity which is moved, taken, collected, distributed, etc. by an agent, as in *regal-are* 'to gift' from *regalo* 'gift'. Moreover, the nominal base may represent the place/entity where something/someone (is) placed/moved/etc. The derived verbs can be paraphrased as "to place/locate something in/on/over N", as in *parcheggiare* 'to park' from *parcheggio* 'parking lot'. In addition, converted complex verbs may also designate an event where the role of the nominal referent can be interpreted as an instrument used to perform the action or to achieve the result of that action, as in *rem-are* 'to row' from *remo* 'oar', *telefon-are* 'to telephone' from *telefono* 'telephone', *sci-are* 'to ski' from *sci* 'ski'. Finally, a small portion of complex verbs forms the subgroup of meteorological predicates, which can be paraphrased as "to be/fall down N". They are converted from nominal bases designating weather phenomenon, as in *fiocc-are* ‘to snow’ from *fiocco* ‘snowflake’.

2.3 Affixation and conversion: economy and transparency

Affixation and conversion obey two different principles (Dressler, 1985). While affixation obeys the transparency principle, since each morpheme maps one syntactic-semantic function, conversion obeys the economy principle, whereby no additional material is inserted.[4] Affixation is at the same time more iconic and transparent than conversion. The change in the meaning and in the grammatical class of the derived form is iconic, being morphologically overtly signaled. Likewise, the compositionality of meaning of the new derived word is transparently signaled in affixation: the base conveys the original meaning, and the suffix conveys the new meaning obtained via the morphological process (Pavesi, 1998: 214). In other words, each morpheme maps one syntactic-semantic function. Conversely, conversion is the morphological process by which a word is formed without any overtly-realized derivational mark (Pavesi, 1998: 213). Hence, conversion is considered a highly economic operation, since the base on which the process applies does not undergo any morpho-phonological change, except acquiring the inflection of the new grammatical class in a language like Italian (Clark, 2014, 2017). Interestingly, the two principles are in competition. Dressler’s theory of Natural Morphology claims that conversion should be dispreferred due to its unnaturalness along several parameters. Accordingly, affixation is predicted to be more frequent than conversion in the languages of the world (Dressler, 1985; Giacalone-Ramat, 1995). This prediction seems to be borne out. Drawing on data from twenty-eight language families and forty-five language genera, Štekauer et al. (2012) showed that the morphological means for derivation most commonly attested in languages is indeed affixation. Conversely, many languages all over the world lack conversion or have it in very restricted contexts (Giacalone-Ramat, 1995; Štekauer et al., 2012). Nonetheless, this common pattern does not hold consistently. A case in point is represented by English, a language which applies conversion as a rather widespread process to create new lexemes (Plag, 2003). Likewise, conversion seems to be preferred over affixation in children’s production. Children form novel complex words

[4] Notice that it is not uncontroversial to claim that conversion really obeys the economy principle. Such a claim crucially depends on how conversion is conceived, i.e., as a kind of affixation involving a zero-morpheme or not. Studies have claimed that null elements are harder to process and thus, less economic (see Lieber, 2017 for a review).

starting from the age of eighteen months, at least. The first derived words are created by applying no affix, namely via conversion and only at a later stage do children start to produce novel forms by adding affixes to lexical bases (Clark, 2014). Research has suggested that children rely on some general principles to create new complex forms. First of all, they are guided by the principle "transparency of meaning": they use only elements whose meaning they already know, as the new meaning must be accessible in part from the elements composing the new word. This could explain why they initially rely on conversion (or zero derivation for English) using roots of already known words (i.e., *to button* for *to press* [Age 2;4]). By the time they have assigned a meaning to affixes, they create new forms by applying suffixation as well, (i.e., *crayoner* used in lieu of *painter* [Age 3:11]) (Clark & Hecht, 1982). Meanwhile, also another principle is operative, the one known as "simplicity of form": forms that involve no or few changes to the component elements are produced earlier by children (Clark, 2017: 386).

In conclusion, the two morphological processes obey different principles, which are in competition. Various factors, e.g., development, language properties, etc., seem to determine the result of this competition. With this background, we turn to our experiment.

3. Our experiment

Our study investigates how Italian-speaking AD patients perform on complex word formation, by testing affixation and conversion operations. We formulated three research questions:

(Q1) Can AD patients exploit the morphological processes of Conversion and Affixation to create new lexemes?

(Q2) Does AD patients' performance differ from that of neurologically healthy age-matched adults?

(Q3) Does AD patients' performance differ depending on the morphological operation (affixation or conversion)?

Following Ullman et al.'s (1997) findings on inflectional morphology in AD patients (Section 1), a positive answer to (Q1) is expected. AD patients should exploit the morphological processes of conversion and affixation to create new lexemes. In addition, in case of retrieval difficulties, they should create novel word-forms online, applying WFRs.

As for (Q2), on the basis of Ullman et al. (1997), we predict a difference between AD patients and neurologically healthy age-matched adults in the creation of novel complex words. While AD patients are expected to create novel legitimate complex words online, we do not expect such novel formations in neurologically healthy adults.

Different expectations can be formulated for (Q3), depending on how conversion is formally conceived and, if a zero morpheme is postulated in conversion, how morphosyntactic null categories are processed in AD patients. As clarified in Section 2.3, conversion and affixation obey two different principles: while affixation is transparent and iconic, conversion is a more economical process. This observation holds also if we postulate the presence of a zero morpheme in conversion, assuming that null realizations are more economical than their lexicalizations, as in Clark (2017). Under this view, the more economical process might be preferred over the more transparent one since AD affects the memory system. A similar prediction arises under Jakobson's Regression Hypothesis, which assumes that the order of language loss is identical, yet opposite in direction, to the order of language acquisition. As discussed in Section 2.3, studies on the acquisition of English morphology have shown that children in their first stages of production preferably or only opt for conversion and, only after they have acquired the meaning of the suffixes do they produce complex words formed via affixation (Clark, 2014). Under Jakobson's Regression Hypothesis, we may indeed expect conversion to be preferred over affixation. Alternatively, we may expect that, when AD patients create novel words online, they might apply the more transparent process, namely affixation, thereby clearly mapping each function onto each morpheme overtly.

3.1 Participants

Twenty AD participants were recruited and tested in the retirement home AltaVita IRA in Padova (Italy). All participants were Italian native speakers, presenting different degrees of dementia, ranking from mild to severe (MMSE: 0-24). To assess the mental status of our patients, the psychologists of the retirement home administrated to each participant the Mini Mental-State Examination (MMSE), which is a neuropsychological test used in clinical and research settings. The test consists of thirty questions, used for grading cognitive impairment. Any score above 24 denotes normal cognitive functioning. scores below 25 indicate very severe (<5), severe (6-9), moderate (10-20) and mild (21-24) cognitive impairment conditions. The AD group comprised thirteen women and seven men, mean age 85 years, with an educational level ranging from Elementary School to High School. The demographical and clinical details for each AD participant are reported in Table 1.

Patient	Gender	Age	Education level	MMSE scores*	MMSE levels
F17	F	88	Elementary School	01/30	Very severe
G4	F	91	Elementary School	01/30	Very severe
G5	F	72	High School	02/30	Very severe
SD19	M	79	Elementary School	2.7/30	Very severe
T1	F	87	Elementary School (3-5 years)	4.2/30	Very severe
G6	F	88	Elementary School (3-5 years)	5.2/30	Very severe
F11	M	89	Elementary School	5.4/30	Very severe
F18	F	86	Middle School	08/30	Severe
SD20	F	96	Elementary School	11/30	Moderate
G3	M	87	Elementary School	11.4/30	Moderate
M16	M	83	Middle School	12.7/30	Moderate
R10	F	91	Elementary School	13/30	Moderate
M14	M	85	Middle School	15.8/30	Moderate
G7	M	85	High School (3/5 years)	15.8/30	Moderate
M9	F	84	Elementary School	19.4/30	Moderate
M15	F	90	Middle School	20/30	Moderate
M13	F	81	Elementary School	21.4/30	Mild
M12	M	81	High School	22.1/30	Mild
G8	F	80	High School	23.7/30	Mild
R2	F	77	Middle School	24/30	Mild

Note. *Score corrected for educational attainment and age

Table 1. Demographic and Clinical information of AD Patients

We further recruited 20 neurologically healthy subjects, age-matching the AD patients, who represented our Control Group. These participants were recruited from personal acquaintances in the Mantua area (Northern Italy). They were all Italian native speakers, presenting normal cognitive functioning, with MMSE scores ranging from 25 to 30. The demographical details for each Control participant are reported in Table 2.

Patient	Gender	Age	Education level	MMSE scores*
RF	F	72	University	30/30
GC	M	77	High School	29/30
FGK	F	79	University	28/30
BR	F	80	High School	28/30
MB2	F	81	Elementary School	27/30
NA	M	81	Middle School	27/30
RDC	M	83	Middle School	26/30
FV	M	84	Elementary School	27/30
BVM	F	85	University	27/30
BLM	M	85	Middle School	26/30
TEC	M	86	Middle School	26/30
LM	F	87	High School	25/30
CR8	M	87	Elementary School	26/30
SB	M	88	Elementary School	26/30
MA	F	88	High School	27/30
MRC	F	89	University	26/30
MB1	M	90	Elementary School	25/30
NFV	M	91	University	26/30
PR	F	91	Elementary School	25/30
TTC	F	96	Elementary School	25/30

Table 2. Demographical information of the Control Group

Informed consent to participate in the study was signed by all patients, autonomously, when possible, or by support administrators/ a family member, as well as by all the Control Group participants.

3.2 Materials, design and procedure

A picture-supported sentence completion task, presented in a multiple-choice fashion, was designed. We chose this task because it offered considerable advantages when testing AD patients: the presence of item-related images may compensate the attention deficit and the working-memory difficulties of AD patients; the presence of a depictive context may help lexical retrieval.

For the experimental task a total of 34 items were accurately selected: 20 target items, 12 fillers and 2 warmups. The experimental items were selected considering two variables: (i) the syntactic category of the lexeme (noun or verb) and (ii) the type of morphological processes applied to derive complex lexemes (conversion or affixation). The test items comprised 10 nouns derived from a verbal base, namely DVNs, and 10 verbs derived from a nominal base, namely DNVs. The 10 items were further manipulated for the morphological process: 5 items were derived via conversion and 5 via affixation. The lexical items were chosen on the basis of their frequency: we selected only lexical items exhibiting a high frequency of use in Italian, by checking the online CoLFIS corpus (Lessico di Frequenza dell'Italiano Scritto - Bertinetto et al., 2005). Since each test item was paired with a picture, among the highly frequent lexemes, we further selected those with a high degree of imageability**.** The complete list of test items is provided in Table 3.

	Conversion	Affixation
DVNs	arrivo 'arrival'	scrittura 'writing'
	ricerca 'research'	cambiamento 'change'
	spinta 'push'	spostamento 'repositioning'
	stampante 'printer'	bruciatura 'burn'
	stretta 'grasp'	costruzione 'construction'
DNVs	baciata 'kissed'	fiammeggiando 'flaming'
	fioccando 'snowing'	nidificando 'nesting'
	pettinando 'combing'	ondeggiare 'to wave'
	regalato 'gifted'	pianificare 'to plan'
	sciando 'skiing'	ramificato 'branched out'

Table 3. List of test items

As for the 12 fillers, highly imageable primitive nouns and verbs were chosen. The 6 primitive nouns were either concrete or abstract nouns. As for the 6 primitive verbs, they were conjugated at the gerundive, infinitive and past participle forms respectively, as we did for experimental items. The complete list of fillers is provided in Table 4.

Nouns	Verbs
gelato (concrete noun) 'icecream'	mangiare (I conjugation) 'to eat'
libro (concrete noun) 'book'	volare (I conjugation) 'to fly'
treno (concrete noun) 'train'	venduto (II conjugation) 'sold'
panico (abstract noun) 'panic'	rotto (II conjugation) 'broken'
domenica (abstract noun) 'Sunday'	costruendo (III conjugation) 'building'
estate (abstract noun) 'summer'	dormendo (III conjugation) 'sleeping

Table 4. List of fillers

Finally, one concrete primitive noun, *mondo* 'world', and one primitive verb belonging to the II conjugation and conjugated at the past participle, *bevuto* 'drank', were chosen as warmups.

All items, except for the warmups, were presented in a randomized order. The items were presented orally and visually in a support booklet. Each page of the book represented an item, which consisted of three parts: a picture drawn by us, which illustrates the event; a sentence containing missing word; three words to fill the gap in the previous sentence (Figure 1). The English translation of the sentence in Figure 1 is ‘To introduce myself, I always give the other person a handshake’.

Per presentarmi do ogni volta una _________ di mano.

a. stretta

b. stringitura

c. stringata

Figure 1. Example of a test item (deverbal nominal via conversion)

As seen in Figure 1, the three words listed under the gap (a-c) consisted of the target item and two distractors. The two distractors were morpho-phonologically plausible Italian complex words, artificially built by merging together meaningful bound and free morphemes. Moreover, of the two distractors one was created by applying the same morphological process as in the target item and the other by applying the competing mechanism. The order of presentation of the three words was randomized. To compose the sentences, we respected the following criteria: (i) when the target word was a noun, the DP was always in post-verbal position; (ii) verbs were conjugated in gerundive, past participle and infinitive form; (iii) the maximum number of syllables per sentence was 15/16; (iv) all predicates were inflected in the active voice.

The experimental task was administered individually in a private and quiet room during the morning or the first part of the afternoon. Each session started with instructions followed by a short practice and the warmup phase. The experimenter read aloud the sentence and the three options, with an appropriate and unmarked intonation. Participants were asked to choose one of the three lexemes to fill the gap in the sentence. They could either point to the chosen word or produce it orally. All participants completed the task.

3.3 Results

We report the results providing three measures. First, we calculate the accuracy of our participants in the selection of the target item, depending on the morphological process. We therefore measure how many times our participants selected the target item when the underlying process was conversion or affixation. Next, we calculate the accuracy of our participants in the selection of the target morphological process, independent of whether they chose the target item or the distractor created with the same morphological process of the target item. Finally, we calculate our participants' accuracy in selecting the target item across the two morphological processes, depending on the output of the word formation, namely DVNs and DNVs.

As for the first measure, Figure 2 illustrates the accuracy in the selection of the target item across the two morphological processes divided for the two groups of participants, namely AD patients and neurologically healthy age-matched adults, which was our Control Group.

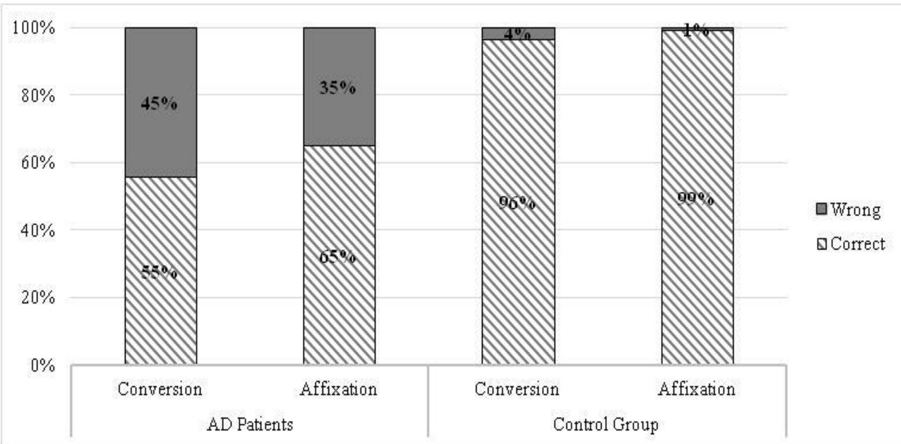

Figure 2. Accuracy in the selection of the target item by AD patients and the Control Group across morphological processes

Figure 2 shows that AD patients' performance differed from that of the Control Group. While the accuracy of the Control Group was at ceiling in both conversion and affixation, AD patients selected the distractors 45% of the times when the target items were derived via conversion and 35% of the times when the target items were derived via affixation.

To understand whether the reason for the low accuracy of AD patients lied in the retrieval of the target item or in the morphological process involved, we calculated how many times the participants selected the expected morphological process, independently of whether they chose the target item or a distractor created with the same morphological process as the target item. Hence, we considered as correct choices the instances in which the participants chose the same morphological process present in the target item. Recall that the two distractors contained an item formed with the same morphological process as the target item, but a different suffix or a different verbal base, and one item formed with the opposite morphological process to that of the target item. Figure 3 illustrates the accuracy rate in the selection of the morphological process.

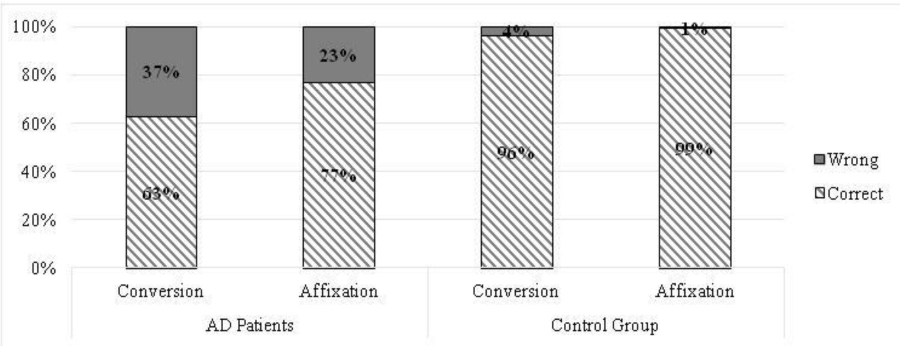

Figure 3. Accuracy in the selection of the morphological process by AD patients and the Control Group

Figure 3 shows a pattern similar to that of Figure 2: AD patients' rate of accuracy was lower than that of the Control Group. The Control Group chose the correct morphological process more frequently than AD patients, in both conditions. Comparing Figure 2 and Figure 3, we notice that the rate of accuracy in the target morphological process is slightly higher than the accuracy based on the target test item.

Finally, we calculated whether the rate of accuracy in the selection of the morphological process was affected by the syntactic category of the complex word (DNVs or DNVs). We considered as correct answers the instances in which the chosen morphological process was identical to the one involved in the formation of the target item, as we did for the accuracy in the morphological process. Figure 4 depicts the results. Note that a wrong answer means that participants selected the opposite morphological process.

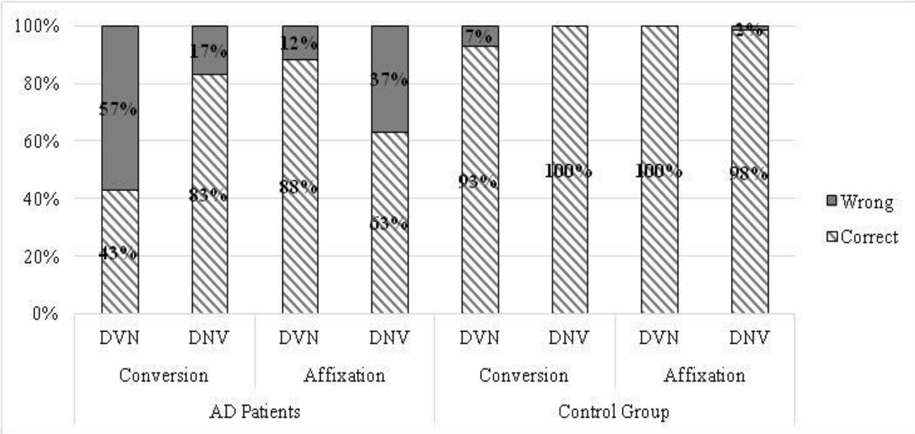

Figure 4. Accuracy in the selection of the morphological process by AD patients and the Control Group depending on the syntactic category of the complex word (DVN/DNV)

Figure 4 shows that AD patients selected the correct morphological process depending on the syntactic category of the complex word. Affixation was correctly selected in 88% of the times when the complex word was a DVN, like *cambiamento* 'change'. More errors emerged in affixation when the complex word was a DNV, like *ramificato* 'branched out'. With DNVs derived with affixation, AD patients selected the distractor formed via conversion in 37% of the cases, thereby choosing *ram-ato* instead of *ram-ific-ato*. Vice versa, when the target item was a DVN derived via conversion, AD patients chose the distractor formed via affixation in 57% of the cases. On the other hand, when DNVs were derived via conversion, their performance was quite accurate, as they chose the target morphological process in 83% of the cases. The same observation holds for DVNs derived via affixation: AD patients provided the correct answer in 88% of the cases.

Statistical analyses were performed fitting our data to a linear mixed-effect model with Jasp. The morphological process chosen by our participants (same process as the target vs. opposite process) was our dependent variable. Participants were added as a random factor. We considered the following fixed factors: the MMSE groups (very severe, severe, moderate, mild, control); the diagnosis (AD vs. Control); the gender of our participants (female vs. male); the morphological process of the target item (conversion vs. affixation); the syntactic category of the test items (DNVs vs. DVNs). The model revealed a significant effect of the factors MMSE Groups (F=15.484, $p<.001$), Diagnosis (F=110.7, $p<.001$), a significant interaction of syntactic category * morphological process (F=21.2, $p<.001$), and a significant interaction between three factors, syntactic category * morphological process * Diagnosis (F=3.5, *p*<.001). The summary of the fixed effects estimates is reported in Table 5.

Predictors	Estimate	SE	df	t	p
Intercept	1.098	0.184	183.986	5.976	< .001
Diagnosis (1)	0.775	0.361	202.680	2.148	0.033
Syntactic Category of the Test Item (1)	0.591	0.183	321.467	3.235	0.001
Morphological Process in the Test Item (1)	-0.073	0.040	342.713	-1.813	0.071
Gender (1)	0.007	0.018	327.458	0.388	0.698
Group MMSE: Mild	-0.896	0.544	199.002	-1.648	0.101
Group MMSE: Moderate	0.552	0.186	157.704	2.966	0.003
Group MMSE: Severe	0.230	0.183	192.871	1.261	0.209
Diagnosis (1) * Syntactic Category (1)	1.123	0.359	319.942	3.130	0.002
Diagnosis (1) * Morphological Process (1)	-0.107	0.065	342.352	-1.642	0.102
Syntactic Category (1) * Morphological Process (1)	0.079	0.017	324.314	4.770	<.001
Syntactic Category (1) * Morphological Process (1) * Diagnosis	-0.177	0.066	297.571	-2.691	0.008

Note. The intercept corresponds to the (unweighted) grand mean; for each factor with k levels, k - 1 parameters are estimated with sum contrast coding. Full model summary (N=371; REML= 238.122). The model was fitted using restricted maximum likelihood (Barr, Levy, Scheepers & Tily, 2013).

Table 5. Summary of the linear mixed-effect model.

AD patients' performance differed from that of the neurologically healthy age-matched adults, thereby confirming our descriptive observations based on Figures 2-4: AD patients chose the target morphological process fewer times than the Control Group. In addition, the model revealed that AD patients differed from the Control Group in a specific way. To further investigate the two interactions, we ran post-hoc multiple comparisons with Tukey corrections. The analyses revealed that AD patients' accuracy was higher with denominal verbs formed via conversion than via affixation (Estimate=0.23, SE=.070, Z=-3.25, *p*=.007). Indeed, AD patients more frequently chose items like *nid-ando* instead of the expected *nid-ific-ando* 'nesting'. In addition, denominal verbs formed via conversion were more frequently correctly chosen than deverbal nominals formed via conversion (Estimate=0.398, SE=.067, Z=5.9, *p*<.001). Conversely, AD patients' accuracy was higher with deverbal nominals formed via affixation than via conversion (Estimate=-0.42, SE=.076, Z=-5.6, *p*<.001). Indeed, AD patients were more likely to choose a complex noun like *sping(i)-tura* than the expected *spinta* 'push'. Moreover, deverbal nominals formed via affixation were more frequently correctly chosen than denominal verbs formed via affixation (Estimate=-0.25, SE=.078, Z=-3.25, *p*=.007). These patterns were peculiar to the AD patients' performance. Finally, post-hoc comparisons across the MMSE Groups revealed that the performance of the control group did not differ from that of the Mild Group (Estimate= 0.1, SE=.06, t=1.8, *p*=.36) but it differed from that of the Moderate and Very Severe Groups (Moderate: Estimate= 0.4, SE=.05, t=8.9, *p*<.001; Very Severe: Estimate= 0.6, SE=.05, t=11.02, *p*<.001). The performance of the Mild Group differed from that of the Moderate and Very Severe Groups (Moderate: Estimate= 0.3, SE=.06, t=4.7, *p*<.001; Very Severe: Estimate= 0.5, SE=.07, t=6.8, *p*<.001). Finally, the performance of the Moderate Group differed from that of the Very Severe Group (Estimate= 0.2, SE=.06, t=2.8, *p*=.046). We report that none of the groups, including the Control one, differed from the Severe one (all p's were above .24). This may be due to the fact that this profile includes only a single patient. In Figure 5 we report the accuracy rate in the selection of the morphological process depending on the syntactic category of the complex word (DVN/DNV) across MMSE Groups.

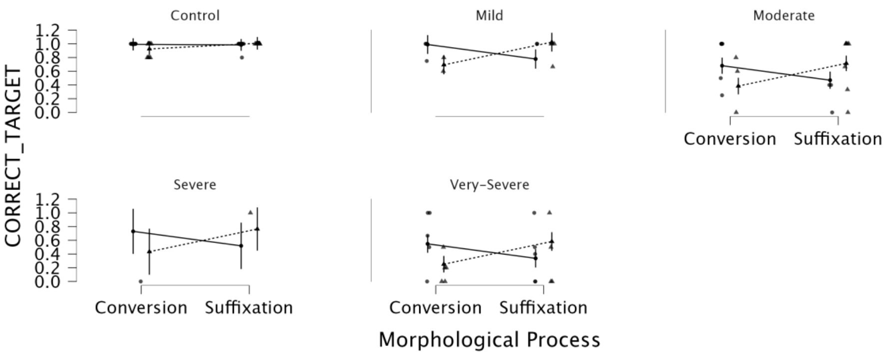

Figure 5. Accuracy in the selection of the morphological process depending on the syntactic category of the complex word (DVN/DNV), across MMSE Groups

4. Discussion and concluding remarks

In this paper we addressed how Italian-speaking AD patients perform on complex-word formation by testing affixation and conversion operations. Three research questions were formulated: (Q1) Can AD patients exploit the morphological processes of Conversion and Affixation to create new lexemes?, (Q2) Does AD patients' performance differ from that of neurologically healthy age-matched adults?, (Q3) Does AD patients' performance differ depending on the morphological operation, whether affixation or conversion?

As for (Q1), our findings suggest that overall, AD patients retain the ability to create complex words applying morphological rules. These results are in line with those reported in Ullman et al. (1997) on inflectional morphological operations in AD patients, according to which AD patients can inflect past tense verbal forms. Moreover, our analyses revealed that in case of retrieval difficulties, AD patients choose novel legitimate word-forms applying word formation rules. A similar result is reported in the study by Semenza et al. (1990), which tested the competence on Italian derivational morphology in three aphasic patients. Our results may be taken as evidence in support of a dual-route model of lexical access, suggesting that stems, affixes and word formation rules are separately stored, as proposed in Ullman et al. (1997).

As for (Q2), our findings show that AD patients and neurologically healthy age-matched adults differ in two ways. First, they differ in the accuracy rate. In the selection of the target item and of the morphological process, AD patients were less accurate than the Control Group. In addition, the two groups differed with respect to their response patterns. While the Control Group performed at ceiling in all conditions, the statistical analyses revealed a bipartite response pattern peculiar to AD patients. For deverbal nominals, the form derived via affixation was more frequently chosen than the form derived via conversion. Conversely, for denominal verbs, the form derived via conversion was more frequently chosen than the form derived via affixation. Hence, despite the overall success of AD patients in the task, word formation abilities seem to be affected in AD patients.

Finally, addressing (Q3), our results show that the two morphological operations, conversion and affixation, do not differ *per se*, rather they are selectively distributed. Conversion was the preferred morphological process to derive a complex verb from a nominal base (*baci-ato* ‘kissed’, *nid-ando* ‘nesting’), while affixation was the preferred morphological mechanism to derive a complex noun from a verbal base (*brucia-tura* ‘burn’, *spingi-tura* ‘push’). These results may receive various interpretations. Although further research is needed, the lack of a difference between the two morphological operations *per se* is in line with the predictions raised under the zero-morpheme approach to conversion. According to various studies, conversion is affixation of a zero morpheme to a base (Marchand, 1969; Bauer & Valera, 2005; Valera, 2014). Under this approach, items that have undergone conversion are predicted to display the same properties as items derived by overt affixation. Both conversion and affixation seem to be equally spared and at the same time to be equally impaired in AD patients, suggesting a unified treatment of both operations, as proposed in Bauer (2008).

The selective application of the morphological process depending on the syntactic category of the word was a rather unexpected result, to which we do not find any reference in the literature on AD, aphasics and acquisition. Under Jakobson’s Regression Hypothesis, we expected conversion to be preferred over affixation, since acquisitional studies have shown that children, in their first stages of production, preferably or only opt for conversion. Only after they have acquired the meaning of the suffixes do they produce complex words formed via affixation (Clark, 2014). However, this prediction was not met. More generally, our results cannot be interpreted in terms of competition between different principles (Dressler, 1985). Indeed, the transparency principle did not win over the economy one, i.e., affixation was not preferred over conversion, nor did the economy principle win over the transparency one, since both morphological processes were selectively applied. This selective application of the two morphological mechanisms seems to be a peculiarity of the AD population. We may think that AD patients preferred conversion to create verbs because verbal affixes always have an aspectual import (i.e., *iterative*, *inchoative*) and maybe aspect is problematic for AD patients (Manouilidou et al., 2020). Vice versa, affixation may be preferred in forming complex nouns because AD patients have problems in retrieving nouns but not verbs (see Section 1). The lexical affix clearly marks the nominal element which is formed online. Yet, this opens the question as to what the base of conversion in denominal verbs is: if the problem lies in retrieving nouns, why are denominal verbs created via conversion? One may then speculate and suggest that in this case the converted verb is not morphologically converted, which means that in AD patients there is a verb *nevare* 'to snow' but not the noun *neve* 'snow'. Alternatively, we may view the bipartite response patterns as an effect of frequency (on the role of frequency in AD see Zimmerer et al., 2016). As a matter of fact, more than a half of all derived verbs in Italian is formed via conversion, mostly of a nominal base (Rainer, 2016), while the majority of derived nouns in Italian are created via affixation (Grossmann & Rainer, 2004). Future research is needed to test these hypotheses. Regardless of the underlying motivation, we propose that AD patients' divergent and lower performance on word formation can be considered a consequence of the neurodegenerative disease and its resulting cognitive deficits. Indeed, both the lower accuracy and the selective application of the two morphological processes were peculiar to AD patients and differentiated AD patients, at least those within the moderate MMSE Group, from neurologically healthy age-matched adults. Hence, word formation may be a fruitful tool in testing and diagnosing Alzheimer's Disease.

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