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Repeating Non-Canonical Linguistic Constructions in Mild Cognitive Impairment (MCI): An Experimental Investigation

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Il linguaggio, dal momento in cui ogni essere umano nasce, accompagna non solo ogni istante della nostra vita di relazione con gli altri, ma anche la dimensione della nostra interiorità. Da questo punto di vista il linguaggio sembra qualche cosa di ovvio, di banale, di congenito, come il respirare. Basta però volgere lo sguardo intorno, cosa avvenuta assai per tempo nella storia della nostra tradizione culturale e dell'umanità, per accorgersi che nel linguaggio c'è qualche cosa di profondamente diverso dal respirare, dal camminare, dal nutrirsi.

Tullio De Mauro (1995)

Introduction

Mild Cognitive Impairment (MCI) is a relatively new clinical classification that indicates a cognition and memory deficit in people usually over 65 years old. It impairs even doing simple tasks, such as homeworking or shopping, making life harder. Healthy elderly subjects instead are able to perform each task without any problems, even though a small cognitive decline due to age is still present. This syndrome has been hypothesized to represent a preclinical stage of Alzheimer's disease (AD), although some individuals never convert to AD. Due to the high rate of conversion, research on MCI has been increasing in the recent years in order to slow down the disease progression and trying to find a treatment or, at least, to improve the main symptoms (e.g. low attention, language difficulties, forgetting or planning deficit).

Research on language abilities in MCI is very poor because the majority of studies focus on memory performance or rehabilitation programs. Memory and language are linked and when memory is impaired, language will be affected, so a subject with memory deficit will have also difficulties in learning and in repetition of complex sentences.

The aim of this study is to investigate the relation between memory and syntax, in particular analysing non-canonical syntactic structures (such as topicalization) in a language production task. We believe that MCI participants have an overall decreased performance, in particular with recalling complex structures.

After having evaluated their cognitive performance, a sentence repetition tasks was used to investigate this process. Repetition requires both language comprehension and production in order to reconstruct the target. In order to understand how repetition works, how language is processed both in production and in comprehension in healthy subjects must be explained. Repetition requires also memory to keep in mind what has been said with the exactly same words and structure. For this reason, the two most widely used memory models are described.

Chapter 1: Linguistic Framework

1.1 Human Language

Language is a unique system among all forms of animal communication. Lenneberg (1964) set different criterion about the human-specific biological capacity for language. First, a communication system is species specific. Humans are the only one to have an organized communication system like human language as highlighted in different experiments on primates, in which they cannot learn a language but rather they learn words, gestures or patterns. Second, a language must be universal. Children learn an entirely linguistic system in a very short period and with little effort in every part of the world. Third, language acquisition cannot be blocked. Language does not need to be taught since it is a natural process like walking. Every infant who is exposed to a language will acquire it and they will pass through the same milestones, learning first phonology, then lexicon and syntax, which becomes more complex as the child grows. Forth, certain aspects of language can be learned only before the early teen years. The period of language acquisition is called *critical period of language acquisition*. This statement is supported by "wild children[1]" attempting to learn their first language in their teens. Last, it is necessary an interaction with the environment in order to trigger the acquisition process. Children will not develop a language system if the target language is not accessible and nobody interacts with them, as happens with "wild children".

Language acquisition is possible thank to a biologically based preposition to acquire a language, in fact an infant will acquire a linguistic system as its brain develops. However, this is not sufficient to trigger the acquisition of a language. The *nativist model of language acquisition* is based upon this claim. It states that it is impossible for children to acquire underlying features of a language without the

[1] Human children who have lived isolated from human contact from a very young age where they have little or no experience of human care, behaviour, or language.

Universal Grammar[2] (UG) and without an *environmental input* to stimulate the acquisition process. Newborns have already a developed visual system, but they are unable to distinguish which eye sees what, so they have not depth perception. During his first month of life, visual inputs trigger how the brain distinguishes stimuli that enter from the left eye from the right eye. If something interferes during this period, the infant will never develop a normal sight.

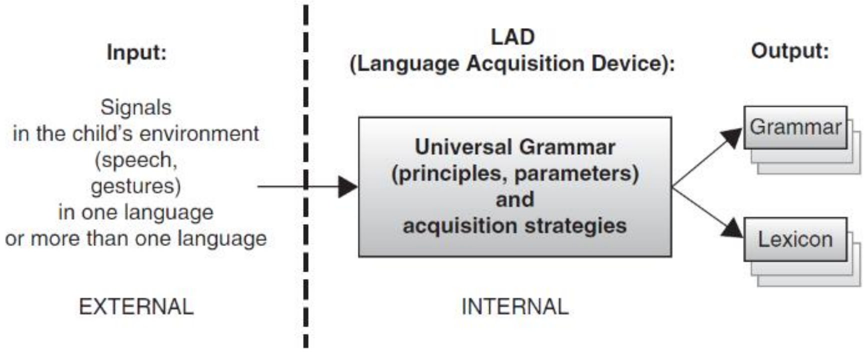

Fig. 1 The Nativist Model of Language Acquisition.
From: Fernández E.M. & Cairns H.S. (2010). Fundamentals of Psycholinguistics (p.100). Hoboken: Wiley-Blackwell)

Chomsky (1965) has called the part of the brain dedicated to acquire a language LAD (*Language Acquisition Device*). After being exposed to a language through the environment, the child processes the input using biologically endowed systems, such as UG and *acquisition strategies*[3]. The result is a grammar and a lexicon. The LAD does not generate an adult-like language performance, which will be developed as the child grows up and it will be likely completed around the age of 5 or 6.

UG plays an important role in the development of a language because it helps children setting universal principles (abstract rules) and language parameters (language specific rules). An example of universal principle is that all languages must have a subject, which can be expressed (e.g. *He eats ice* cream) or left out (e.g. *Mangia gelato*)

[2] It provides a general form of language organization, providing a set of principles that are common to all languages and a set of parameters that reflect languages differences. The child will develop first the components of phonology, morphology and syntax common to all languages, and then the child will test the parameters in order to determine which ones are appropriate for the target language.
[3] They enable the child to re-elaborate the input received from the environment in order to construct a grammar that conforms the principles of UG.

depending on the language, while an instance of language parameters is word-order. Additionally, acquisition strategies help children to determine what will be the most salient and easily acquired aspects of language, but they need time to define the correct use. If we consider verb tenses or plural forms, children usually regularize them saying *goed* instead of *went* or *gooses* instead of *geese*.

The main goal of environmental input, instead, is to provide information about the target language the child is acquiring. This is called positive evidence, since it gives all data the child needs in order to set parameters and develop an adult-like grammar. Most of this kind of data is received from other people who interact with them. The majority of adults think that correcting errors is important, but errors produced by children usually go unnoticed or are not always corrected and when they *are* corrected, the child will still continue to commit that error, as we can see in the transcription below between the linguistic Braine and his son:

(1) Child: Want other one spoon, Daddy.
Adult: You mean, you want the other spoon.
Child: Yes, I want other one spoon, please, Daddy.
Adult: Can you say “the other spoon”?
Child: Other … one … spoon
Adult: Say “other.”
Child: Other.
Adult: Say “spoon.”
Child: Spoon.
Adult: Other … spoon.
Child: Other … spoon. Now can I have other one spoon?

(Braine, 1989)

There is also negative evidence, which does not provide grammatical features of that language. Nonetheless, children will acquire their first language basing it only on positive evidence, even without rewarding or correcting their errors. Using exaggerated prosody or simplify the speech might make the item easier to understand for the child, but he will learn even without these simplifications since it is in his nature to acquire a language.

1.2 Language Anatomy

Language is stored in different areas of the brain. The first evidence of this statement comes from an aphasic[4] patient presented by Broca at the Anthropological Society in Paris (1861). The patient had received a blow to the head and from this injury he could only utter *tan tan*. After his death, it was discovered that he had a lesion in the frontal lobe of the left hemisphere. Another case was found by Wernicke, whose patient had an incomprehensible speech. He also had a lesion in the left hemisphere of the brain, but in the temporal lobe. After years of studying, it was discover that patients with Broca's aphasia had problems with speech production, whereas patients with Wernicke's aphasia can produce sentences (even though sometimes meaningless) and have problems in comprehension.

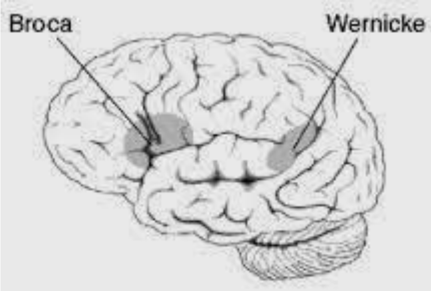

Fig. 2 Side view of the left hemisphere of the brain. Broca's and Wernicke's areas are indicated.
From: http://id.wikipedia.org/wiki/Area_Broca

These two areas are near the motor area and the auditory area. It is obvious to wonder if other components than language are affected in an aphasic patient. The explanation is given by sign users. If they become aphasic, their signed language becomes impaired, but they do not have any motor deficits.

It is generally belived that linguistic functions are located in the left hemisphere, but there are people where language is lateralized in the right hemisphere and others where language is not lateralized at all. This process, known as *hemisphere specialisation*, begins early in life and as a consequence the left side of the brain is larger than the right before birth allowing infants to distinguish better speech from non-speech. Early language seems not to be lateralized until the age of 2, so if there is a damage to the left hemisphere during infancy, the right hemisphere will take over its function.

Many investigation on language lateralization are based on studies of patients who undergo brain surgery since surgeons must know where language functions are located in order to avoid an aphasic outcome. The most common method to find out this

[4] language impairment linked to brain lesions

is the *Wada Test*, which consist in an injection of sodium amobarbital in one hemisphere. Then, the patient is asked to perform different tasks, such as counting or picture naming. Since each hemisphere controls the functioning of the contralateral part of the body and this injection produces an inhibition of the side of the brain injected, the injected hemisphere cannot communicate with the other hemisphere. Another method is *brain mapping* (Penfield and Roberts, 1959), in which a brief electric current is administered as the patient is performing a verbal task. If the patient is unable to say what he see in a picture, it is a linguistic area. If the area is not linguistic there will be no interruption.

The same results can also be obtained through less invasive operations, such as *visual field studies*[5], *dichotic listening*[6] or *neuroimaging*[7]. Thank to this studies, it was discovered that some areas in the brain where specialized in one task, such as syntax or lexicon, while others in other components. Visual field and dichotic listening studies have shown that every linguistic item presented in the right eye or ear is processed far quicker than if presented in the left eye/ear. This is because the decodification of the item follows a more direct route. If the linguistic input comes from the left side, it goes first to right hemisphere (due to contralateral nerve paths) and then to the left, where linguistic messages are processed, through the *corpus callosum,* which links the two hemispheres.

[5] The visual field is not the same thing as what one eye sees, because a visual field comes from both eyes. However, information from the left visual field goes only to the right hemisphere, and vice versa.

[6] Subjects are presented with different inputs to each ear. Studies have proven that linguistic stimuli coming from the right ear are processed faster since they arrive directly into the left hemisphere.

[7] It analyses the neuronal electrical activity while performing different tasks.

1.3 Language Production

The goal of the speaker is to encode an idea into a verbal message, which has to be comprehensible to the hearer. The message must have information that the hearer uses to decode the speech message. Encoding and decoding are the mirror images of the same process. In figure 3 encoding is represented in all its main components, whereas decoding will be analysed in the next paragraph.

The process begins with the intention of the speaker to say *The girl pets the dog*. Then, the speaker must find and select the correct words, including both semantic, morphological and phonological information. Once the lexical items are retrieved, the syntactic form is first needed and then the phonological one. The phonological representation is sent finally to the articulatory system, which produces the correspondent speech signal. All this passages last just few seconds, so we would believe that speaking is quite simple since we do it everyday without thinking. In reality, speaking is a complex mechanism that requires several components to work together. If one of these components does not work correctly, the speaker could commit a mistake, but if they are permanently compromised, it is a sign of a speech pathology.

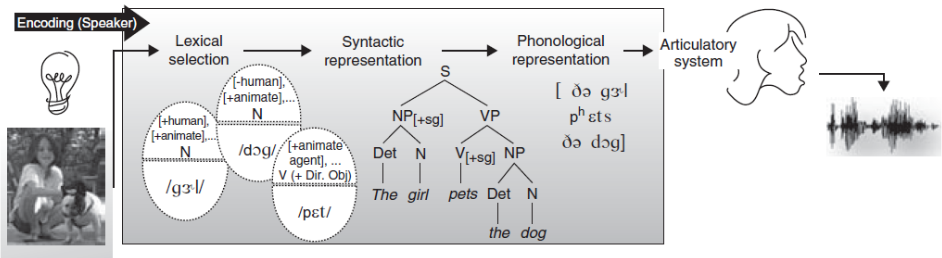

Fig. 3 Diagram of language production
From: From: Fernández E.M. & Cairns H.S. (2010). Fundamentals of Psycholinguistics (p.136). Hoboken: Wiley-Blackwell)

1.3.1 From Thought to Words

There are different theories of language production. One argues that the speaker has access to one word at a time following a rather discrete and unidirectional flow of information between levels. Models of this type are referred to as *serial processing models*.

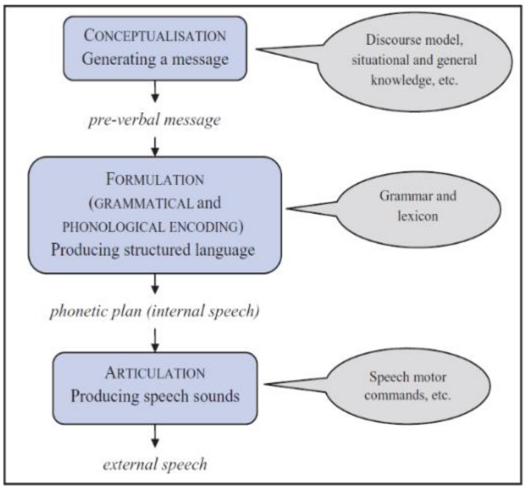

Fig. 4 Levelt and Garret's Standard Model of Language Production.
From: Warren P. (2012). Introducing Psycholinguistics (p.16). Cambridge: Cambridge University Press.

According to the *Standard Model of Language Production,* a serial model combined from Garret (1980) and Levelt (1989), language production requires assembling multiple levels of linguistic structures accurately and fluently, in real time. The speaker starts with some notion or abstract idea of what he want to say, without at first generating the words or sentences to express this. This is the pre-linguistic process of *conceptualisation*, during which we rely on our general knowledge and the setting in order to sort out our ideas. It does not involve forms of language, but it is all done 'in the head' in abstract terms. In other words, conceptualisation involves first some *macroplanning*, i.e. deciding how to achieve an intended communicative goal in a given context using speech acts. When a communicative task requires a series of speech acts, then the speaker needs both to select which information will go into the main structure and which will go into side structures, and linearize (word order), those speech acts. The speaker also needs to decide how much and what sort of information to include. Once the speaker has made initial decisions about the sequence of speech acts, each of these can be planned in detail. Through *microplanning* the speaker sets the perspective and the information structure of every speech act and decides what should be emphasised as topic information. Macro- and microplanning should be thought of as two levels of planning, rather than temporally distinct stages. That is, once a speaker has made initial decisions about the sequence of speech acts required to achieve some communicative goals, individual acts can be planned in more detail, even before the overall plan has been finished.

Proof about the existence of a planning-step in linguistic production comes from the hesitation phenomena. On these occasions, speakers interrupt their speech to choose which ideas should be expressed, which words best convey these ideas and which types of sentence structure are best vehicles for them. Planning involves mental activity that competes with the actual process of speaking. As a result, the more planning we do, the less easy it is for us to continue speaking and the more likely it is that we will hesitate. Pauses are indeed considered a measure of planning and are of different kinds: articulatory pauses (space between sounds), delimitative pauses (where a written text might have punctuation) and physiological pauses (help speakers to regulate their breathing while speaking). If we consider the difference between read speech and spontaneous speech, we could get an idea of the importance of pauses and other hesitations from a psycholinguistic point of view. Pauses are more frequent and often much longer in spontaneous speech than in reading, since spontaneous speech involves considerably more planning, and planning of quite different kinds. Since the speaker continuously monitors what he is saying and frequently decides whether there is a better or more appropriate way of getting our message across, spontaneous speech also contains more self-interruptions, false starts, and so on.

By looking at the patterns of speaking and pausing that correspond to "ideas", we generally find that the early part of each idea is marked by a lot of pausing, whereas later parts have more speaking and less pausing. The greater hesitancy at the beginning of a new idea reflects the fact that the expression of the idea has not been planned in detail in advance, but it has to be sorted out once it is started. On the contrary, if the information you want to express is readily available, macroplanning will be much briefer and less hesitant.

The result of the process of conceptualisation is a *pre-verbal message*. It consists of a set of ideas in what has sometimes been called *mentalese*, or the language of thought. These ideas form part of the mental model of what to say. They are not yet organised into an ordered string of phrases and words, which will be the task of the formulation component, also known as *lexicalisation* or *lexical selection*, where the elements of language that will express this idea are put together, drawing on our knowledge of our language, including grammar and the lexicon.

Formulation involves two types of encoding which differ according to aspects of lexical entries. First, g*rammatical encoding* involves the use of grammatical knowledge to create sentence structures that will convey a message. At this point, words are accessed from the mental lexicon on the basis of their semantic meaning, and they are known as *lemmas*. Grammatical encoding involves two separate but related components

– *functional processing* and *positional processing*. The aim of functional processing is to select lemmas from the mental lexicon and to give them the appropriate role in the sentence. Positional processing, instead, organises lemmas into an ordered string. Second, *phonological encoding* gives shape to lemmas, turning them into *lexemes* (i.e. words in their spoken and/or written form).

The final step of language production is *articulation*, involving the movement of tongue, lips, jaw and other speech organs (e.g. vocal cords). All these components work together to produce speech sounds.

Let's imagine the speaker wants to communicate the idea that a girl pets a dog. In the first step the pre-verbal message will reflect their intention to communicate at least three concepts: the concept of petting, the concept of a girl as agent, and the concept of a dog as patient. It will also include information about whether the speaker wants to highlight any of these concepts, e.g. focus on the agent or on the theme. Then, the speaker selects the lemmas {pet}, {girl}, and {dog}. Depending on how the speaker wants to convey the message, different possible grammatical roles could be given. If we say *the girl pets the dog*, the agent {girl} is assigned the job of grammatical subject, and the theme {dog} is set up to be the grammatical object.

In an alternative sentence expressing the same concept, but with different focus, (a passive sentence) *the dog was petted by the girl*, {girl} is the grammatical object, even though it is still agent, and the theme {dog} is the subject. Both the subject and the object are marked as singular and definite, which will lead to the selection of the determiner *the*. The time of the event being described will be 'past'. A possible "mental" sentence might be:

(2) (determiner) N1(= girl, sing def) V[past] (= pet) (determiner) N2(= dog, sing def)

Finally, each component of the message is given its spoken/written form.

Evidence that sentence frameworks are developed at least in part independently of the words that are placed into them comes from studies of *syntactic priming*, or structural persistence, i.e. the tendency to re-use a previously encountered structure. One form of this task requires participants to read aloud a sentence (*prime*) before then describing a picture. Typically, the kind of sentence frame that participants choose for describing the picture is biased towards the structure of the prime sentence. More specifically, if the prime sentence used a PP (Prepositional Phrase) to show the recipient, e.g. the phrase starting with *to* of a trivalent verb, participants were likely to describe the picture using the prepositional dative *to* (3). However, if the prime sentence is a double-object construction, then participants are more likely to describe the picture with a double-object (4). This syntactic priming appears to involve the syntactic structures, rather than the actual words in the sentence.

(3) Prime: *The rock star sold some cocaine to an undercover agent.*
Prepositional Dative: *The man in reading a story to the boy.*

(4) Prime: *The rock star sold the undercover agent some cocaine.*
Double-object construction*: The man is reading the boy a story.*

1.3.2 Lexical Access

The production of a sentence is more complicated then explained so far. After the planning step, where we organise our thoughts in order to create a sentence, we need to find the right words. The process of lexicalisation is divided into two stages: *lexical selection* and *phonological encoding*.

The first is the retrieval of the lemma, the abstract form of a word, from the mental lexicon. Pauses, speech errors and other data can tell us about how we put out thoughts into words. As mentioned above, pause patterns vary across speech tasks because these tasks require different amounts and types of planning. Speakers start off with a general abstract idea of what they want to say and they need to find linguistic expression for this, including finding the appropriate words. But not all words are equal – there are some words that are used more frequently than others; and there are some words that fit a particular topic or context better than others. As a result of such frequency and predictability effects, we would expect to find that some words are easier to retrieve from the mental lexicon than others. If lexical retrieval is hard, it may take longer, and may be more likely to result in a pause before the difficult word. Studies of large corpora of pause data have shown that pauses are more likely and longer before content words than before function words, since the latter is a closed and limited set of words. There are alternative explanations for this effect. One is that function words sit in a separate part of the mental lexicon with faster access. Another is that function words become available at a different stage of the production process, when the grammatical sentence frame is constructed.

One measure taken in order to better understand this phenomenon is known as *transitional probability*. It will be higher if only one word fit (*Don't look a gift horse in the mouth)* and lower when more alternatives are possible (*She was looking at the*-___). The pattern of transitional probabilities for the content words have then been compared with the likelihood and duration of pauses before each of these words. A long-attested effect is that pauses are both likely and longer when the word is unpredictable. This shows that predictability and lexical selection are based not just on what is the most likely next word in a linear string of words. Rather, it depends also on more hierarchical structure, with aspects of what we want to go on to say influencing our current word choice.

The second stage is finding the *lexeme*, which is the specification of the word form. Evidence from the difference between lemma and lexeme is given from the phenomenon called *tip of the tongue*, in which a lemma is retrieved without its lexeme due to a partial activation of the lemma from the conceptual representation. As a result, the speaker can often identify correctly some elements of the word they are looking for, such as its beginning sounds, or its stress pattern, or find other similar-sounding words. Better memory for the beginning of words ties in with the finding that word beginnings are important for finding words in the mental lexicon during comprehension. Whereas, the finding that word endings are also recalled better than the middles of words could reflect the important role of suffixes in English as markers of grammatical information and word class[8].

A similar study was carried out with native speaker of Italian, which is a language that has a grammatical gender. The researchers chose target words where the gender was arbitrary, so they avoided examples like *man* and *woman* where there would be a semantic reason for the gender, and also words where a particular ending indicated the gender, such as *tavolo* vs *sedia*. They found that participants in a tip of the tongue state could successfully report the gender of the target word, independently if they could

[8] Brown and McNeill (1966) gave participants definitions of uncommon English words, and asked them to give the word corresponding to each definitions.

report anything about the sound shape of the word. This last finding supports the idea of the two-stage process of lexicalisation – grammatical information linked to the lemma is available separately form phonological information linked to the lexeme.

Interactive Models of Lexical Access

Serial models are not universally accepted. Interactive models deals with an exchange of information both top-down (as in serial models) and bottom-up.

Caramazza presented the *Independent Network Model* (1997), which is against the idea of two lexical stages (lemma and lexeme). He proposed the existence of three separate networks, in which lexical, syntactic and phonological information of each word are specified. The lexical-semantic network deals with the word meaning, while the syntactic network deals with the syntactic traits of words, such as category, gender, auxiliary needed and so on. Unlike the Garret and Levelt's model, the lexical information can activate directly the phonological form, without passing through an intermediate lemma level. The syntactic information activation happens at the same time of the lexeme retrieval.

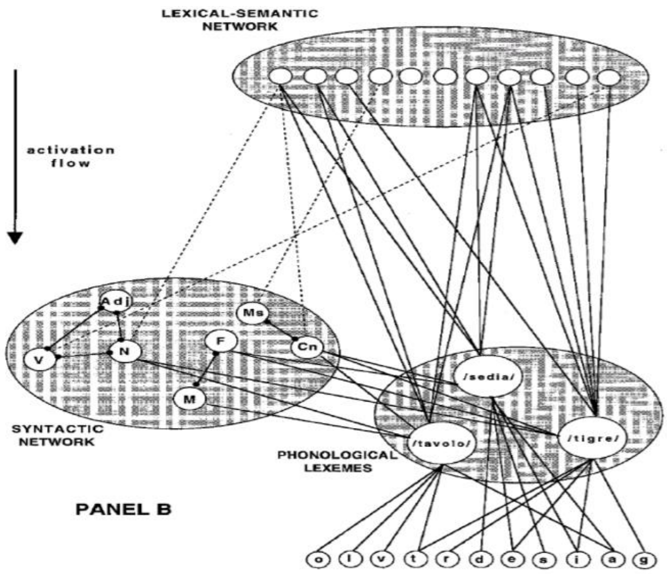

Fig. 5 Caramazza's Independent Network Model.
From: Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, 14, 177–208

In the *Interactive Activation Model* (Dell, 1986) information spreads by way of activation from units at one level down to multiple units at the next level, but then also back up to the higher-level units. This set of interconnected networks works with different aspects of word knowledge, including semantic, syntactic, phonological and orthographic knowledge. Activation flows between these networks, and during speaking, the phonological representations for words are activated to the extent that they are connected to the semantic and syntactic information that represents what the speaker plans to say.

In addition to speech errors, there is also experimental evidence which shows that both meaning- (e.g. *dog*) and phonologically-based (e.g. *rat*) relationships are important in lexical selection (e.g. *cat*). If a speaker wants to say {cat}, he will first activate the semantic features of the word. Then, the most active word from proper category is selected and linked to the syntactic frame. In turn, a jolt of activation is given to the selected word, so as to give rise to the phonological process. Again, activation spreads through the network until the single phonemes of the target word are selected: /k/ /æ/ /t/.

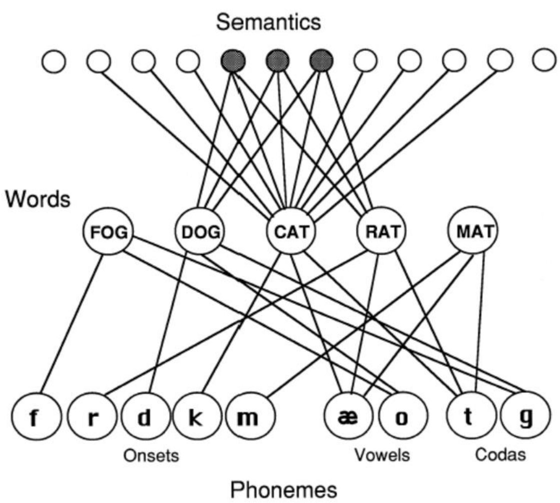

Fig. 6 Dell's Interactive Activation Model
From: Knott R., Patterson K. & Hodges J.R. (1997). Lexical and Semantic Binding Effects in Short-term Memory: Evidence from Semantic Dementia. *Cognitive Neuropsychology*, 14, 1165-1216.

Word Factors

Both models include the notion of *inhibition* trough competitive links, usually between units at the same level. The more active a candidate word is, the more strongly it inhibits its competitor. This effect is strictly linked to *word frequency*. As the name suggest, it indicates how frequent a word is used and as a consequence how fast the speaker can retrieve it form his mental lexicon. For example, a high-frequency word will quickly dominate other candidate words both because it starts off being more active and also because it will inhibit other less used words.

Other effects influencing word production include imageability and word length. *Imageability* defines the degree to which a concept can be mentally pictured (Paivio, Yuille & Madigan 1968). It can influence storage and processing of words in the mental lexicon, along with other factor such as frequency, word length and phonological proprieties. Several studies have proven that verbs are generally less imageable than nouns because nouns principally denote entities, while verbs denote relations between entities. However, due to similarities in form and meaning, a name related verb can increase its imageability through coactivation of the noun counterpart. The opposite phenomena does not show any improvement in noun retrieval. Imageability effects usually do not show up in confrontation naming, but in naming on definition.

Also *word length* induces errors. In fact, longer words are harder to produce than shorter ones. The reverse length effect can be demonstrated through repetition tests, focusing on phonological network. Short words may cause errors in comprehension, on the contrary, output errors are much probable to arise from long words.

1.3.3 Producing Morphologically Complex Words

Once we have found the words, we have to build them following some morphological and phonological rules. The *morphology* of a word is its structure defined in terms of the meaningful parts that constitute it, which is called *morpheme*, whereas the spoken form of words are made of *phonemes*, which can have more than one *allophone* or phonetic realisation. Morphological and phonological production processes occur at the same local level, i.e. at the *positional level* of the grammatical encoding.

A key issue in the discussion of the production of morphological structure is if morphologically complex words are constructed as and when needed or if they are fully listed in the mental lexicon. Evidence of the constructed nature of morphological words is given by *inflectional morphology*. Stranding errors (when the movement of the word leaves behind an affix) typically involve grammatical endings, traditionally known as inflections, for example *It just started to sound* > *It just sounded to start*. This shows that the affixed form is constructed during speech production. If this were not the case and the complete affixed form is retrieved from the mental lexicon, then we would predict that the affix remains with the relevant stem.

If we take in consideration a language with plenty of irregular forms, such as English, we note that not all English plural and past tense forms involve the simple affixation of ending onto stems. It would be reasonable to expect that the irregular forms are stored as complete forms in the lexicon and accessed as such rather than being constructed as and when needed. Nevertheless, irregular past tense forms are also involved in English speech errors:

(5) *I'd know one if I heard it* → *I'd hear one if I knew one*

Here the exchange is clearly of the underlying morphemes for the stems 'know' and 'hear', and not of the full forms, which would have resulted in the error *I'd heard one if I know it*. The location that 'know' has been moved to in the error is a location that has been specified at the functional processing stage as {past}, and the subsequent process of specifying word forms results in the insertion of the correct irregular form, rather than a regularised *knowed*. The abstract entity {past} is merged with 'know' in the error in any case, even if it is not as specific as /d/.

There are some arguments against the idea that all inflected forms are looked up in the mental lexicon. First of all, it is clear that the regular forms are used, in a rule-like way, to form past tenses or plurals of new words. Children learn at quite an early stage that forming plurals – an inflectional process – is highly regular and therefore predictable. One of the first tests that demonstrated generalisation is J. Berko-Gleason's *Wug Test*. If we asked participants – even children – to give a plural form for the not-existing noun *wug*, then they would respond with wugs (/z/).

Other evidence comes from morpheme shift errors, such as *pointed out* > *point outed*. There is no reason to expect that looking up a stored past tense form of 'point out' in the mental dictionary would produce anything other than 'pointed out'. The error arises because the regular past-tense rule is applied to the entire multiword unit *point out*.

Errors involving a negative prefix provide further support for the argument that negative prefixes are stores in an abstract form {NEG} in the mental lexicon. At the functional level, the abstract form of the target sentence *I regard this as imprecise* → *I disregard this as precise* would include a {NEG} element linked to the object clause. In fleshing out the utterance during positional processing, the {NEG} gets misplaced, and modifies the verb in the main clause. In the error it is clearly the abstract {NEG} form that is misplaced, rather than the exact phonological form that would have been attached to the target stem, which would have produced the nonword 'imregard'[9].

1.3.4 Syntactic Processing

Lexical entries that are retrieved must be combined into a syntactic structure. In Garret's and Levelt's language production model, this is hypothesised to involve two separable stages of processing - functional processing and positional processing. At this second level, lemmas and their previously grammatical function are converted into phrase structure. In other words, individual words are structured into larger linguistic units.

Bock (1986) argues that activation processes appear to have an important impact on the mechanisms of language use, including those responsible for syntactic structures in speech. Some implications of this claim were examined with a syntactic priming procedure, which showed that the probability of a particular syntactic form being used increased when that form had occurred in the prime. This *syntactic repetition*

[9] Accommodation, i.e. the allomorph of the morpheme that occurs in the error is appropriate to the word on which it occurs, and not to the word on which it should have occurred.

effect suggests that sentence formulation processes are inertial and subject to probabilistic factors as the frequency or recency of use of a particular structural form.

The effects of priming were specific to features of sentence form, independent of sentence content. The empirical isolability of structural features from conceptual characteristics is consistent with the assumption that some syntactic processes are organized into a functionally independent sub-system. In essence, the activation or strengthening of information persists over time, increasing the probability that the activated or strengthened information will influence subsequent cognitive processes.

The evidence for activation processes in language production is most striking in everyday speech errors. For example, mistakes such as "*Do I have to put* <u>*on*</u> *my seatbelt* <u>*on*</u>*?*" have been interpreted as a reflection of the simultaneous activation of two different syntactic structures capable of expressing the same semantic intention.

A different notion is that an episodic representation of a previous heard or spoken sentence *directly* influences the formation of subsequent utterances. Unlike Bock's claim, a number of experiments suggested that the repetition effect could *not* be fully explained by the maintenance of the question in working memory, or by its persistence in an articulatory buffer or by long term storage of the surface structure. It is unlikely that syntactic preservations result from anything along the lines of the activation of words, since grammatical sentences do not constitute a discrete set.

Another alternative hypothesis is that the syntactic processes are responsible for sentence generation or interpretation. It assumes that grammatical patterning in speech results from the application of cognitive realizations of syntactic rules. However, there have been too few systematic observations of syntactic persistence to make identification of its possible causes, and most of those that appear in the literature can perhaps be explained without appealing to the activation of syntactic procedures, for example though maintenance or reinstantiation of information in memory.

Syntactic Activation Hypothesis – Bock

The advantage of the syntactic activation hypothesis is that it provides a unitary explanation for phenomena that otherwise seem quite disparate. Bock's experiments (1986) were embedded in a recognition memory test that made speaking appear incidental in order to minimize participants' attention to their speech. Thus, there was no need for subjects to maintain active the priming sentence in memory. On each priming trial, the participant heard and then repeated a priming sentence in a particular syntactic form, for example the sentence *The corrupt inspector offered a deal to the bar owner*. After repetition, a drawing unrelated to the priming sentence was presented, such as a picture of a boy handing a flower to a girl, and the participant described it. The picture might be described either as *The boy is handing a flower to a girl* or *The boy is handing the girl a flower*. The first of these descriptions has the same syntactic form as the priming sentence, while the second is different.

Bock demonstrated that an utterance takes the grammatical form that it does because the procedures controlling its syntax are more activated than the procedures responsible for an alternative form. In the priming experiments the higher level of activation was an automatic consequence of the prior production of the same syntactic construction.

Her experiments are consistent with the hypothesis that syntactic processing is *isolable,* so it can be manipulated independently of higher level conceptual processes. Evidence supporting this claim comes from the syntactic repetition effect. Changes in conceptual relationships between the priming sentences and the sentences used to describe the pictures neither eliminated nor significantly modified it. This argues that syntactic processes to some degree follow their own lead.

There are two broad implications of such evidence for isolability, one methodological and the other theoretical. Methodologically, these experiments address a classic problem in the study of syntax in language production – the need for experimental paradigms in which structural variables can be manipulated independently of content variables. Because the priming technique introduced in these experiments allowed some control over the forms of utterances that were used, but in a relatively natural speech situation, it provides a way to explore many unanswered questions about syntactic processes in sentence production.

The theoretical implications of isolability derive from the relevance of such findings to the claim that the structural features of sentences are determined somewhat independently of message-level processes, i.e. they do not have access to all of the information available to message formulation processes. Garrett's and Levelt's model assumes such encapsulation, postulating a specifically linguistic representation created during the formulation of an utterance that is neutral with respect to certain message features. This provides a natural explanation for the occurrence of syntactic repetition effects despite changes in conceptual relationships.

Bock's *Conceptual Accessibility Hypothesis* assumes that (a) variations in conceptual accessibility influence the assignment of semantically specified words to grammatical functions, and (b) the grammatical functions correspond to surface rather than deep structure roles. (a) implies that assignments to grammatical functions such as subject and direct object will be affected by the ease of finding a lexical representation consistent with the intended meaning. Whereas (b) assumes that the subject is assigned first with other functions following according to a hierarchy of grammatical relations. In this hierarchy, the subject dominates the direct object, which dominates the indirect object, which dominates yet other objects.

There is obviously much more than conceptual accessibility to be taken account of in the functional integration process, for instance thematic roles (agent, patient, beneficiary, etc.) of message elements, the compatibility of these roles with the types of arguments allowed by the verb or predicate to which words are linked (the verb's specification of functional relations), and the strength of alternative verb forms (e.g., the passive versus the active form of a transitive verb).

Some evidence for an *integration process* with these characteristics can be found in an experiment by Bock & Warren (1985), where they examined grammatical function assignments. If functional integration proceeds by assigning the subject role to the first available and appropriate noun, as the accessibility hypothesis predicts, the subject of sentences should tend to be more imageable than the direct objects. Likewise, concepts assigned as direct objects should tend to be more imageable than those assigned as indirect objects. There was indeed a reliable tendency for more concrete concepts to appear as the subjects rather than direct objects in active and passive sentences, and for direct objects to be more concrete than indirect objects in prepositional and double object dative sentences. In addition, concreteness did *not* predict the order of words**,** suggesting that the effects were indeed attributable to the assignment of grammatical functions and not to simple serial ordering mechanisms.

The conceptual accessibility hypothesis also predicts that the integration process will be influenced by *semantic activation*. A highly activated word should be integrated into a functional representation faster than a less activated word. As a result, highly activated words will tend to occur more often as the subjects of sentences than as the objects.

According to *language production model* proposed by Pickering and Branigan (1998) [10], the lemma stratum (functional processing) encodes the selection of combinatorial nodes, representing the base form of words, and syntactic property nodes. After this activation, information is sent for construction of a fully specified constituent structure (positional processing). It appears that once people have constructed earlier levels of representation, they are ready to make a choice about which construction to use. And priming affects that choice. For example, the lemma {give} is connected to the syntactic category node 'verb' and various nodes related to 'time', 'aspect', and 'number'. The verb node is activated whenever {give} is activated, and the relevant feature nodes are activated as appropriate. When the form *gives* is used in a sentence, it means that the present tense and singular number nodes have been activated.

Syntactic Process: One-Stage or Multi-Stage Operation

A final question is whether syntactic process is a one-stage operation or not. The multiple-stage (dominance-only or two-stage) account draws on the assumptions of transformational grammar, namely that sentences involve (at least) two fully specified levels of constituent representations - a surface structure, and a deep structure. The one-stage (or single-stage) account, instead, draws on the assumption that the syntactic structure is a random choice.

Evidence in favour of the single-stage account comes from Bock, Loebell, and Morey (1992). They found that speakers processed (and hence represented) in a related manner the subject of an active sentence and the subject of a passive sentence. They argue that the argument associated with the subject role of a passive sentence is directly assigned to the structure position reserved for subjects and production does not involve

[10] Recent revisions of language production models have suggested an alternative, specifically related to verbal configuration of sentences. Basically, it has been proposed that some verbal features might be accessed and constructed.

relation-changing operations during functional processing (such as underlying objects becoming surface subjects). Further evidence comes from Bock and Loebell (1990), who found that sentences containing a locative by-phrase such as *The foreigner was loitering by the broken traffic light* primed passive descriptions involving an agentive by-phrase just as much as another agentive sentence did.

There are also theoretical and experimental reasons to advocate an alternative multiple-stage account. This model hypothesizes two stages. The first specifies the hierarchical aspects of constituent structure but does not specify linear order. It would compute a representation consisting of, for instance, a verb phrase (VP) node that dominates a verb node, a noun phrase (NP) node without specifying that the verb node preceded the NP node. This representation contains only "dominance" information about which phrases dominate others (e.g. a VP node dominates verb, NP, and prepositional phrase nodes) but not "precedence" information about the order of phrases.

In the second stage, the speaker converts this representation into a second one called *linearization*, which specifies word order.

To better understand the difference between the single-stage and dominance-only account, let us consider the choices to be made in the production of dative sentences. Dative verbs are compatible with three constructions, namely:

(8) Prepositional Object: *The girl gave the flowers to her mum* → V NP PP
Shifted: *The girl gave to her mum the flowers* → V PP NP[11]
Direct Objects: *The girl gave her mum the flowers* → V NP NP

All three sentences have different constituent structures, but the first two share dominance relations, in the sense that both involve a VP dominating a verb, a NP and a prepositional phrase (PP). By contrast, the last one involves a VP dominating a verb and two NP. Figure 6-A illustrates the one-stage account, where a simple choice among the three structures is made. Figure 6-B illustrates the two-stage account, where the first

[11]In English, shifted constructions (PP precedes NP) are acceptable but relatively rare. Their occurrence appears to be closely linked to the length and new information content of the direct object noun phrase (that is why it is also called "heavy NP shift"). Indeed, when the noun phrase is longer than the prepositional phrase and conveys new information, shifted constructions may actually be produced more frequently than PO constructions.

stage involves selecting between the Direct Objects or shifted analysis and the Prepositional Object analysis, and where the second stage involves selecting between the Prepositional Object and shifted analyses if the appropriate choice is made at the first stage.

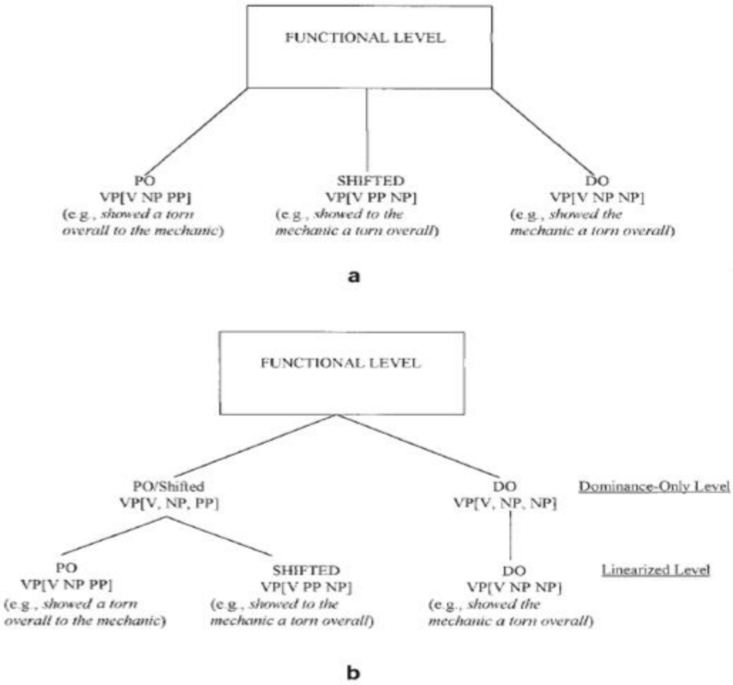

Fig. 7 Pickering and Branigan's one-stage account and two-stage account. PO=Prepositional Object; DO=Direct Objects). From: Braningan H.P., McLean J.F. & Pickering M.J. (2002). Constituent Structure is formulated in One Stage. *Journal of Memory and Language*. Vol. 46, Issue 3, 586-605.

Pickering and Branigan (1998) used a syntactic priming experiment to distinguish the dominance-only and one-stage accounts. Encoding should be sensitive to priming, so it should be possible to prime the construction in the one-stage account. In the two-stage account, it should be possible to prime both the dominance-only representation and the linearized representation. In the one-stage account, if the prime is a shifted sentence, there is a binary choice between Prepositional Object and Direct Objects response. If there are no priming effects on these constructions, then the shifted prime should be indistinguishable from a baseline prime. On the other hand, the two-stage account predicts that both Prepositional Object and shifted primes should increase the likelihood that the Prepositional Object/shifted representation is activated. Because shifted responses are hardly produced, activation should proceed to the Prepositional Object representation at the linearized level. Therefore, both Prepositional Object primes and shifted primes should prime the production of Prepositional Object responses, whereas Direct Objects primes should prime the production of Direct Objects sentences.

The data suggests that shifted responses are affected by the prior production of shifted sentences but not by the prior production of Prepositional Object responses. This is in accordance with the one-stage account but not the two-stage account, because the shifted prime bears no special relationship with Prepositional Object target responses any more than with Direct Objects target responses. In other words, the choice between different structures is random, but it can still be affected by frequency and recency of use of a particular syntactic structure.

1.3.5 Phonological Encoding

After the morphological components of a word have been selected, they need to be given form. This process of giving sound to the abstract form of the word is known as *phonological encoding*. The lexemes are made available via links with the lemmas that have been accessed during the grammatical encoding. So the concept {cat} is linked in the mental dictionary both to the written from <cat> and to the spoken form /kæt/. The process of phonological encoding inserts the appropriate word-forms into the structure. Subsequently, the function words are filled in, along with grammatical endings such as the marker of past tense or plural form. A phonetic plan is then generated for this string, which will drive the articulators. The detail of the phonetic plan will depend on the chosen word-form and on the utterance context, which will affect aspects of pronunciation such as which words will be stressed for emphasis or contrast.

Evidence for phonological encoding comes from studying speech errors. The majority of sound errors occur within local phrases rather than across larger sentence structures. Since there tend not to be many words of the same word class within a phrase, most sound errors also involve two words of different word classes.

(6) Role of simplicity → soul of simplicity
Copy of my paper → poppy of my caper
Cup cake → cuck cape

Sudden death → sedden duth

The non-randomness of sound errors leads to some important conclusions concerning language production at this level. One observation is that sound errors are more likely to result in real words, rather than in nonwords. One possible answer to this pattern is *illusory*. This means that we misperceive or reinterpret the nonsense resulting from sound errors as real words. Another is that there are important constraints on sound errors:

- *Metrical structure constraints*: the sound involved in sound errors tends to come from syllables that are either both stressed or both unstressed. The interpretation is that the stored specifications of words include information about their stress patterns. The good recall of stress position when people are in the tip of the tongue state is a further piece of evidence. An experimental evidence is given from tongue-twisters. It is achieved by asking participants to spend a short time silently reading a sequence of words (e.g. *parrot fad foot peril, repeat fad foot repaid, parade fad foot parole*) and then to say them out loud repeatedly and as quickly as possible. By careful choice of the words, experimenters have been able to explore whether certain properties are more likely to result in confusion and therefore in error. Errors are more likely when both sounds (e.g. /p/ and /f/) are in word-initial position compared to when one sound is the initial sound in one word and the other is a medial sound in another word. They are also more likely between two sounds that are stressed syllables than between a sound that begins a stressed syllable and another that begins an unstressed syllable.
- *Syllable structure*[12] *constraints*: peaks exchange with other peaks (e.g. *sudden death* > *sedden duth*), coda consonants swap with other coda consonants (e.g. c*up cake* > *cuck cape*), and onset consonants exchange with other onset consonants (e.g. *start smoking* > *smart stoking*). This last class, where onsets swap with other onsets, is the type of speech error known as

[12] English syllable structure is hierarchical. The syllable must minimally have a peak, which is usually a vowel (*eye* /a^{i}/. The peak is the only obligatory part of the rhyme. The rhyme can also have a final consonant or sequence of consonants, forming the coda (*ice* /a^{i}s/). A coda-less peak can also combine with an onset consonant (*lie* /la^{i}/). Finally, both onset and coda position can be occupied (*lice* /la^{i}s/.

spoonerism. Their distinctiveness could derive from the fact that onsets of words are very important for accessing words from the mental dictionary, so that any disruption to onsets will have noticeable effects for the listener.

- *Phonetic similarity*: there is a strong tendency for the sounds involved to be phonetically similar and to come from phonetically similar contexts (onset with onset, peak with peak, etc.). It has been observed that the onset consonants in spoonerisms are likely to be phonetically similar (e.g. *car park* > *par cark,* /k/ and /p/ are both voiceless stops and both are followed by the /a/ vowel).

These constraints have been interpreted in terms of *slots-and-fillers approach* to phonological encoding. It suggests that when a lexeme is converted into a sound pattern, phonetic segments are mapped onto a template for the lexeme, in which metrical and syllabic structures are specified. Since the speaker has a number of words lined up for production, there is potential for the sounds of these words to be misallocated. Errors reflect the need to match the proprieties of the sounds to those of their places in the template, then these are likely to attract the sound, resulting in error.

The discussion above has assumed that there is no controversy over the interpretation of the errors as being of a certain type, as either sound errors or word errors. In some cases, though, this is not clear. For instance, in (7) there could be a perseveration of the /v/ in 'you've' or a word substitution of 'prevented' for 'presented'.

(7) *And you've prevented – presented us with a problem*

1.3.6 Articulation

After the abstract phonetic representation is ready, it is sent to the motor areas of the brain, where it is converted into directions to the vocal tract to produce the requested sounds. With this final step, the speaker is able to actually produce words and sentences that were in his intentions.

During speech, air from the lungs must be released with a precise amount of strength in order for the larynx to control the vibrations of the vocal folds and allowing the right pitch, loudness and duration of the signal. In addition, the muscles of the lips and tongue must be coordinated to produce that précised sound. During a conversation there are not pauses, so neither the phones nor the words are segmented.

The most important aspect of speech production is *coarticulation*. The articulators are always performing motions for more than one speech sound at a time, so sounds are influenced from upcoming sounds and produced sounds. Speech sounds overlap and blur together in order to help the articulators to work better, producing 10 to 15 sounds per seconds or even more if the speech is quicker. For example, when the speaker pronounces the word *key*, while the back of the tongue is making closure with the top of the mouth for the [k], the lips begins to spread in anticipation of the following [i]. This would be impossible if each sound were produced entirely and without coarticulation, the speech rate would be too slow and disconnected to be comprehended correctly.

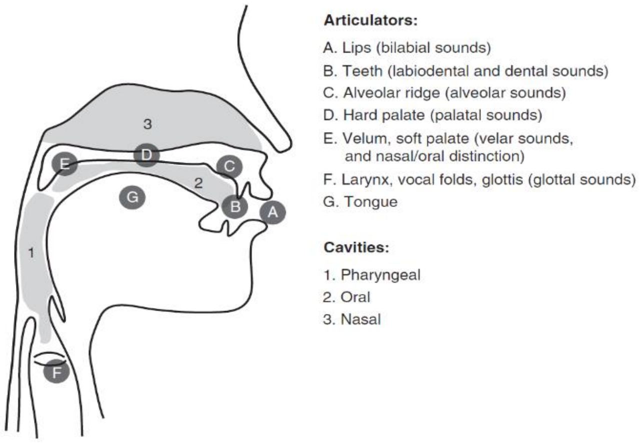

Fig. 8 Vocal tract. Articulators and cavities are indicated,
From: Fernández E.M. & Cairns H.S. (2010). Fundamentals of Psycholinguistics (p.155). Hoboken: Wiley-Blackwell.

1.4 Language Comprehension

After having analysed how language is produced, we will see how the hearer recognises and understands the message. From the perspective of the individual listener, starting from Bachman and Palmer (1996), researchers generally assume that listening comprehension is the ultimate product of the interaction of two separate competences: grammatical knowledge (phonology, morphology, syntax and lexicon) and *metacognitive strategies*. More precisely, listening comprehension implies both bottom-up processes, namely speech perception and word recognition, and top-down processes. That is to say, it is greatly affected by non-linguistic knowledge about the world and about the topic/context, cognitive and metacognitive strategies, semantic, cultural and pragmatic knowledge. To decode a message, the hearer must first reconstruct the phonological representation and then he matches it to the lexical item with the same sound. However, this is not enough to understand the message. The hearer has to analyse also the syntactic form, which is necessary to comprehend the meaning of the sentence.

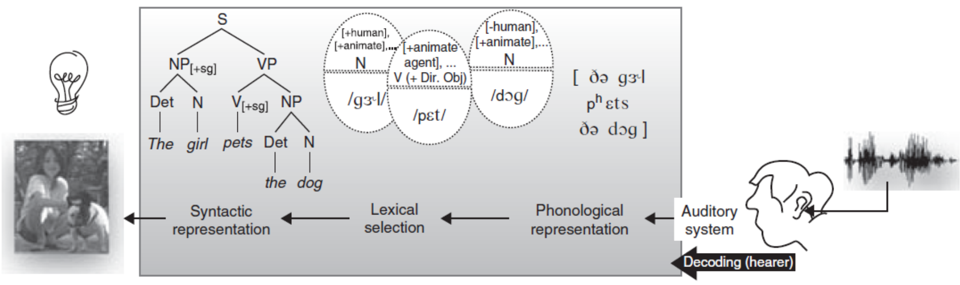

Fig. 9 Decoding process from hearing to understanding.
From: From: Fernández E.M. & Cairns H.S. (2010). Fundamentals of Psycholinguistics (p.170). Hoboken: Wiley-Blackwell.

1.4.1 Perception of Language

The first step of comprehension is to identify the phonetic elements that are mixed together by articulatory processes. There are seldom clear boundaries between words, but signal continuity helps the listeners to follow better a stream of speech. This is called is *pre-lexical analysis*, and involves perceptual processes which organise the input into linguistically relevant units known as phonemes[13] in order to identify word-differentiating units. Hearers are able to recognise a word even before the auditory signal corresponding to it is incomplete, since pre-lexical analysis can start with a small portion of speech.

There have been various attempts to frame aspects of speech perception in models. One distinction made in these models is the degree of involvement of the listener. In *passive models* it is assumed that we have a stored system of patterns against which we match the heard sound. Then a score is given for how well it matches and the best match is selected. Automatic speech recognition systems work with this method. *Active models*, on the other hand, affirm that our perception is based on our abilities as speakers. The input is matched not against a stored data, but against the patterns the listener would use to say the same concept.

Speech perception is overloaded by *variability*. The received input is highly variable, so speech sounds differ from speaker to speaker even though the abstract idea is the same. This is due to physical factors (vocal tract shapes and sizes, chest cavity sizes, etc.), emotional state (if the speaker is angry, he will shout) and ambient noise (the voice might sound different in a quiet room or through a phone). Another factors that cause variability are phonological units, sentence context and neighbouring words because they affect how the speaker pronounces individual lexical items. All of these factors can be a problem for the hearer because too much variability will result in difficulty in identifying the intended sound or message. Think about how hard is to hear someone talking to you in a loud room – most of the time the message has to be repeated or you misunderstand some words.

The speech perception mechanism overcomes variability thank to the hearer's knowledge of their own speech production system. The hearer perceives different sounds as belonging to the same phonetic category, so a speech stimuli will be classified either as belonging to category X or to category Y. This phenomenon is called *categorical perception* (Liberman et al. 1957). It is the speech perception system's way to convert an acoustic signal into a phonological representation and can be explained by voice onset time (VOT). VOT is the lag between the release of a stop[14] consonant and

[13] The phoneme is the smallest unit of sound that distinguishes one word from another (e.g. *cat* vs *cap*).
[14] Stop consonants are /p/, /b/, /t/, /d/, /k/, /g/.

the onset of voicing for the following vowel. If we consider /b/ and /p/, /b/ has a VOT between 0 and 30 milliseconds, whereas /p/ has a VOT between 40 to 100 milliseconds. The results of a test where subjects were asked to identify which of these two sounds they heard proved that if the sound was short, 80% of the time they heard /b/; in contrast, if the sound was long, 80% they heard /p/. This experiment has demonstrated that categories have sharp boundaries. On the other hand, recent approaches to language perception have claimed that our memory allow us to store multiple representation for a given unit or *exemplar*, which can provide a possible coping mechanism for variation.

Another characteristic of speech perception is that is constructive. This means that the speech perception system tries to construct a linguistic image from any acoustic sound. Evidence of this occurrence is given by *phoneme restoration* (Warren, 1970), in which if a stimulus arrives while a linguistic unit is being processed, the stimulus will be perceived as happening either before or after the linguistic item. The phoneme restoration illusion is stronger when the replaced sound and the sound used to fill in the gap are closed acoustically (Samuel, 1981). Warren recorded the sentence *The state governors met with their respective legislatures convening in the capital city* and replaced the [s] in *legislatures* with a cough with the exactly duration of the [s] sound. Most of the listeners believed to have heard the [s] with a cough in background either before or after the word and not in the middle of it. The [s] and the cough are high-frequency tones, so this replacement is more effective than replacing the [s] with a silence. The reason of the phonological illusion’s success lies in the lexical retrieval system, which checks the phonological representation of a word against what has been heard. This process is known as *post-access matching*. If the match is good enough, the word is retrieved.

The phoneme restoration also demonstrated the perceptual system’s ability to “fill in” missing information while recovering the meaning. This fill-in process is based on using contextual information in order to check among different possibilities. For example, your mother tells you a sentence, from which you have understood only some words – *fluffy, bowl, buy.* Thanks to contextual information (in this scenario you own a cat and you are the one who usually buys him food), you can understand the meaning of that sentence even without having heard all the words. At the same time, people can understand nonsense words as words, so speech perception based only on acoustic signal can be possible.

The fill-in process is helped by *cue integration*, which helps distinguishing a particular sound from another in the sound inventory of a language. The McGurk effect (McGurk & MacDonald, 1976) is a valid example. Normally, we are able to see people we are listening to, and their mouth gives us cues about the sound they are saying. If visual cues and auditory cues do not match, we will merge them. For instance, if the auditory cues indicates /ba/, but the visual one is /ga/, we will hear /da/. However, this is not enough to distinguish words because there is also suprasegmental information (duration, pitch and loudness) that needs to be recovered, which make distinguishing words easier. Think about the pronunciation of [hæm] in *ham* and in *hamster*. In the first word [hæm] lasts longer than in the second one, so the hearer can use this information to identify the correct item.

1.4.2 Lexical Access

Once the acoustic signal is decoded, the hearer has to match the phonological representation to a lexical entry. When there is a match, the word is retrieved with its meaning and structural information.

The first step to achieve this is to establish a link between the input and the stored word. The search can be simultaneous with more than one stored word or one word at time. This process is known as *contact*. Regarding parallel lexical processing, the *Cohort*[15] *Model* of Marslen-Wilson and Tyler (1980) shows that once the acoustic signal is converted into a phonological representation, all the

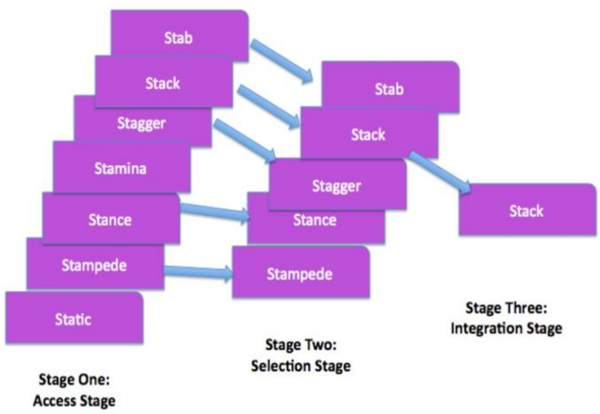

Fig. 10 The Cohort Model – Marslen-Wilson and Tyler (1980). The three stages of input-word matching are indicating with examples.
From: Lexical Access – Wikipedia (https://en.wikiversity.org/wiki/Psycholinguistics/Lexical_Access)

[15] A word's cohort consists of all the lexical items that share an initial sequence of phonemes, such as *spoke*, *splendid* and *spare*.

lexical items matching the stimulus are activated. After the first syllable is processed, all the lexical entries in its cohort will be activated (access stage), but as soon as the second syllable is analysed, just a subset of them will remain activated (selection stage) Before the end of the word, if the target word is unambiguous, a single lexical item will be retrieved (integration stage). This point is called the *recognition point*. However, if the word is ambiguous, the recognition point will be found only at the end of the word since all lexical entries with the same sound will be retrieved. If there is no match the word is deactivated.

Evidence the presence of these stages comes from mispronunciation of word beginnings, which is detect more often than mispronunciation of word endings, supporting the importance of the first two stages to comprehend the input word. The phoneme restoration phenomena is another proof since it is stronger in the middle or in the final part of the word.

Forster's *Search Model* (1976) affirms that the checking of the input against the mental lexicon is only done one word at a time. The input is known as *access file*. It is first checked according to the type of input (orthographic, phonetic and syntactic/semantic input) and then to a *master file*, which is a complete list of words in the mental lexicon.

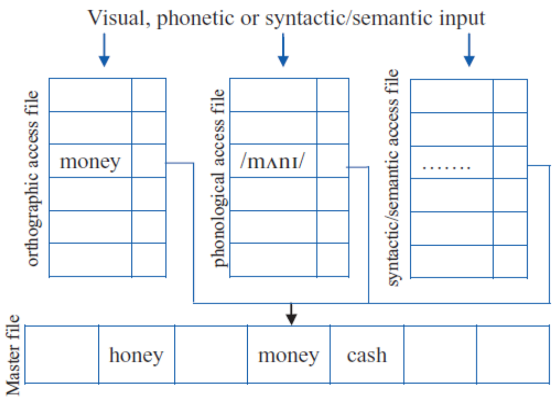

Fig. 11 Forster's Search Model (1976). An example for input-word matching in visual and phonetic input.
From: Warren P. (2012). Introducing Psycholinguistics (p.145). Cambridge: Cambridge University Press.

The speed of matching is influenced by lexical frequency and lexical ambiguity. Lexical frequency indicates how many times a word appears in a large corpus, hence a frequent word will be retrieved faster than an unusual one. Since retrieval depends on a lexical item reaching some activation threshold, high-frequency words reach this threshold faster than low-frequency. Lexical ambiguity, instead, designates a word with multiple meanings, which compete against each other, slowing the retrieval. An example of misleading interpretation is given by garden path sentences (8):

(8) The two masked man drew their guns and approached the bank, but the boat was already moving down the river.

Their name comes from an English idom (*lead down the garden path*) meaning misleading. The hearer gets first to an incorrect interpretation, then to the realization that the sentence has little sense, and finally to the correct reanalysis of the sentence. *Bank* was first interpreted as the financial institution, but only arrived to *river* the hearer will realise that the writer intended *river bank*.

Another example of lexical ambiguity processing is given by Cairns and Kamerman (1976). Both *pipe* and *cigar* are high-frequency words, but only *pipe* is ambiguous. The results of their study proved that the reaction time after *pipe* was longer, confirming that ambiguous words needed additional processing resources. In case of lexical ambiguity, all possible meanings linked to the phonological entry are activated and then the rightful meaning is selected among the entries to best fit the context. If the context gives a bias for one of the activated meanings, the context-appropriate word is selected, otherwise the most frequent meaning is selected.

(9) a. Frank took the pipe down from the rack in the store.
b. Frank took the cigar down from the rack in the store.

Lexical retrieval can be affected by *neighbourhood density* and *similarity*. A word's neighbourhood are all the phonologically items similar to the lexical item. Words with larger neighbourhoods, or cohorts, take longer to be retrieved since more phonological information is required to activate the right word. Regarding similarity, the closer is the phonological input to the phonological representation, the faster is the retrieval.

Once the matching process is finished, a word must be selected. Each word has a uniqueness point, where a word can be clearly identified. If we consider non-words, the same process is claimed to occur, even though they do not have stored representation. This is possible because we do not know before whether a word is real or not, so we are not able to use different strategies in advance. Therefore, sound-matching words will be activated and then deactivated until no candidate remains. This will be the *deviation point* from a real word.

1.4.3 Syntactic Processing

The next step is identifying the syntactic relations which leads to recover the basic meaning of the sentence. This process involves recovering abstract mental structures based only on the hearer's knowledge of language.

Simple Clauses

The incoming signal must be deconstructed into individual clauses. According to constrain-based accounts, only certain types of information are used in the initial analyses of sentences. In globally ambiguous sentences people have a preferred interpretation since they usually fail to notice the ambiguity. (10) has two interpretations – *with the binoculars* is either the modifier of *boy* or an argument of the verb *saw*.

(10) The man saw the boy with the binoculars.

In local ambiguities, instead, the information coming later in the sentence will disambiguate it, as seen in garden path sentences. In these models, syntax is logically independent of semantics. This claim has been demonstrated in sentences like (11):

(11) Colourless green ideas sleep furiously

Chomsky (1957) affirm that the significance of this sentence is that it is syntactically well-formed, despite being semantically anomalous. Psycholinguistics have affirmed that syntactic considerations determine the initial and preferred structural analysis of a sentence, which is then compared with the semantic interpretation. If this matching is incompatible, a reanalysis is needed. In other words, the initial syntactic analyses is checked by the semantic processor.

An alternative view is the *Unrestricted Race Model* (Van Gompel & Pickering, 2007). When there is an ambiguous sentence, the various possible analyses compete each other and the fastest structure that is built is then activated. Like in garden path sentences, a syntactic analysis is built before it is evaluated.

Complex Clauses

The syntactic processor must also compute the hierarchical information among words and put them in a linear sequence. It has to choose which syntactical structure to build and it usually chooses the simplest structure available due to minimal attachment (a subject, a verb and an object). For example (12), *Michelle* is a good candidate for a subject, *knows* for the verb and *the boys* for the object. If the next word is *are*, the sentence must be reanalysed, which is easily done in this case.

(12) Michelle knows the boys are noisy

Minimal attachment (Frazier, 1978) is a theory that one interprets a sentence in terms of the simplest syntactic structure. If we consider the sentence below, the preferred interpretation has *that everybody hated a lie* as a complement of the verb *told*. The other alternative, which is less preferred, is one where *that everybody hated* is a modifier of the noun *professor*.

(13) The student told the professor that everyone hated a lie.

The verb *told* needs two arguments – what was told and who it is told to. Who was told to is *the professor* and what was told can be expressed with a complement, which is analysed as containing a subject (*everyone*), a verb (*hated*) and an object (*a lie*). The complement is analysed as a relative clause according to the minimal attachment since it is the simplest structure.

Sometimes the syntactic processing must choose between equally complex structures. Such ambiguities can be resolved with *late closure strategy*, i.e. the integration of new words into the current syntactic constituent. In (14) the relative clause *who was on the balcony* refers either to the maid or to the actress, but, according to the late closure, there is a preference for modification of the more recent noun (*actress*).

(14) Someone shot the maid of the actress who was on the balcony

After each sentence has been processed, the hearer must understand the entire message. The interpretation of longer stretches of speech requires integration of information and the construction of a mental model (Johnson-Laird, 1983). First, the hearer does not remember the information as separate pieces, but rather he integrates the new information in a unique message. The mental representation constructed needs a mental model, where world knowledge and inferences about the situation are integrated.

Chapter 2: Memory

2.1 Neuroanatomy of Memory

Our nervous system is essential to receive and elaborate any information in order to give the appropriate response. It is divided into two subsystems – *central nervous system* (CNS) and *peripheral nervous system* (PNS). PNS is formed by all nervous cells except brain and spinal cord, which are part of the CNS. It works as an auxiliary to the CNS and its main function is to manage information flow between the nerves and the CNS.

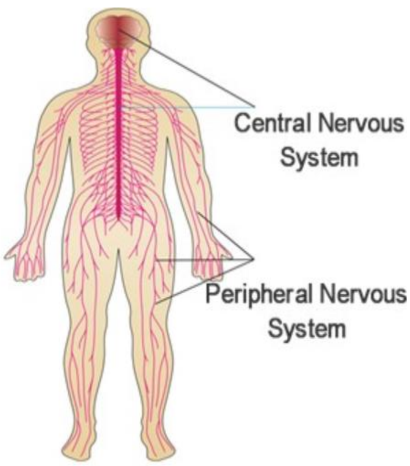

Fig. 12 Human nervous system, divided into CNS and PNS.
From: The Nervous System (http://www.womens-health-advice.com/nervous-system.html)

CNS is formed by brain and spinal cord, both located inside bones in order to be more protected against traumas. In addition to the protection from the bones, they are protected by a fluid called *cerebrospinal fluid*, which takes care of waste coming from the brain. However, these two forms of protection are not enough. To prevent infections, when our blood stream arrives to the brain, it has to go through a blood-brain barrier, a network of small blood vessels that filtrates beneficial substances from damaging ones.

Brain and spinal cord have different functions – the brain works as a manager that can be influenced by its subordinates (the organs), whereas spinal cord functions as an intermediate that handles information from and to the brain. This bidirectional flow of information is controlled by *receptor nerves* and *effector nerves* located in the spinal cord. As their name suggests, receptors receive the information from the peripheral nerves and effectors convey the motor information from the brain. Nevertheless, the spinal cord can act on its own, i.e. the information will be sent to the brain later, in order to minimize damage, for example when we fell pain we step back from the source. These actions are known as reflexes.

The brain is a complex structure divided into two hemispheres linked through the *corpus callosum*. The importance of the corpus callosum has been clearly understood from surgeries on patients with severe epilepsy during the 1960s. Their corpus callosum was cut creating a split brain, where each hemisphere was unable to communicate with the other. Gazzaniga (1967) tested the visual information processing of a patient who underwent this surgery. The visual elaboration of the left field happens in the right hemisphere and vice versa. If the stimuli were presented to left side, he could tell what he saw, while if the stimuli were presented to the right side, he said that he saw nothing even though he was able to draw it. This happens because left hemisphere is the one that elaborates verbal processing and due to the split brain the right hemisphere is unable to send the information to the left one.

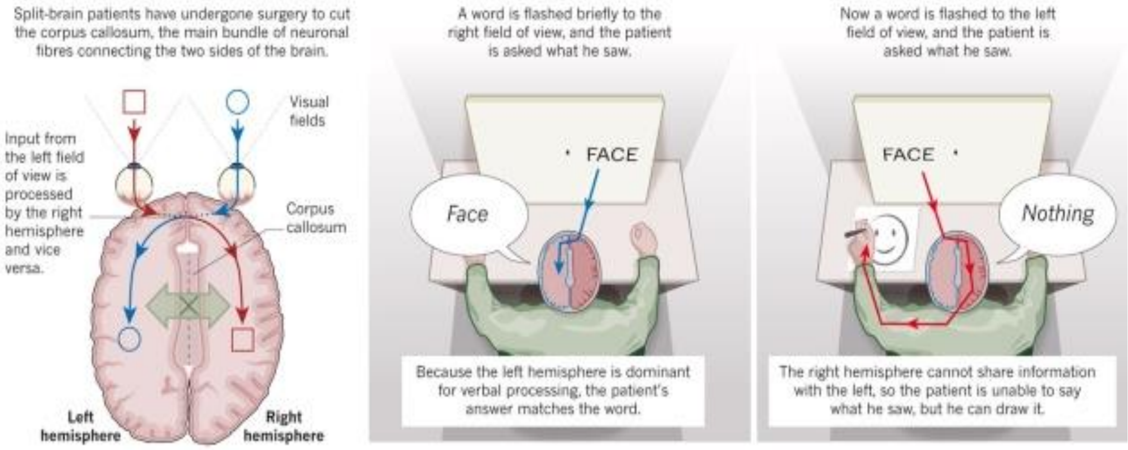

Fig. 13 Visual processing of split-brain with right or left eye.
From: Wolman D. (2012). The Split Brain: A tale of Two Halves. *Nature*, Vol. 483, Issue 7389. Online. (https://www.nature.com/news/the-split-brain-a-tale-of-two-halves-1.10213)

Alternative Classification of the Brain

An alternative division of the brain is *forebrain*, *midbrain* and *hidbrain*. Forebrain is the forward-most region of the brain, which controls body temperature, reproductive functions, eating, sleeping and emotions. Throughout embryonic development, it will divide into two hemispheres. It is formed by the diencephalon and the telencephalon. Thalamus and hypothalamus are part of the diencephalon, whereas the cerebrum is developed from the telencephalon. The cerebrum includes the basal

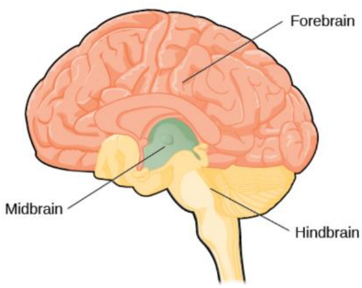

Fig. 14 Brain division into regions.
From: https://www.researchgate.net/figure/The-three-parts-of-the-brain-Hindbrain-Midbrain-and-Forebrain-source_fig2_317485174

ganglia and the cerebral cortex, which covers all the brain. The cerebral cortex is also known as grey matter because in this site there are the nervous cells whose colour is grey. The complexity of brain functions is strictly connected with the size of the cerebral cortex.

Most of input goes though the thalamus, which works as an intermediate station that directs sensory input to the right brain area. An important brain area located in the thalamus linked to memory is the *limbic system*. Unlike fishes and reptiles, humans (and all mammals) have a developed limbic system. Therefore, humans are more able to control their instincts and to adapt. Part of the limbic system are the amygdala, linked to anger and aggression, septum, linked to anger and fear, and hippocampus, linked to creation of memories. The hypothalamus operates with the limbic system in order to regulate survival behaviour.

The midbrain is less important for mammals than for other species since it controls visual and auditory information. It also works as connection between the forebrain and the hindbrain.

Hindbrain contains medulla oblongata, pons and cerebellum, all of which support vital functions. Medulla oblongata controls heart activity, breathing and digestion and at the same time works also as meeting point where the nerves coming from the right side go to the left side of the brain and vice versa, but the role of transmitting information from one side to the other is given to the pons. The cerebellum regulates movement, balance and some aspects of memory.

Memory Location

Memory is characterized by the storage of fleeting or life-long information. In the first case is called *short-term memory* and in the second *long-term memory*. When we think about ‘memory’, we are referring to conscious long-term memory. In other words, all those information that we are able to recall consciously.

Short-term memory functions as a temporary storage to process new information or hold old one while we engage in other cognitive tasks (e.g. reading), whereas long-term memory is a permanent information storage. *Declarative memory* and *non-declarative memory* are two major classification of long-term memory. Declarative (or explicit) memory is the conscious recollection of facts and events. Episodic memory is formed by personal experiences and semantic memory by all general facts and concepts. Non-declarative (or implicit) memory is a collection of skills, habits and disposition that are inaccessible to conscious recollection. It may be procedural, i.e. involving motor skills (e.g. riding a bike) or it may result from priming, which occurs when exposure to a stimulus influences the response to another.

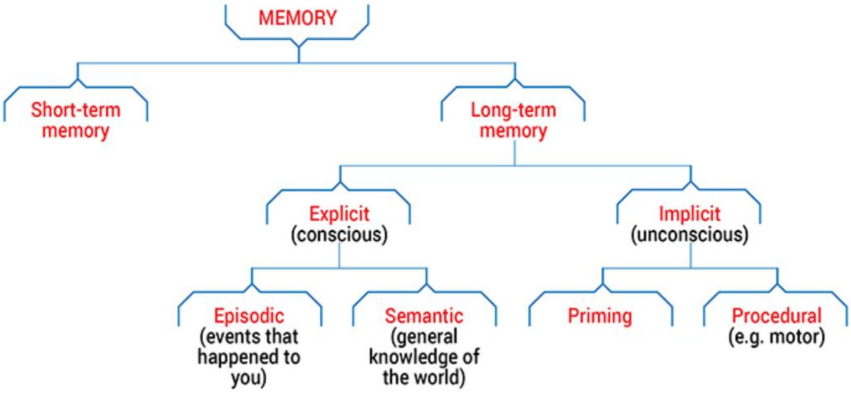

Fig. 15 Types of human memory divided in short-term memory and long-term memory.
From: https://qbi.uq.edu.au/brain-basics/memory/types-memory

Neuroimaging on patients with and without brain lesions has shown that the mechanisms of memory are located in different areas of the brain. The functions associated with each area are not meant to indicate a single function as the brain works as a connected network.

The temporal lobe, the hippocampus in particular, is the location of declarative memory. The hippocampus is essential for the formation of memory and its consolidation after learning, hence, damages to this area impair the ability to create new memories. It works together with neocortex[16] to support long-term storage. The role of the hippocampus slowly declines once gradual changes in neocortex establish long-term storage. The successful retrieval of stored memories happens when brain activity resembles the original brain state that was present during learning. Evidence in supporting role of the hippocampus comes from research on monkeys and on humans suffering from memory impairment of declarative memory. The findings have

[16] It is located in the cerebral cortex.

demonstrated that memory does not work as a unitary entity, but rather as separate subsystem that collaborates with the other subsystems.

The basal ganglia and the cerebellum are both responsible for habit formation, movement, learning and motor control. They are essential for non-declarative memory, otherwise we will be unable to dance, drive or play an instrument. Evidence supporting the role of the basal ganglia as motor controls comes from Parkinson's patients, who have impaired movement due to damage to this brain area.

The amygdala (located in the hippocampus) helps with the formation of memories, both in declarative and non-declarative memory. The memory storage depends on the release of stress hormones from the adrenal gland, which influence the forebrain. Emotional arousing is located in this area and thanks to it emotionally linked events are remembered better than neutral ones. This occurrence explain phobias, post-traumatic stress disorder (PSTD) and other anxiety disorders. For example, if a child is attacked by a large dog, he might have a long-lasting fear for dogs.

2.2 Atkinson-Shiffrin Multi-Store Memory Model

Human memory is a complex system which is based on dynamic mechanisms of retention and storage of information. The basic operations of memory are *coding*, transformation of sensory data into a mental representation, *storage*, how the information is stored in the brain, and *retrieval*, how the stored information is retrieved from the memory and used.

According to Atkinson and Shiffrin (1968), memory is characterised by permanent structural features and control processes. Permanent structural features indicates the memory structure, whereas control processes are processes selected and controlled by the subject in his effort to remember.

Coding

Their multi-store model breaks down memory into three components, which interacts one with another not only to help memorizing, but also to allow the individual to perform different tasks, such as reading or making decisions. The first component is the *sensory register*. Here the incoming sensory information is processed for an immediate registration. Most of information we receive decay after several hundreds of milliseconds if it is not selected as important by our attentional processing[17], otherwise we would be bombed with thousands of irrelevant information. For this reason, the most important function of control processes is the selection of relevant parts of information to be transferred to short-term store.

After being processed, the information goes into the *short-term store* (STS), which works also as subject's *working memory* (WM). STS has an important role because it relieves the system from moment-to-moment attention to environmental changes. The selected information decays after 15-30 seconds, if rehearsal mechanisms creating a STS trace of the selected information are not used. Each new item that enters in the STS must eliminate an item already there due to the limited space of the STS. The

[17] The phenomenon of attention helps to elaborate only a limited amount of information from a wider amount, from which we get in touch through the senses, memories and other cognitive processes.

eliminated item is supposed to decay faster than a new one, probably because it is already in a state of decay.

Afterwards, the information arrives to a fairly permanent store[18], the *long-term store* (LTS). Even though the item is stored in a stable form here, reliable access to it may be maintained only temporary. In this level the primary function of control processes is locating the wanted information. Evidence in favour of the existence of a short-term memory (STM) and a long-term memory (LTM) is given by people with brain lesions, which can impair the ability to store new information or retrieve them. For example, patients affected by Korsakoff's syndrome[19] are unable to create new memories, but they can still remember events and people prior to their illness.

Storage

To store any kind of information, it must be transferred into LTS, but not every detail of the information will be stored. Transfer includes those control processes by which the subject decides what to store, when to store and how to store in the LTS. Then, we must find the correct placement for the information. There might be multiple copy of the same memory trace since a word can have different meanings according to the context, for example the word *division* might go with "addition" and "subtraction", but also with "platoon" and "regiment". Finally, we create an image of that information containing both the characteristics of the item itself and characteristics added by the subject. An image can also contain links to other images.

Search and Retrieval

To retrieve an information, we have to search it through the memory system. Atkison and Shiffrin (1969) claimed that memory works primary as c*ontent-addressable*. It means that when the system receives the content of, for instance, a word,

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[18] Information can be stored in LTM only after it has been stored in STM, and even then, storage in LTM is a probabilistic event. Hence, subjects cannot control storage in LTM because they are unable to predict what information will be useful later.

[19]It is an amnestic disorder caused by thiamine (vitamin B1) deficiency usually associated with prolonged ingestion of alcohol. It is rare among other people but some cases have been observed after bariatric surgeries, i.e. weight loss surgeries, when deficiency was not prevented by use of nutritional supplements.

it will return all the matched locations thank to a parallel search through all memory location. It is highly improbable that the system works the other way around, i.e. given a certain location, the memory system will return with the contents stored there, as happens in computers. Others state that the retrieval of information from memory is *self-addressing* – the contents themselves contain the information necessary to find the storage location. This means that the word has salient characteristics which help to identify the storage location. It functions with the same method adopted in libraries, where the books are ordered according to their contents.

Search is a recursive loop in which locations or images are successively exanimated in order to find the right one. Once the item is presented, the subject activates a set of linked information called *probe information* and scans the LTS for a matched image. The closest associated set found will then be transferred to STS. This subset is known as *search-set*. When a hypothetical location is found, a response is then generated, in which the subject must decide either to continue or to terminate the search. If he decides to continue, the subject begins another cycle of search with a new probe. If the search is concluded, it can be a successful or an unsuccessful search. In the first case, the information is correctly found and retrieved, whereas in the second one the information is not located. The tip of the tongue phenomenon is an example of the failure to find the searched information. It is important not to confuse interference and search failure because they are different events. Interference refers to the loss of information due to either a following input or a competitor, whereas search failure indicates the inability to find the information because the set it too big. The final step is the recovery of information, i.e. when the recovered information is placed in the STS.

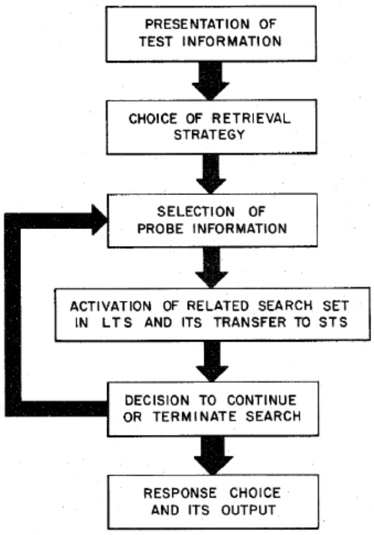

Fig. 16 Information flow during information search.
From: Atkinson R.C. & Shiffrin R.M. (1971). The Control Processes of Short-Term Memory. Technical Report 173. Psychology Series. Stanford: Stanford University.

Incidental learning supports the claim of information transfer from STS to LTS, since learning can happen even when the subject is not trying to store material in the LTS. Information transfer can also happen the other way round (from LTS to STS). In this case the flow of information is under control of the subject, since it is the subject itself who uses control processes in other to retrieve a stored information. The transfer of information from one store to another does not imply the loss of that information from the previous store because the information is not removed from one store and placed in another, but rather it is copied. The copied information remains in the store from which it is transferred and decays accordingly to the decay characteristics of that store.

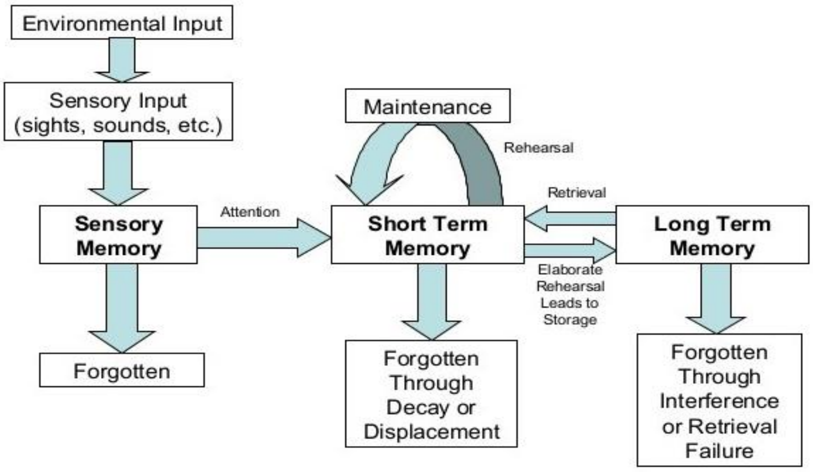

Fig. 17 Multi-Store Model – Atkinson and Shiffrin (1968).

From: Information Processing Model - Atkinson & Shiffrin. Wikipedia.

2.3 Baddeley and Hitch's Model of Working Memory

An alternative view of memory is the *Working Memory Model* of Baddeley and Hitch (1974), which concentrates on the functioning of STM. STM is divided into separable components, which work together as part of a bigger working memory system involving the temporary storage of information that is necessary for different tasks. That is to say, it works as a link between sensory information, actions and LTM.

Instead of being a unitary store as in Atkinson-Shiffrin's model, Baddeley and Hitch claim that working memory is divided into different subsets – central executive, phonological loop, visuo-spatial sketchpad and episodic buffer[20].

The *phonological loop* is a temporary storage, which holds input traces. They usually decay over a matter of seconds unless refreshed by a subvocal rehearsal system, which helps to maintain and register the information within the store. Once an auditory input is received, it is analysed and transferred to a phonological storage system. From this point, information can be fed into the articulatory control system either for direct recall or rehearsal. Subjects were tested in a recall test to support the existence of the phonological store. If the participant has to recall *cat, man, map, cab,* he will have more difficulty than with less similar sounds. The same experiment has proven that words are influenced only by sounds and not by meaning, since a list with *huge, big, long, tall, large* will be easily remembered.

Evidence for the rehearsal system comes from the word length effect. Using the same test, Baddeley has proved that longer words, such as *university, opportunity, international* and *constitutional*, are recalled less than monosyllabic words. If the participant repeats irrelevant words (e.g. *the*), the word length effect is blocked due to the maintenance of the memory trace through rehearsal of a different task. Phonological similarity can also be blocked with the same method, but only works with visual input. The two-component structure of the phonological loop is also proven by neuropsychological evidence. When words are presented visually to participants with phonological STM deficits, they show neither phonological similarity effect nor word-length effect.

[20] Added in 2000.

We need to elaborate also visual input – spatial, visual and possibly kinaesthetic information can be integrated thanks to a *visuo-spatial sketchpad*. The capacity to hold and manipulate visuo-spatial representations help to understand complex systems as well as for spatial orientation and geographical knowledge.

The role of supervision is given to the *central executive*, which is responsible for limited attentional processes. It divides attention into a number of executive subprocesses in order to perform different tasks. Hence, interference among these subsystems by a secondary task degrades the performance on the primary task only slightly.

Norman and Shallice (1980) proposed that control processes were either one called *routine control* (habit patterns), implicitly guided by cues in the environment, and another called *supervisory activation system* (SAS), which intervenes when routine control is not sufficient. SAS is one of the main factors determining individual differences in memory span, which has been proved to be a predictor of complex cognitive skills, such as reading or comprehension. Evidence of the presence of routine control comes from *slips of action*, i.e. a familiar pattern takes over another action (e.g. driving to work takes over driving to the supermarket). Evidence of SAS comes from, instead, researches on subjects with frontal lobe damage. They have impaired SAS which led to inappropriate perseveration or excessive distractibility.

The final step is the *episodic buffer,* which is assumed to form a temporary storage that allows information coming from the phonological and visual subsystems to be combined together with the matching information in LTM into integrated chunks, hence the term *episodic*. It is called *buffer* because of its ability to combine information from different modalities into a single code. Even if presented as a separate subsystem, it can be thought as the storage component of the central executive, which controls it. As a result, working memory does not simply reactivates old memories, but rather creates new representations.

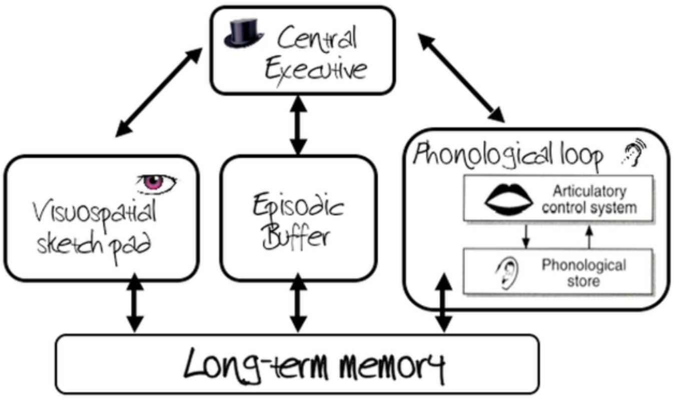

Fig. 18 Working Memory Model – Baddeley and Hitch. (1974)
From: The Working Memory Model (http://aspsychologyblackpoolsixth.weebly.com/working-memory-model.html)

Working Memory in Language Processing

Working memory plays an important role in different tasks concerning also language. If we consider syntactic processing, individual differences in working memory (either the size of the pod, the efficiency of the processes that perform computations, or both) can strongly affect the individual performance in transforming a linear sequence of words into a nonlinear hierarchical structure. This passage is essential to comprehend since a temporary storage of word representations is needed during left-to-right processing of a sentence.

Let's take into consideration an object relative (15), which is a demanding structure because it requires both movement[21], subordination[22] and long-distance relationships. The first demand on the WM system is to retain the preceding segment of the main clause (15) *the reporter* during the processing of the embedded clause since the embedded clause *that the senator attacked* interrupts the main clause. The first part of the main clause must then be reactivated at the conclusion of the embedded clause in order to understand it. Afterwards, the proper thematic roles must be assigned. This is a process that requires extra computational resources because they must be assigned simultaneously.

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[21] Movement indicates the dislocation of certain constituents from their original position to a higher one.
[22] Subordination indicates that one sentence depends on another known as main clause. This type of sentences are introduced by subordinators such as *because, which, if, that, when, while,* etc.

If we want to transform the base sentence (16) in an interrogative question, it will appear as (17). Bold script indicates which constituent has moved and the blanks mark the position out of which movement takes place. Movement causes long-distance relationships between the base position and the arrival one. In this case, we want to know which story Mary liked. The answer of the question (*the first story*) moves from its base position to a higher one, where it acquires interrogative trait.

(15) The reporter that the senator attacked __ admitted the error.

(16) John has told Peter that Mary likes **the first story.**

(17) **Which story** has John told Peter that Mary likes __?

According to the *Immediacy of Interpretation Hypothesis*, subjects try to understand each word as soon as they encounter it. In case of object relative (15), the subject needs to switch perspective from one actor to another in the construction of the referential representation of the sentence. The first actor encountered (*the reporter*) is not the subject but the object of the sentence, but it is analysed first as the subject until the verb is encountered. In a subject relative clause, instead, these demands are all mitigated because the preceding segment of the main clause is maintained shorter in the WM and the thematic roles can be assigned as soon as the verb is processed, leaving only one role to be assigned later.

Text comprehension works in the same way. According to Ericsson and Kintsch (1995) the major role of WM during reading is the storage of a representation of the text. This representation is divided into linguistic surface structure (traces of the words in the text syntactically, semantically, and pragmatically integrated), propositional textbase (a representation of a text and its structure), and a situation model, which integrates textual information and background knowledge. During reading a structure of the text is created and continually expanded to integrate new information, therefore relevant parts of the text must remain accessible creating a cohort representation. If the text comprehension processes fail to generate a representation due to text difficulty or lacking of knowledge, the retrieval of the information needed may involve time- and research-consuming searches.

Demanding structure comprehension, such as (15), can be explained by retrieval operations, since the main cause for comprehension error is retrieval failure. Foraker and McElree (2011) supported Atkinson and Shiffrin's content-addressable memory. They analysed two types of retrieval operations – serial search retrieval and direct-access retrieval. *Serial search retrieval* is characterised by one-by-one search and it is strongly affect by the number of items in the memory set that must be searched through. As the number of items increases, retrieval time will slow down. *Direct-access retrieval*, on the other hand, is a one-step one-cue operation which provides access to the needed information via a content-addressable representation. To clarify, cues make contact with memory representations, so it avoids searching through irrelevant items. Unlike serial search retrieval, direct-access retrieval is not affect by the width of the item set.

Through a Speed-Accuracy Tradeoff (SAT) Procedure[23], Foraker and McElree demonstrated that the speed of comprehension was not affected by the amount of material intervening between the dependent elements (18-21):

(18) The book <u>that the editor admired</u> ripped.

(19) The book <u>from the prestigious press that the editor admired</u> ripped.

(20) The book <u>that the editor who quit the journal admired</u> ripped.

(21) The book <u>that the editor who the receptionist married admired</u> ripped.

Results reinforced the assertion that the representation formed during comprehension is content-addressable, allowing a direct access to the information linked to the cues. Thus, the rapidity of language comprehension can be a consequence of the use of cue-driven operations, since direct-access retrieval permits the rapid recovery of past representation without the time cost found in serial search. At the same time, it is highly susceptible to interference due to matching cues to different items. In language comprehension, failure of retrieval or wrong retrieval would result in a degraded interpretation, which can only be corrected with reanalysis.

[23] One can perform a task at a faster speed but with the cost of lower accuracy, or vice versa.

Chapter 3: Mild Cognitive Impairment

3.1 What is MCI?

3.1.1 Pathophysiology

Mild Cognitive Impairment (MCI) is not a specific condition, but rather a descriptive condition that affects cognition, memory and thinking in particular. A cognitive decline is normal with age, however, between 5 to 20% of people over 65 years old have a decline that is greater than in healthy subjects but less severe than with dementia. The National Institute of Aging and Alzheimer's Association Workgroup has recognized MCI as an intermediate stage between normal cognitive aging and Alzheimer's Disease (AD) and other types of dementia. Given the high rate of conversion from MCI to AD (40-60%), it is important to treat MCI in order to slow down the dementia progression.

Compared to research on other pathologies, MCI research is still at an early stage. Even the definition of MCI itself is still a "work in progress" – over the years different terms have been used to describe this intermediate stage of cognitive decline. At first it was called *benign sentence forgetfulness*, but, as the name suggested, it included only memory deficits. In 1986, the National Institute of Mental Health workgroup proposed *age-associated memory impairment*. This new criteria confronted memory performance of old people to young people. Later, the term *age-associated cognitive decline* was proposed and it was the first to include multiple domain decline. Alternatively, the Canadian Study of Health and Ageing has used the term *cognitive impairment – no dementia* to indicate a stage characterized by cognitive impairment insufficient to constitute dementia. The term MCI was initially used in the 1980s by Reisberg and colleagues to indicate individuals with a Global Deterioration Scale rating of 3. Unfortunately, the degree of disability alone does not determine a specific diagnosis.

MCI describes a set of symptoms and not a specific disease. The more common symptoms are forgetting, planning deficit, problem-solving impairment, low attention, language difficulties and visual depth perception deficit. Since the symptoms are mild, daily life is not significantly affected.

Burns and Zaudig (2002) stated the existence of an asymptomatic stage of dementia, in AD in particular, where small cognitive changes are present, but they are indistinguishable from normal ageing. There are also histopathological changes related to dementia, such as *neurofibrillary tangles*[24], but they can be present without symptoms. Hence, they postulate a continuum, which starts with the histopathological changes present in the brain and arrives to diagnose of dementia (Fig. 27). For this reason it is very important to diagnose MCI as soon as possible, so patients can be kept under review and if they develop dementia, they can get treatment sooner. However, it is not always so immediate to distinguish between normal ageing and MCI, and MCI and dementia because many changes are subtle.

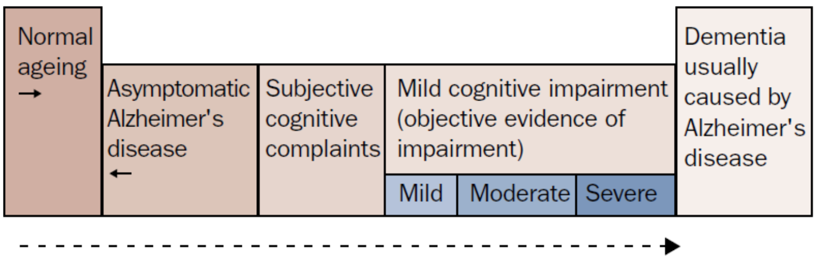


Fig. 19 Evolution of dementia.

From: Burns & Zaudig (2002). Mild Cognitive Impairment in Older People. *The Lancet*, 360, 1963-1965.

Subtypes

MCI can be divided according to which cognitive function is impaired. The most common subtype is *amnestic* MCI, in which memory loss is the main symptom, while other cognitive abilities are relative preserved. Another subtype of MCI is *non-amnestic*, in which other cognitive abilities, such as executive function, use of language and visual-spatial skills, are impaired. The non-amnestic type (4.9%) is less common than the amnestic one (11.1%) and it is usually linked to the development of non-Alzheimer dementia.

[24] They are aggregates of tau proteins that are known as the primary marker of Alzheimer’s disease.

Each subtype is then divided according to how many domains are impaired. We will talk about "single" domain when just one component of cognition is impaired (e.g. memory) and "multiple" domains when more domains are impaired (e.g. language and reasoning).

Probable Causes

There are different causes of MCI. In some cases, this condition works as a "pre-dementia", i.e. the brain disease that causes dementia is already present. Here the symptoms will get worse over time as the disease progresses. For example, a worsening of memory abilities will probably develop in AD (10-15% of MCI patients with memory loss per year). Amnestic MCI seems to have a stronger association with developing AD due to brain changes, which appear similar to the ones in AD, whereas non-amnestic MCI is linked instead with other forms of dementia. Generally, multiple-domain MCI is a precursor of both AD and vascular dementia[25] and single domain non-amnestic MCI usually develops in frontotemporal dementia[26], in vascular dementia, in dementia with Lewy bodies[27] or in depressive disorders. However, not every patient will develop a form of dementia.

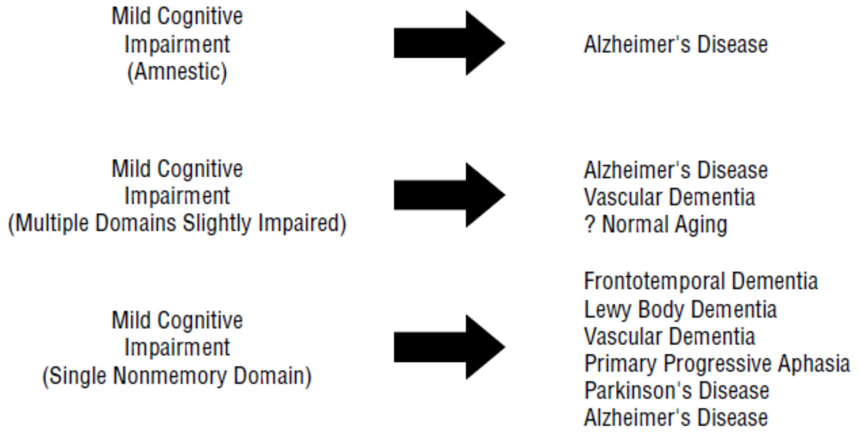


Fig. 20 Some subtypes of MCI and their probable evolution.

From: Peterson R.C. et al. (2001). Current Concepts in Mild Cognitive Impairment. *Archives of Neurology*, 58, 1985-1992.

[25] It indicates a type of dementia caused by reduced blood supply to the brain due to diseased blood vessels, for example after a stroke.
[26] It is caused by a progressive loss of brain cells in the frontal lobe or in the temporal lobe areas.
[27] It is a kind of progressive dementia due to abnormal deposits that damage brain cells.

It has been discovered that developing dementia might be linked to heart conditions, diabetes, strokes or depression, so MCI subjects will take drugs to low these problems and at the same time the chance of developing dementia gets lower.

In other cases (10-30% of patients), MCI is caused by anxiety, stress, thyroid problems, sleep apnoea, hearing problems or side effect of medications. All of these are treatable and the physician can link MCI symptoms with the type of condition rather than with MCI. In 20% of cases MCI improves or even regress. Unfortunately, this is not enough – a healthy lifestyle and keeping the brain active are usually recommended since a positive lifestyle can have a significant impact on brain health and cognitive abilities. Staying socially connected and mentally stimulated through different activities and interests are also essential to improve cognitive abilities.

3.1.2 Assessment of MCI

A clinical diagnosis of MCI is done through an evaluation of cognitive abilities and behavioural changes. This condition is still quite controversial in defining normal vs pathological cognitive decline and lacks standardized assessment tools.

Even the clinical criteria of MCI have changed over time due to its heterogeneity. Peterson et al. (1999) presented the first diagnostic criteria, where MCI population was considered a fairly uniform group. According to this criteria, the subject must complain memory loss, which should ideally documented by an informant. Then, this memory loss complain must be checked through a neuropsychological test and compared to age-matched memory performance. A specific test or score is not indicated, but generally the cut-off score is 1.5 SD below mean. A neuropsychological test includes other nonmemory cognitive domains, such as language, executive functions and visual-spatial skills, which have to result preserved. The ability to perform normal daily activities has to be conserved, even though minor inconveniences are present due to memory deficit but they are not as severe as in dementia patients. Finally, the subject must be not demented because MCI is pre-dementia stage, in which cognitive decline is less severe than in demented patients.

Later on the criteria was refined and, based on whether a principal memory deficit was present or absent, two MCI subtypes were described: amnestic and non-amnestic (Peterson, 2004; 2007). The most common criteria for MCI used states that the subject must meet:

1. Subjective complaint of memory loss.
2. Memory impairment.
3. Other cognitive functions preserved.
4. Preserved daily functions.
5. No other explanation for memory loss.
6. Criteria for dementia not met.

Recently, this criteria has been expanded to include other cognitive domains (Fig. 29), such as executive functioning and language, since general thinking, reasoning and language deficit. The expansion of the criteria was needed to determine which subtype of MCI had the subject, because each neuropsychological profile (single and multiple-domain amnestic or non-amnestic MCI) was linked to a different outcome, as seen in Fig 28. Yet, the criteria still includes a heterogeneous group, in which many MCI patients remain stable over time or even resume a normal cognitive functioning. The probable reason of the development of a broader criteria was to include less severe patients.

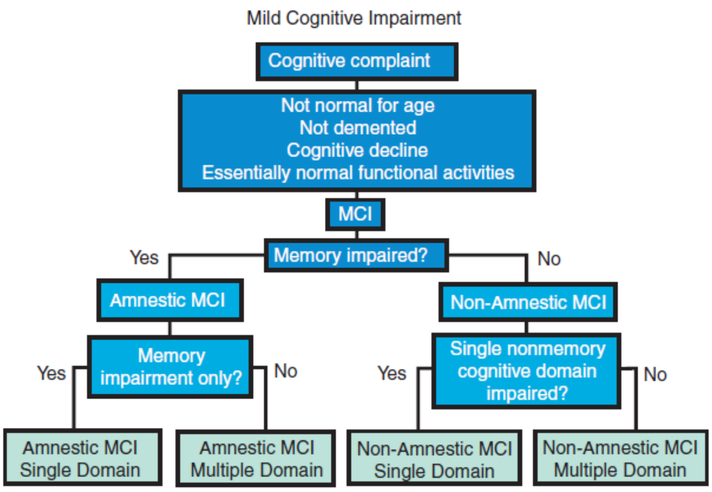


Fig. 21 MCI diagnostic algortihm.

From: Petersen R.C. (2004). Mild Cognitive Impairment as a Diagnostic Entity. *Journal of Internal Medicine*, 256, 183-194.

The process of diagnose MCI may involve medical history, observation from a family member or a friend, neurological examination and brief cognitive screening tests. Medical history and a report from family or friends is essential to exclude other pathologies, but also to detect in the first place forgetfulness. People with amnestic MCI start to forget important information, appointments, conversation or events that interest them.

After a meeting with a neurologist, a cognitive test would be likely administrated in order to distinguish MCI from normal ageing. Unfortunately not all tests have standardized cut-off scores for MCI. The selection of a screening test over the other is linked to their reliability and validity as well as the cognitive domains included in the test. Some tests are *St. Louis Univeristy Status Exam* (SLUMS), *A Quick Test of Cognitive Speed* (AQT), *Mini-Mental State Examination* (MMSE, Folstein et al., 1975) or the *Montreal Cognitive Assessment* (MoCA, Nasreddine et al., 2005).

The MMSE is one of the most common test for the identification of dementia, which is available in numerous languages and validated in as many clinical population. Clinicians have noted that it is not very sensitive to evaluate MCI individuals, subjects with early stage of AD, subjects with high IQ or subjects with Lewy body dementia or frontotemporal dementia. In all these cases, clinicians have to retake the test later because their performance is usually above the cut-off points (i.e. they obtain a score of more than 24 points).

Another widely used test is the MoCA, which was developed later then the MMSE. It has been developed as a screening tool and not as a diagnostic instrument, in which thresholds indicate the need for further work-up. Unlike MMSE, it includes executive and attentional tasks and even high level language tasks.

Recall and repetition items are too easy in the MMSE, so a subject's cognitive abilities might result normal in the MMSE and abnormal in the MoCA. This difference is also due to the fact that MoCA memory test has more words to recall with fewer learning trials and a longer delay before recall. Moreover, it differentiates well between levels of cognitive ability, so it is more sensitive to detect other forms of dementia. This test has been used also with other population, such as with subjects affected by Parkinson's disease (20-30% of patients have diagnosed with MCI), where its sensitivity to determine the presence of cognitive decline has been confirmed.

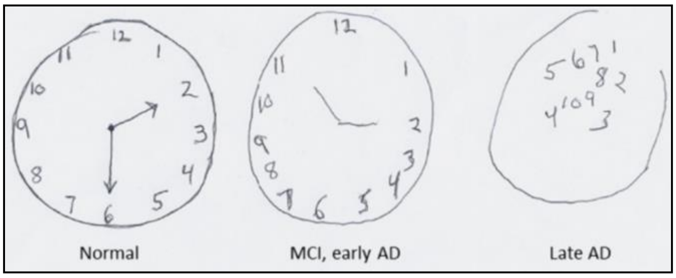


Fig. 22 An example of different performances in a processing ability task of the MoCA. The subjects were asked to draw a clock with the hours and showing the time 2:30.
From: The Montreal Cognitive Assessment, Wikipedia. https://en.wikipedia.org/wiki/Montreal_Cognitive_Assessment

Diniz et al. (2008) tested over 200 MCI patients with different cognitive tests in order to determine which was the most effective. The MMSE and the *Cambridge Cognition Examination* (CAMCOG) had moderate accuracy for the identification of MCI subjects, but the authors underline the importance of developing the MoCA, which is not based on comprehensive neuropsychological evaluation.

In some cases, MRI scans can be helpful to determine the speed of progression. Figure 31 shows the different stages of hippocampus atrophy, (indicated by the arrow) present in a healthy subject in a MCI subject and in an Alzheimer subject.

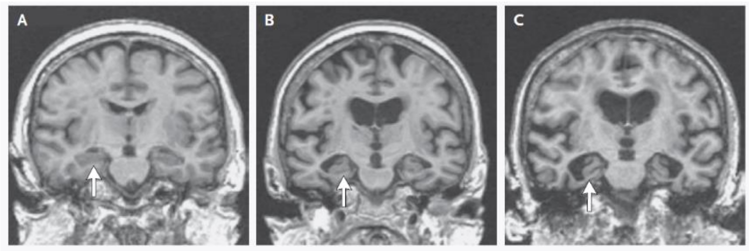


Fig. 23 Brain MRI scan showing hippocampus atrophy (arrow) in the subjects (a) healthy, (b) MCI, (c) Alzheimer.
From: Petersen R.C. (2011). Mild Cognitive Impairment. *The New England Journal of Medicine*, 23, 2227-2234.

3.1.3 Rehabilitation

There are several reason to treat MCI – memory loss can be upsetting to the patient, lowering the rate of development of MCI to dementia and slow the disease progression. MCI is a heterogeneous condition, so not every patient will develop dementia. For this reason, the risk-benefit ratio is different from other pathologies.

Unfortunately, there are not medication available to cure MCI. Most drug treatments have tested Alzheimer's medication (e.g. donepezil) to gain a lower rate of conversion of MCI to AD, but several studies have demonstrated no real change after the first year of treatment.

Regarding improving MCI symptoms, Europe and North America (USA and Canada) have different regulations. In Europe some medications, such as Ginkgo biloba[28] and hydergine, have been approved for treating memory impairment, while in North America there is not a specific treatment for MCI. In these countries, cholinesterase inhibitors (CIs) are usually administered to MCI patients because it seems to improve memory performance. Some clinicians claim that nootripcs can strengthen the neurons involved in memory activities, but proof of their efficacy is modest.

Alternative treatments include cognitive training and stimulation in order to improve memory and verbal skills. Huckans et al. (2013) have developed different types of training with different difficulty levels. According to the author, mild cognitive compromise patients find beneficial *restorative cognitive training*, which is based on repeated practice of specific tasks (e.g. recalling common objects' name). Mild functional difficulties are improved with *compensatory cognitive training*, where subjects are taught alternative strategies or skills that can compensate for functional deficits (e.g. association strategies). Last, neuropsychiatric issues are treated with *traditional psychotherapy techniques* (e.g. relaxation exercises).

Several studies have proven the positive effect on memory tests, but the evidence at the present time is still insufficient to conclude that cognitive training is beneficial in lowering progression rate in MCI. Therapists usually suggest cognitive activities with physical training even though studies on MCI subjects assessing physical exercise have not been carried out yet. A healthy lifestyle is the widest used therapy, hence be socially active and a healthy diet can lower the risk of developing dementia and other pathologies, for example hypertension, stroke and obesity.

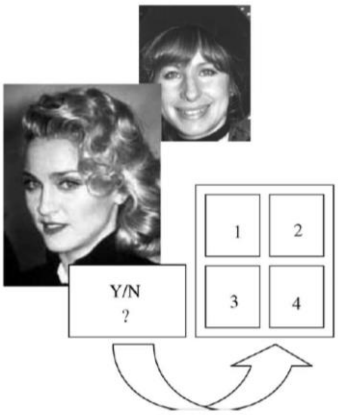
[28] It is believed to improve blood and oxygen flow to the brain supporting memory functions.

3.2 Linguistic Abilities

Numerous cognitive tests assess language performance because of its link to memory. Some studies have shown that MCI subjects have impaired semantic memory, thus they have problem in performing fluency tasks, word-picture naming tasks and object-function matching tasks, but the literature on this topic is very poor. Researchers believe that MCI subjects can show selective loss of person knowledge, which can be a predictor of Alzheimer’s Disease (AD) progression.

Some theorists state that semantic memory is linked to episodic memory, while others claim that semantic identification precedes episodic memory. Dudas R.B. et al (2005) designed a new test to evaluate the different components of semantic and episodic memory both in AD and MCI. Since AD and MCI patients have difficulties both in recognising famous people and in remembering spatial locations of patterns and faces, they tested both populations in the *Face Place Test* (FPT). It consists in:

1. Famous people identification
2. Item recognition
3. Spatial association learning



(2005).Episodic and Semantic Memory in Mild Cognitive Impairment. *Neuropsychologia*, 43, 1266-1276.

Their study demonstrated that MCI participants had indeed a significant deficit both in the placing task and in the item recognition and naming tasks. Compared to AD subjects, MCI performance was slightly better only in the placing task suggesting that non-hippocampal abilities (e.g. naming and item recognition) are impaired from early stage. Hippocampaly dependent memory (e.g. placing) gets worse as the disease progresses. Unfortunately, it is not clear whether the naming deficit in MCI participants indicates a loss of knowledge or an access deficit of proper names. Unlike common names, proper name have a single attributes making them harder to retrieve.

Semenza et al. (2003) found a person naming and identification deficit in a MCI group, which received a diagnosis of AD in the next 6 months. At the same time, a study by Delanzer et al. (2003) did not find any naming or semantic deficit in the MCI group.

In some cases, linguistic performance can vary from subject to subject, for instance some might have a single-word processing deficit while other perform as healthy subjects. When the performance was impaired, the percentage of conversion to AD was higher. This issue was first noted by Massoud et al. (2002) and then developed by Vandenbulcke et al. (2007), who tested MCI subjects and healthy subject in a semantic-associative task during an fMRI. The lower bank of the posterior third of the left superior temporal sulcus (STS) of MCI patients, where word-specific processing takes place, had a significant lower activation than healthy individuals. This finding suggest that STS might be the cause of the semantic deficit.

Others have tested other language components, such as comprehension and sensitivity to expectations. Regarding comprehension, Croot, Hodges and Patterson (1999) found that both AD and MCI individuals had impaired gist-level processing (i.e. summary, main idea of a text and express a lesson learned from the text), while detail-level was also impaired, but AD performance was worse.

Concerning sensitivity to expectations, Davie et al. (2004) used a prime task based on category vs item-specific relations to raise response biases. Becker (1980) theorised that people use their expectations to generate a set of possible answers. If the target is part of the expected set, responses are faster, while it causes inhibition if the target is not part of the set. If the prime is the word *day*, the subject might anticipate *night* as the target. If *night* is the target, then the response is fast and accurate, but if *week* is the target, the response is slow and error prone. Thus, David et al. induced specific biases manipulating the proportion of category pairs (e.g. *dog – animal*). As the proportion increases, the expectation of category target (e.g. *animal*) should increase, but if a coordinate target (e.g. *dog – cat*), inhibition will arise making the response slower. To achieve an optimal performance the participant needed vigilance to recognise the pattern and flexibility to avoid inhibition when the target did not conform to expectancy. The MCI group showed hyperinhibition likely due to a selective reduction in working memory resources. Generally, their study confirmed that MCI individuals were influenced by the expectancy bias manipulation.

Chapter 4: Experimental Investigation

4.1 Introduction

Repetition

This study used two repetition experiments to evaluate the performance of syntactic complex sentences in MCI participants, old controls and young controls. Unlike other experiments types, repetition does not require particular training and it is sensitive to differences in syntactic complexity as many studies with participants with SLI[29] (Dollaghan & Campbell, 1998; Conti-Ramsden & Botting, 2001; Bortolini et al. 2002, 2006; Friedmann, Yachini & Szterman, 2014; Arosio et al. 2014), dyslexia (Brkanac et al., 2008; Melby-Lervåg & Lervåg, 2011; Talli, Sprenger-Charolles & Stavrakaki, 2016), and autism (Riches et al., 2011; Williams, Payne & Marshall, 2012) have shown. Moreover, repetition can be used to see whether language systems differ or not (Greenfield & Savage-Rumbaugh, 1993; Gass & Mackey, 1999).

Repetition is a type of language processing task (specifically language production) that taps both into the speaker's implicit grammatical knowledge or competence in addition requires processing resources (Ellis, 2005; Erlam 2006). Under normal circumstance it involves both language comprehension and production, since the target must be first deconstructed, analysed and then re-composed in all its components (phonological, semantic and morpho-syntactic) to repeat it correctly. Potter and Lombardi (1998) used the term *reconstruction* to indicate how the stimulus can be reassembled from information stored in LTM and STM, even if the STM trace is decayed.

However, the individual must know the specific structures that he is repeating, otherwise repetition will fail. In addition, the target has to be maintained active in the WM determining a load to the memory system. Jefferies et al. (2004) discovered that an attention-demanding task affects the performance supporting the role of information integration from STM and LTM of the central executive (Baddley & Hitch WM Model,

[29] Specific Language Impairment

1974) in repetition tasks. Along with the central executive, the episodic buffer and the phonological loop play an important role in keeping the stimuli active in the brain.

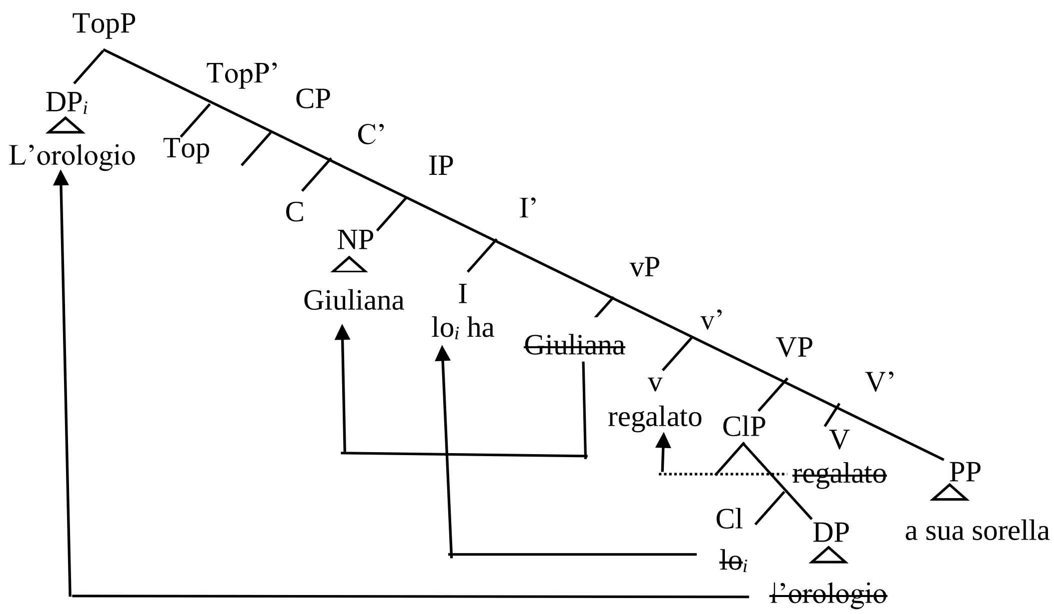
Topicalized Sentences

We examined the repetition performance of participants with Mild Cognitive Impairment (MCI), old controls and young controls on two types of topicalized sentences. A topicalized (TOP) sentence is a *marked structure* (or non-canonical word order), i.e. it does not have the canonical world order[30]. The non-canonical word order is OSV instead of SVO, which might sound weird. This word order change might be due to the fact that communicative reasons overcome syntactic rules. In other words, one element takes priority over another because the speaker finds this element more important and wants to underline it.

However, this is not just a simple reorganisation of surface word order. It is characterized by the presence of the topic, a syntactically moved element[31] in the left periphery of the clause. This moved element also bears an accent. Thus, the moved element is in a peripheral position, outside of the sentence, to which it is linked via a resumptive pronoun (Rizzi, 1997). Cinque (1990) called this structure *Clitic Left Dislocation* (CLLD), because it involves a *resumptive clitic* which refers to the topic (in the example 22 written in bold). The resumptive pronoun has the role of restating the moved object. It is obligatory only if the topic is a direct object, as in 22. This label is just a synonym for topicalization and some authors used this term to include both left and right dislocation. In this paper we will only analyse left dislocation.

[30] Italian canonical word order is Subject-Verb-Object (SVO). When this order is not kept, we talk about marked word order. The marked word order occurs only in some structures, such as TOP.
[31] The moved constituent is usually a direct or indirect object. Many linguists claim that subject dislocation is impossible in Italian because of the lack of nominative clitics.

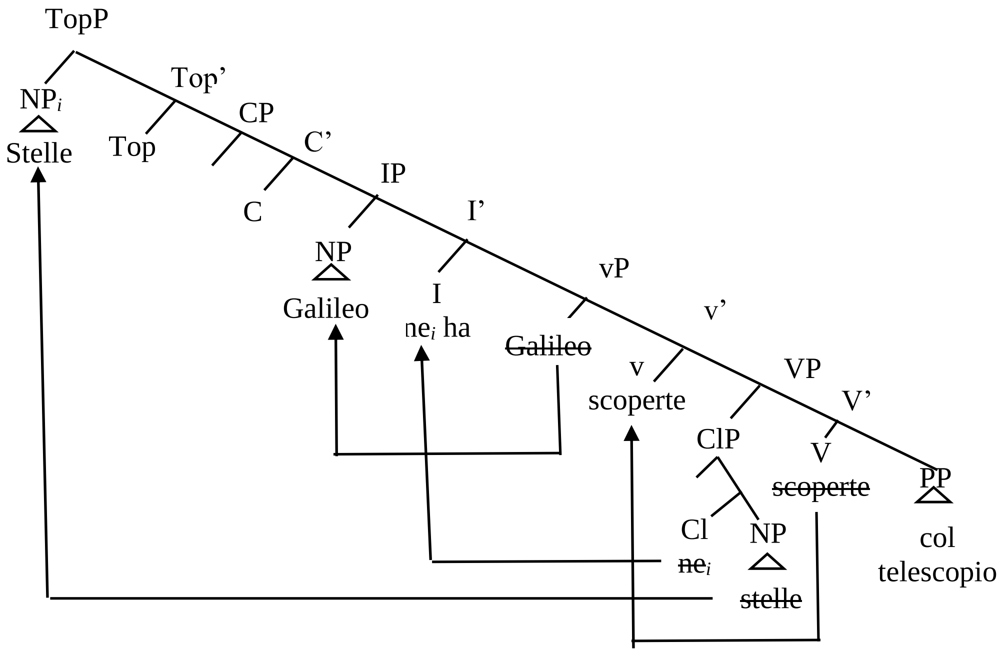
(22) L'orologio Giuliana **lo** ha regalato a sua sorella.



The syntactic tree above shows the deep structure of the TOP sentence. The resumptive pronoun and the topicalized item are indexed (written in the syntactic tree as $_i$), i.e. they depend on each other. In this case, the gender and noun of the clitic depends on the noun that it refers to, hence *lo* is singular and masculine since *orologio* is a singular masculine noun. The clitic originates in the SpecVP and then raises to I together with the auxiliary. The clitic moves because it cannot stand alone, it has to be as near as possible to the inflected verb or the auxiliary.

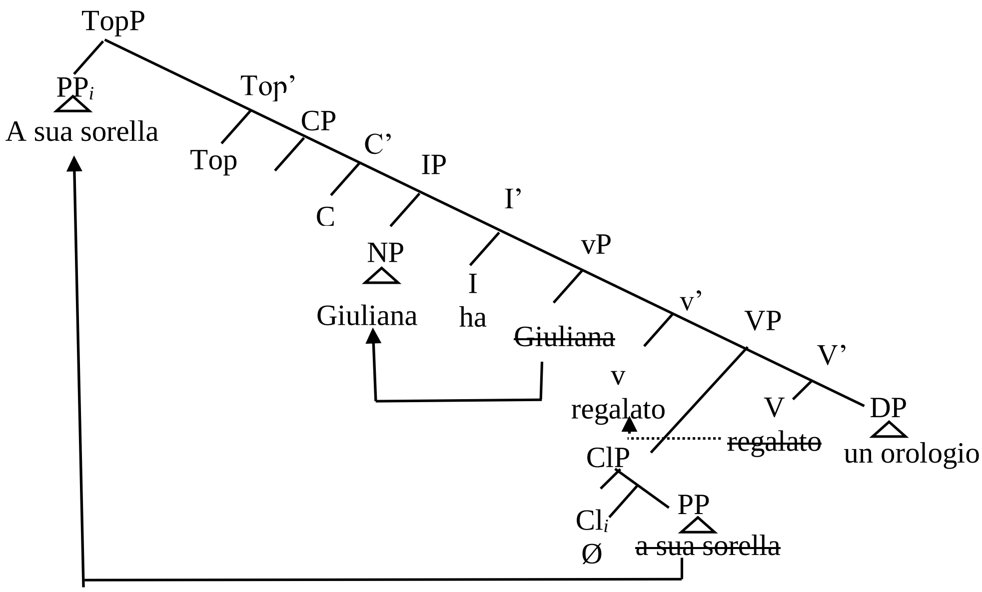
In some cases, the clitic can be substituted by partitive *ne*. It is usually used when the NP is a plural noun or a mass noun without article. The syntactic structure, however, is not changed, as you can see in 23.

(23) Stelle Galileo **ne** ha scoperte col telescopio.



Benincà et al. (1988) used the term *preposing* to describe a moved constituent to the left periphery without resumptive pronoun, as in 24. However, as the author claims, in some cases, CLLD cannot be distinguished from preposing, because if the moved constituent is not a direct object, the clitic pronoun can be omitted. Here, we will consider both structures as instances of topicalization. When the resumptive pronoun is obligatory, we will talk about Top-O (Topic on Object), while it is optional, we will talk about Top-P (Topic on Preposition).

(24) A sua sorella Giuliana Ø ha regalato un orologio



The deep structure here is the same as in 22 and 23. The only difference regards the clitic presence. In other words, the resumptive pronoun is not expressed in this sentence, however, it can still be added (e.g. *A sua sorella Giuiana* ***le*** *ha regalato un orologio*) since it is an optional item. This is the reason why its position is empty (Ø), but still present, in the syntactic tree. Moreover, the two items remain indexed.

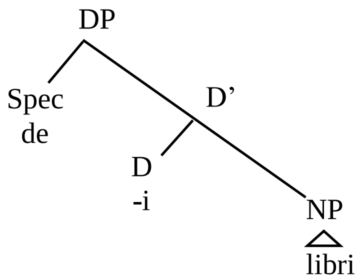
Articles

Among the filler sentences, article production was analysed. Italian articles can be either be definite or indefinite. Unlike definite determiners, the indefinite determiners of a noun can be expressed in different ways in Italian – bare noun, or zero determiner, a quantifier followed by a noun, or *de* followed by a noun, as you can see in the following examples.

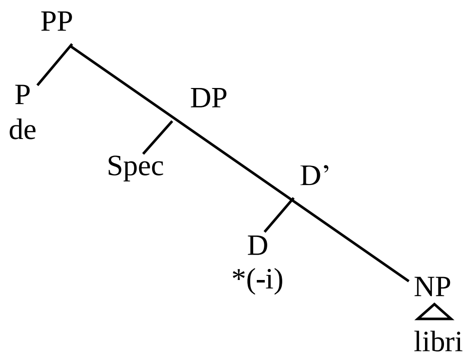
(25) a. libri
b. un po' di libri
c. dei libri

Cardinaletti and Giusti (2012) claimed that the indefinite article is formed by *de*+morpheme. This morpheme might seem an article because they are semantically identical, but it is a morpheme that realises the nominal features of gender and number. Therefore, it is believed that the indefinite DP is the parallel counterpart to the indefinite singular DP *un(o)*. Moreover, the indefinite article location in the syntactic tree appears to be in the specifier (Spec) of the determiner phrase (DP). Evidence in support of this statement derives from Italian central dialects, Anconetano in particular. Unlike standard Italian, Anconetano allows the drop of plural masculine *–i* of the indefinite DP and demonstrative *quei*, but *–i* cannot be dropped with articles. For example, in Anconentano *ho cumprato de libri* is possible, while *la cupertina de libri è sbregata* is impossible. In the first example *de* behaves as a partitive meaning "some", whereas in the second example it works as specifier of *cupertina*. The difference of *–i* dropping suggests that standard Italian (26) and Anconetano (27) have two different realisation of the indefinite article.

(26)



(27)



Further evidence against the indefinite DP being a partitive is given by Storto (2003). He claimed that unlike partitives, the indefinite DP does not respect the *proper part relation* (Baker, 1998), according to which the denotation of the partitive must be larger than the denotation of the indefinite DP. If we consider (28), we note that *alcuni dei pinguini* implies the existence of others of that species, but the following part of the sentence denies it.

(28) Alcuni dei pinguini che sono nello zoo sono gli ultimi della loro specie.

Giusti and Cardinaletti (2012; 2016) studied the behaviour of indefinite DP compared to quantifiers. Unlike quantifiers, which need *ne* as resumptive pronoun and the prepositional phrase (PP) introduced by partitive *di*, indefinite DP needs an accusative resumptive pronoun (29) and the PP introduced by partitive *tra* (30). Quantifiers like *alcuni* select two arguments, an obligatory indefinite DP and an optional partitive PP, indicating that quantifiers are external to the nominal projection. Indefinite DP are, on the other hand, the highest projections of the noun, as in (33). Thus, Zamparelli (2008) stated that *dei*-nominals can occur as predicates. Predicates need a reduced structure, so full phrases cannot occur. Indefinite DP *can* since they occur in the lower head.

(29) a. Dei libri, **li** ho comprati.
b. *Dei libri, **ne** ho comprati.
c. **Ne** ho comprati alcuni [libri].

(30) a. ?Ho comprato dei libri **di** quelli che erano in programma.
b. Ho comprato dei libri **tra** quelli che erano in programma.

In summary, the indefinite DP is formed by *de* + morpheme, which gives nominal features to the article. It is different from partitives and quantifiers because indefinite DP has a smaller denotation and needs an accusative resumptive pronoun and the partitive *tra*, indicating that it works as a projection.

4.2 Participants

Participants in this study were three groups: MCI, old controls and young controls. All participants gave their informed consent.

MCI Participants

MCI participants were 9 Italian speaking adults aged between 64;1 and 81;4 (M: 70;9; SD: 7,3). They had an average of 9.11 (SD: 5.2) years of schooling,

MCI individuals were recruited from IRCSS San Camillo of Venice (Italy). Not all subjects could take part at the second experiment because either the task was too difficult or they were unable to come again.

Subject Number	Gender	Age	Education (years)	MMSE
1	m	70	10	25,4
2	f	71	5	**20,3**
3	m	70	18	26.7
4	m	81	17	28,1
5	f	64	10	27
6	f	76	5	23,7
7	f	78	5	27,7
8	f	75	7	26
9	m	81	5	27,4

Table 4 MCI participants demographics. MMSE results in bold indicate that the performance was below cut-off.

MCI subjects were tested on cognitive tasks in order to evaluate the severity of their cognitive decline. Not all subject did the same neuropsychological battery because they claimed particular impairments, hence they were tested in that particular cognitive area. Patients were tested with MMSE (M: 26.77, SD: 2.7), but in detailed neuropsychological tests they showed mainly attentional or mnemonic deficits, with a sufficiently preserved abilities in daily life (Petersen et al., 2001).

In the tables below the different neuropsychological tests are divided according to the cognitive area. The scores written in bold indicate that the score is below cut-off.

General

Subject	ACE-R (Raw Score)	ACE-R (Correct Score)	ACE-R (Exact Score)	ACE-R Attention (Raw Score)	ACE-R Attention (Correct Score)	ACE-R Attention (Exact Score)	ACE-R Memory (Raw Score)	ACE-R Memory (Correct Score)	ACE-R Memory (Exact Score)	ACE-R Fluency (Raw Score)	ACE-R Fluency (Correct Score)	ACE-R Fluency (Exact Score)
1												
2												
3	91	93,16	4									
4	79	87,06	3									
5	87	88,77	3	17	17,04	4	20	20,63	3	11	11,3	4
6	67	79,29	1	15	15,9	1	6	10,56	**0**	10	12,54	4
7	82	94,29	4	17	17,9	4	20	24,56	4	10	12,54	4
8	81	90,37	4	16	16,61	2	14	17,45	1	10	11,88	4
9												

Subject	ACE-R Language (Raw Score)	ACE-R Language (Correct Score)	ACE-R Language (Exact Score)	ACE-R Visuo-Spatial (Raw Score)	ACE-R Visuo-Spatial (Correct Score)	ACE-R Visuo-Spatial (Exact Score)
1						
2						
3						
4						
5	26	26	4	13	13,23	2
6	23	25,6	4	13	14,67	4
7	23	25,6	4	12	13,67	2
8	25	27,09	4	16	16	4
9						

Table 5 General neuropsychological tests

Memory

Subject	Digit Span Forward (Raw Score)	Digit Span Forward (Correct Score)	Digit Span Forward (Exact Score)	Digit Span Backward (Raw Score)	Digit Span Backward (Correct Score)	Digit Span Backward (Exact Score)	Words Learning (Raw Score)	Words Learning (Correct Score)	Words Learning (Exact Score)	Corsi Test (Raw Score)	Corsi Test (Correct Score)	Corsi Test (Exact Score)
1	5	5,35	3	3	3,39	2	11	13	4	4	4,25	2
2	5	5,51	3	3	3,64	2	5	8	1	4	4,56	2
3	6	5,99	4	5	4,87	4						
4	5	5,3	2	N.E.								
5	6	6,23	4	4	4,28	3				5	5,25	3
6	5	5,65	3	4	4,77	4						
7	5	5,82	4	4	4,93	4	13	16	4			
8	6	6,45	4	5	5,52	4				5	5,5	4
9	6	6,82	4	3	3,93	3	6	9	2	4	4,5	3

Subject	Prose Memory Immediate (Raw Score)	Prose Memory Dealyed (Raw Score)	Prose Memory Total (Raw Score)	Prose Memory Total (Correct Score)	Rey Immediate (Raw Score)	Rey Immediate (Correct Score)	Rey Immediate (Exact Score)	Rey Delayed (Raw Score)	Rey Delayed (Correct Score)	Rey Delayed (Exact Score)	Span Visuo-Spatial (Raw Score)	Span Visuo-Spatial (Correct Score)	Span Visuo-Spatial (Exact Score)
1	10	13	23	23,26	28,5	29,5	1	**5,5**	**7**	**0**			
2	**5**	**4**	**9**	**11,32**	**25,5**	**28**	**0**	3,5	10	1			
3	8	15	23	20,052	33	33,5	4	21	21,5	4	4	4	1
4	3	3	6	4,124	19,5	20,75	**0**	5,5	8,25	**0**	5	5,25	4
5	8	14	22	21,65	30	31,5	3	14,5	19,5	4			
6	3	0	3	5,631	26	28,75	**0**	0		**0**			
7	**N.E**	**N.E.**	**N.V.**		30	32,75	4	8,5	16	4			
8	9	12	21	22,768	27	29,5	1	6	13	3			
9	6	**2**	**8**	**10,94**	31	34,25	4	8,5	14	3			

Table 6 Memory neuropsychological tests

Attention

Subject	Stroop Errors (Raw Score)	Stroop Errors (Correct Score)	Stroop Errors (Exact Score	Stroop Time (Raw Score)	Stroop Time (Correct Score)	Stroop Time (Exact Score)	Attentional Matrices (Raw Score)	Attentional Matrices (Correct Score)	Attentional Matrices (Exact Score)	Tmt A (Raw Score)	Tmt A (Correct Score)	Tmt A (Exact Score)	Tmt B (Raw Score)	Tmt B (Correct Score)	Tmt B (Exact Score)
1	0	0	4	37	27	2	32	31,5	1						
2	**12,5**	**10,75**	**0**	10,5	-1,25	4	34	38,5	2	99	72	1	N.E.	**N.E.**	
3	0	0	4	16	10	4	59	52,75	4	31	21	4	122	100	4
4	11,5	10,5	**0**	35	24,25	3	50	46,5	3	244	231	**0**	N.E.		
5	22	20,75	**0**	58	50,5	**0**	51	51,75	4						
6	4	2	2	89	75,25	**0**	47	52,75	4						
7	8	5,75	**0**	29,5	13,5	4									
8	2	0,25	3	68,5	56,25	**0**	37	40,5	2						
9	1	0	4	41	25	3	55	59,75	4						

Language

Subject	Figure Naming (Raw Score)	Figure Naming (Correct Score)	Della Sala Naming (Raw Score)	Della Sala Pointing (Raw Score)	Naming – Description (Raw Score)	Naming – Description (Correct Score)	Naming – Description (Exact Score)
1							
2	13	24					
3			15	24			
4			15	24	37	36	2
5			13	24			
6							
7			12	24			
8			12	24			
9	12				**28**	**29,25**	**0**

Table 7 Attention and language neuropsychological tests

Esecutive Functions

Subject	Phonological Fluency (Raw Score)	Phonological Fluency (Correct Score)	Phonological Fluency (Exact Score)	Semantic Fluency (Raw Score)	Semantic Fluency (Correct Score)	Semantic Fluency (Exact Score)
1	13	18	1	25	31	2
2	12	21		**14**	**24**	
3						
4	17	13	**0**	16	16	**0**
5	32	36	4	35	39	4
6						
7	26	35	4	25	35	3
8	20	25	2	37	43	4
9	19	28	3	**13**	**23**	**0**

Praxic Functions

Subject	Clock (Raw Score)	Picture Drawing (Raw Score)	Picture Drawing (Correct Score)	Picture Drawing (Exact Score)	Memory Drawing (Raw Score)
1					
2	**3**	10	10,5	2	
3		13	12	4	
4	9	8	7,5	**0**	**0**
5	7	11	10,75	2	
6					
7		11	11,75	3	
8	7				
9					

Table 8 Executive and praxic function neuropsychological tests

Old Controls

The old control participants were 10 healthy subjects aged between 57;0 and 78;6 (M: 67;2; SD: 6,7). They had an average of 11.8 (SD: 4.9) years of schooling. They were recruited through personal contacts and in some cases they were relatives of the MCI subjects. They were either tested at the hospital or at home. An additional group of speakers was tested but the data were not included because the participants did not meet the inclusion criteria for age.

Subject Number	Gender	Age	Education (years)
11	m	59	9
12	f	69	19
13	m	65	8
14	f	78	13
15	m	63	8
16	f	58	17
17	f	71	13
18	f	61	8
19	m	75	5
20	m	70	18

Table 9 Old control group demographics.

Young Controls

A young adult control group consisting of 10 participants was recruited to see if the linguistic performance was different than old controls in the experimental sentences. Participants were students ranging in age from 18;5 to 25;8 (M: 21;8, SD: 2,49) with an average of 14.4 (SD: 1.7) years of schooling. Participants were recruited through personal contacts. They were tested at home.

Subject Number	Gender	Age	Education (years)
21	m	19	14
22	f	18	12
23	f	19	13
24	m	24	15
25	f	23	16
26	m	24	18
27	f	21	14
28	m	25	14
29	m	20	13
30	f	21	15

Table 10 Young control group demographics.

4.3 Procedures

All participants were tested individually in a sentence repetition task. We analysed the repetition of 135 sentences divided into three lists (45 items for each list), so each subject had a different item order. All the items were arranged in random order.

The study was divided in two experiments – Immediate Recall and Delayed Recall with Distractor. During each session, the participant and the experimenter sat across each other at a table. All the stimuli were presented in Power Point using a computer and we recorded the performance of each individual. No time limit was imposed.

In the Immediate Recall Experiment, the participant had to read aloud the presented stimuli and then repeat it as accurately as possible.

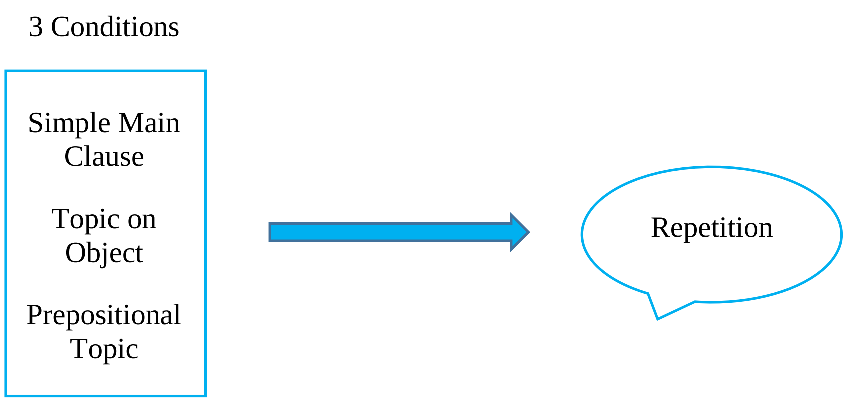


Fig. 25 Experimental design of the Immediate Recall Experiment. The participant read the target sentence and then repeated it as accurately as possible.

In the Delayed Recall with Distractor Experiment, between reading aloud and repeating, they had to count behind of five numbers from a given number, for example "count behind of 5 from 295".

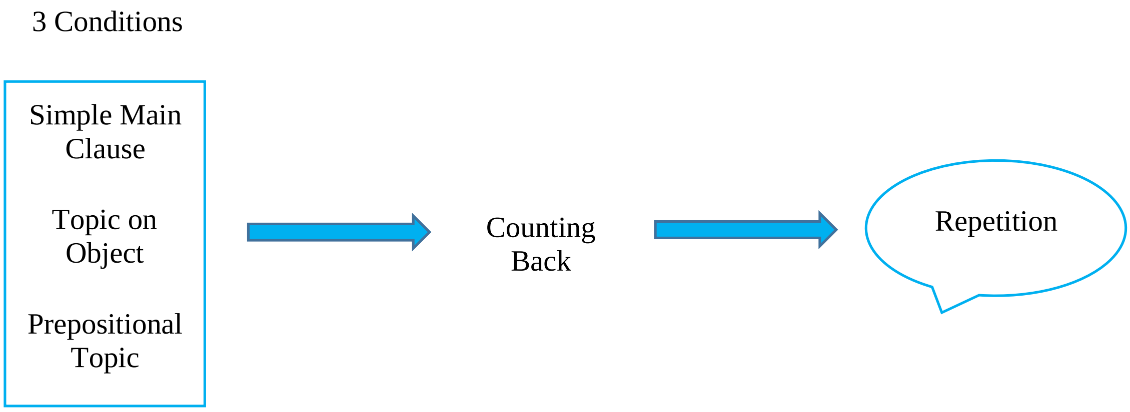


Fig. 26 Experimental design of the Delayed Recall with Distractor Experiment. The participant read the target sentence, counted back from a given number and then repeated it as accurately as possible.

4.4 Stimuli

135 grammatical sentences (experimental or filler) were selected. Experimental sentences were divided in three conditions: 25 Simple Main Clause, 25 Topic on Object (Top-O) and 25 Prepositional Topic (Top-P), as in (31).

(31) a. Simple Main Clause
Giuliana ha regalato l'orologio a sua sorella

b. Topic on Object (Top-O)
L'orologio Giuliana lo ha regalato a sua sorella.

c. Prepositional Topic (Top-P)
A sua sorella Giuliana ha regalato l'orologio

Filler sentences followed the same path, but we focused on the article presence (12 target sentences per condition) – zero article, definite article or indefinite *di* article. We considered only *de* + noun as indefinite article in our filler sentences.

(32) a. Zero Article
Vado in cantina a prendere vino.

b. Definite Article
Vado in cantina a prendere il vino.

c. Indefinite Article
Vado in cantina a prendere del vino.

A list of all experimental materials is given in Appendix B.

4.5 Coding

Participants' repetitions were examined in two steps. First, global repetition ability was examined through the percentage of correct sentences repeated. This means that any change in the repeated sentence (i.e. word position, synonyms, omissions) was considered an error. The second step examined sentence repetition for structure maintenance and article production as an explorative analysis.

4.5.1 Percent Correct

This measure analysed the number of correct words repeated by the participant. A repeated sentence was considered correctly repeated if it was a verbatim repetition of the one presented in the target, i.e. identical in syntax and containing the same lexical items of the target. Each difference in the repeated sentence (for instance synonyms, substitutions, word order, tense changing or thematic roles inversion) was analysed as a mistake.

4.5.2 Scoring of Error Types

All the sentences that were classified as different sentences from the target were scored as described below. Examples are listed in (35). Then, we reclassified the sentences analysing the syntactic structure and the resumptive pronoun, as described in the paragraph 5.3.3.

Structure Maintenance (a): the syntactic structure of the repeated sentence was changed.
Clitic (b)*:* any omission or change of clitics.
Perseveration (c)*:* a previous repeated sentence substitutes the target sentence.

(33) a. Target: Le finestre il papà le ha chiuse alle cinque.
Repeated: Il papa ha chiuso le finestre alle cinque.

b. Target: Stelle Galileo ne ha scoperte con il telescopio.
Repeated: Stelle Galileo **le** ha scoperte con il telescopio.

c. Target: Per pranzo il cuoco ha preparato i carciofi.
Repeated: Il bosco inizia in fondo alla strada.

Regarding structure maintenance, some repeated syntactic structures looked less marked (34). 2 participants produced this type of structure in the RT. The reason that can explain the presence of this solution might be linked to the lack of context. TOP sentences have a contrastive or highlighting use, but they are responses after a statement from another speaker. In the test, instead, they were in isolability, hence they were felt as too much marked or weird. Another reason might be that the participants maintain the canonical word order (subject-object) instead of a marked word order (object-subject).

(34) Target: La carne la nonna la ha comprata al mercato.
Repeated: La nonna la carne la ha comprata al mercato.

Another topic of discussion was clitic scoring due to an ambiguous case. 20 participants simplified TOP on object in declarative sentences. In other words, they avoid both movement of the topicalized object and probably also the clitic production. Example (33a) shows this ambiguity. There were two possible solutions to classify it. The first was to consider it as correct since in the repeated sentence there was no need of a clitic, while the second was to consider it as a mistake because the participant used a technique to avoid the production of a difficult element. After a discussion, the first solution was adopted. Moreover, we considered as correct the opposite case, i.e. when a clitic was added in a structure that needs is.

Then, we considered also the article production (35) analysing the article omission (a), the change of one type of article with another (b) and the article addition (c). There were no particular complication in analysing the filler sentences, however, there were too few to see any error pattern. Errors are indicated in bold.

(35) a. Target: A colazione non voglio la frutta.
Repeated: A colazione non voglio **Ø** frutta.

b. Target: Giorgio ha lasciato le galline in cortile.
Repeated: Giorgio ha lasciato **delle** galline in cortile.

c. Target: Stelle Galileo ne ha scoperte con il telecopio.
Repeated: **Le** stelle Galileo ne ha scoperte con il telescopio.

Finally, we analysed as unscorable (n/a) all the sentences that were not recalled or too few words were recalled.

4.6 Results

Our primary predictions were that complex non-canonical structures with syntactic movement would be harder to be recalled verbatim and would induce sentence reformulations in patients with MCI than in aged matched controls. We thus report patients' and controls' mean percent sentences correctly repeated (percent correct) both in the Immediate Recall and Delayed Recall with Distractor, even though only 5 MCI participants performed the RTD task. If the subject could not recall the target sentence or repeated too few words were scored n/a[32]. Moreover, despite the fact that there were only 12 sentence per condition, we analysed the article production in all participants in both Immediate Recall and Delayed Recall with Distractor.

4.6.1 Immediate Recall

Table 11 shows the mean percent sentences correctly repeated in the RT in *Simple Main Clause*, *Topic on Object* and *Topic on Preposition*. In order to investigate the influence of these types of sentences, a 3 (condition) × 3 (population) mixed MANOVA test was computed of the percentage of correct responses.

Population	Simple Main Clause	Topic on Object	Topic on Preposition
MCI	.853	.835	.88
Old Control	.972	.944	.984
Young Control	.988	.992	1

Table 11 Immediate Recall. Percent correct results: mean percentage of correct sentences produced in each condition by population.

The 3x3 mixed MANOVA showed a significant main effect of population (F_2*=9.369, p=.001*) and condition (F_2*=7.072, p=.004*). The condition × population interaction was not significant (F_4*=1.65, p=.176*).

We followed up with independent t-test for population and repeated t-test for condition. For population, the independent t-test showed a variation of performance

[32] Not available.

between MCI participants and young controls (*t=3.531*, *p=.003*), indicating that MCI participant, on average, are less accurate in repeating than young controls. The general performance between MCI participants and old controls (*t=-2.734*, *p=.014*) and between old controls and young controls (*t=2.058*, *p=.054*) showed no significant variation. These data indicate that recalling is effective in all three populations. For condition, the repeated t-test showed a significant effect only between Top-O and Top-P (*t=-2.807*, *p=.009*), whereas between Simple Main Clause and Top-O (*t=-.817*, *p=.421*) and between Simple Main Clause and Top-P (*t=-1.535*, *p=.136*) was not significant. Our predictions about the presence of a condition effect are confirmed.

We have repeated this analysis with one-way MANOVA even if we have not found any significant interaction. The condition effect was found only in the MCI participants (F_2*=5.646*, *p=.035*), meaning that the sentence type influences the performance, in particular between Top-O and Top-P (*T=-2.294*, *p=.051*).

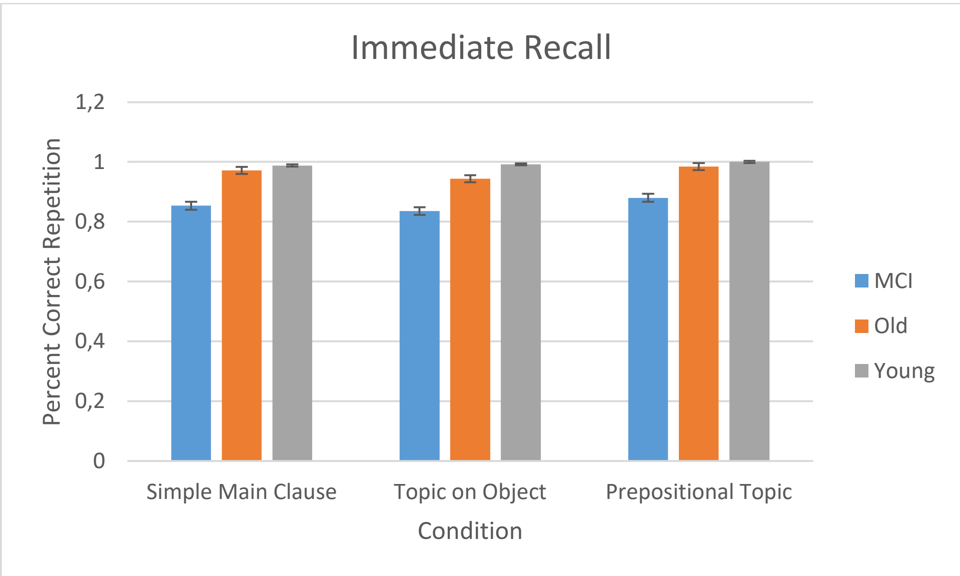


Fig. 27 Immediate Recall. Percent correct sentence repetition results, by sentence condition and participant group. Error bars are standard errors.

Regarding article production, we performed only a descriptive analysis. Table 13 shows mean percent sentences correctly repeated in the Immediate Repetition. In this experimental session, participants did not show any difficulty in article recalling. MCI participants' performance was slightly worse than controls, showing a difficulty with the absence of the article.

Population	Definite Article	Indefinite Article	Zero Article
MCI	.91	.89	.84
Old Controls	.99	.97	.93
Young Controls	1	.99	1

Table 12 Immediate Recall. Mean percent correct of article production in each condition per population.

Generally, all participants performed almost at ceiling level. MCI participants seemed to have difficulties with filler sentences without article. This difficulty might be due to the fact that zero article sentences are less frequent than article sentences. Thus, subjects added an article in order to make the sentence more likely.

In summary, MCI participants were less accurate, particularly between Top-O and Top-P, than the young controls, while the performance between MCI participants and the old controls did not indicate any significant variation. Generally, Top-O and Top-P were more difficult than Simple Main Clause. Regarding article production, MCI participants showed a slightly problematic performance with zero article sentences, and in general their performance is slightly worse than controls.

4.6.2 Delayed Recall with Distractor

As in the Immediate Recall experiment, Table 14 displays the mean percent sentences correctly repeated in the Delayed Recall with Distractor with the three conditions. We have thus to evaluate the following data cautiously. Despite the fact that only 5 MCI participants were able to perform this task, their general performance was almost at floor level. We decided to analyse anyway their performance.

Population	Simple Main Clause	Topic on Object	Topic on Preposition
MCI	.36	.236	.306
Old Control	.686	.604	.648
Young Control	.78	.736	.808

Table 13 Delayed Recall with Distractor. Percent correct results: mean percentage of correct sentences produced in each condition by population.

A 3 (condition) × 2 (population) mixed MANOVA showed significant main effect for population (*F_2=2.262, p<.001*) and condition (*F_2=4.825, p=.019*). However, there are no significant interactions (*F_2=.044*, *p=.911*)

We followed up with independent t-tests for population and repeated t-test for condition. For population, the independent post hoc test showed a variation of means both between MCI group and old controls (*t=-3.623, p=.003*) and between MCI group and young controls (*t*=-6.033, p<.001). These results confirmed that MCI participants were less accurate in repetition after the distractor task than the two control groups. Between young controls and old controls there was no significant difference (*t=-1.853, p=.080*). This might indicate that that ageing might not strongly influence recalling even with more complex syntactic structures as generally thought. At the same time, our old controls might have performed better than other old people. We have to consider also that our old controls were younger than MCI participants. This fact could have affected our results. For condition, the repeated t-test showed a significant difference in the performance of Top-O and Top-P (*t=-2.734, p=.012*) and an almost significant difference in Simple Main Clause × Top-O (*t=2.042, p=.052*), while Simple Main Clause × Top-P, on the other hand, showed no significant variation (*t=.357, p=.724*). This data confirmed the results of the Immediate Recall experiment. Recalling TOP-O sentences was harder than for the other structures. The difference between TOP-O and TOP-P performance might be linked to the presence of the resumptive pronoun, which is an optional element in the TOP-P sentences. This can make them easier to recall correctly. These data confirmed that Top-O is more difficult to recall correctly.

We repeated this analysis with a one-way MANOVA, but there was not any significant interaction.

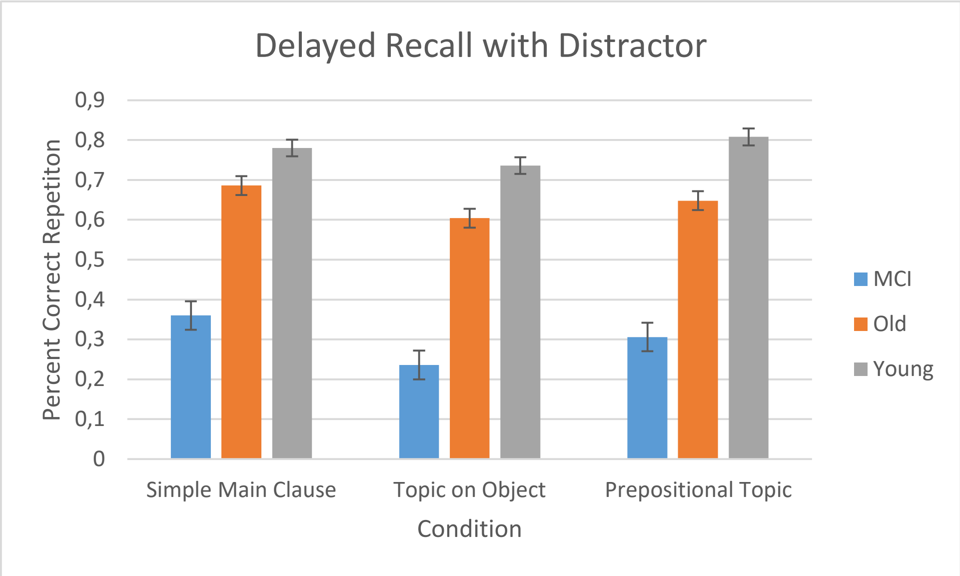


Fig. 28 Delayed Recall with Distractor. Percent correct sentence repetition results, by sentence condition and participant group. Error bars are standard errors.

Regarding article production, table 16 summarizes the mean percent correct in the second experiment. As the general data and the previous article data, we have to evaluate the participant performance cautiously. The general performance is lower than in the Immediate Recall, in particular for MCI participants. As we can see, MCI subjects showed difficulties with indefinite articles, while old controls had problems with zero articles. It is hard to tell if the performance is influenced by the difficulty of the task itself or if it is a problematic constructions as the TOP sentences.

Population	Definite Article	Indefinite Article	Zero Article
MCI	.37	.26	.34
Old Controls	.60	.65	.55
Young Controls	.77	.74	.75

Table 14 Delayed Recall with Distractor. Mean percent correct of article production for each condition per population.

In summary, the general performance of MCI participants is less accurate than old controls and young controls, confirming that MCI subjects found harder recalling non-canonical linguistic structures, in particular Top-O, which are less accurate in all groups. Recalling skills of old controls, instead, were not significantly worse than young controls, suggesting that age might influence only slightly recalling in our group. Article production data, on the other hand, indicated a difficulty for MCI participants in recalling the right article. However, more data is needed in order to confirm the presence of an impairment in article production.

4.6.3 Error Patterns

TOP Sentences

In this section we report a qualitative analysis of errors made in the TOP structures. We analysed errors regarding the syntactic structures and the clitics. A description of these structural errors is provided below, and a summary by population is given in Table 15. In bold the errors are indicated.

Clitic change: the resumptive pronoun is changed with another pronoun (e.g. “Sale Piero ne ha messo sulle sarde” repeated as “Sale Piero **le** ha messo sulle sarde).
Clitic omission: the resumptive pronoun is omitted (e.g. “Del letame il contadino lo ha sparso sui campi” repeated as “Del letame il contadino **Ø** ha sparso sui campi”).
Simplification: the TOP sentence is changed in a simple mail clause (e.g. “Il vestito Daniela lo ha cucito per la cugina” repeated as “Daniela ha cucito **il vestito** per la cugina”).
Top OS > SO: the beginning of the word order in the TOP sentence is inverted (e.g. “Con l’aceto Carla ha lavato la camicia” repeated as “Carla **con l’aceto** ha lavato la camicia”).
Top-P > Clitic: in a TOP sentence a clitic is added when it is absent from the target sentence (e.g. “Al mercato la nonna ha comprato la carne” repeated as “Al mercato la nonna **l**’ha comprata la carne”)

Population	Clitic Change	Clitic Omission	Simplification	Top OS > SO	Top-P > Clitic
MCI	.01	.01	.01	.01	.01
Old Controls	.01	.01	-	-	-
Young Controls	.01	-	-	-	-

Table 15 Immediate Recall. Structural errors divided per population.

In the Immediate Recall participants made less structural mistakes than in the RTD. Despite the fact that only 5 MCI participants were able to complete this experiment, the structural errors have been analysed in order to give a general idea of the difficulties met by the participants.

Population	Clitic Change	Clitic Omission	Simplification	Top OS > SO	Top-P > Clitic
MCI	.01	.01	.13	.03	-
Old Controls	.01	.01	.05	.02	-
Young Controls	.01	.01	.02	.01	.01

Table 16 Delayed Recall with Distractor. Structural errors divided per population.

As reported in Table 16, in the Delayed Recall with Distractor task MCI participants simplified TOP structures as a strategy to avoid this syntactic structure. Clitics were only in some cases omitted or changed in all group indicating that the difficulty is not with the resumptive pronoun, but with the movement. Another strategy less used was to change the elements order – instead of object-subject, subject-object. Probably, it is easier to recall first the subject and then the object.

In some cases, all groups (old controls in particular) changed the Simple Main Clause into a TOP structure, as in 36. This might be due to a priming effect of the syntactic structure.

(36) Target: La maestra ha interrogato gli alunni in cortile.
Repeated: **In cortile** la maestra ha interrogato gli alunni.

Article Production

In this section we report a qualitative analysis of errors made in the article production in the two experiments. We analysed errors regarding the change, omission and addition of an article in the filler sentences. As in the previous section, an error description and a error summary by population are given below. The errors are indicated in bold.

Article Omission: the target article was not produced (e.g. "Per pranzo il cuoco ha preparato i carciofi" repeated as "Per pranzo il cuoco ha preparato **Ø** carciofi").

Article Addition: an article has been added in a zero article sentence (e.g. "Dopo mangiato ordinamo sempre caffè" repeated as "Dopo mangiato ordiniamo sempre **il** caffè").

Definite > Indefinite: the target article was changed from definite to indefinite (e.g. "Marta dipinge spesso i quadri astratti" repeated as "Marta dipinge spesso **dei** quadri astratti").

Indefinite > Definite: the target article was changed from indefinite to definite (e.g. "A colazione non voglio la frutta" repeated as "A colazione non voglio **della** frutta").

Population	Article Omission	Article Addition	Definite > Indefinite	Indefinite > Definite
MCI	.01	.13	.01	.03
Old Controls	.01	.05	-	.01
Young Controls	.01	-	-	-

Table 16 Immediate Recall. Percent correct results of article production by population.

In the Immediate Recall participants' performance with respect to article production was almost at ceiling for all groups. There was a tendency for MCI participants to add articles in Zero Article sentences. This strategy might be used in order to make the sentences less marked, because articles presence is more common than its absence in Italian.

Population	Article Omission	Article Addition	Definite > Indefinite	Indefinite > Definite
MCI	.04	.26	.06	.05
Old Controls	.08	.15	.02	.03
Young Controls	.03	.12	.03	.04

Table 17 Delayed Recall with Distractor. Percent correct results of article production by population.

The difficulty of the Delayed Recall with Distractor did not seem to affect the general performance as happened for the syntactic structure. All populations added the article when it was absent as a strategy to make the target sentence less weird.

4.7 Discussion

The goal of this study was to examine the effect of non-canonical syntactic structures (topicalization) on the sentence repetition performance of patients with probable Mild Cognitive Impairment (MCI).

MCI participants' performance was particularly affected with Topic on Object (Top-O) sentences, which require the presence of a resumptive pronoun (or clitic) and the movement of an object. This syntactic structure is difficult for two reasons. First, clitics follow specific syntactic rules that differentiate them from strong and weak pronouns[33] (Cardinaletti and Starke, 2000) and they are always referential to another phrase. Second, TOP structures are non-canonical structures that involve movement.

Both the Immediate Recall Experiment and the Delayed Recall with Distractor Experiment showed that all groups had difficulties with Top-O suggesting that the difficulties with this syntactic structure might not be linked with age, but with the structure itself. In the Immediate Recall both MCI participants and old controls could not repeat the target elements of Top-O respectively around 8% and 3% of sentences, and in the Delayed Recall these results are even clearer (MCI: 38%; Old Controls: 17%). Young controls changed the target elements in 13% of cases only in the Delayed Recall. With Simple Main Clauses these percentage were lower. In the Immediate Recall MCI changed 7% of sentences, while old controls 1,2%. In the Delayed Recall, MCI were not able to repeat correctly 29% of target elements, old controls 12% and young controls 9%. This data is another proof of difficulty with topicalized structures.

To avoid producing Top-O structure, simplification was used. Participants produced a Simple Main Clause, which does not involve movement and does not require a resumptive pronoun. Sentences with Prepositional Topics (Top-P) were more accurate than Top-O. This proves that clitics and movement are more difficult than movement alone. However, few clitics were omitted or changed in both experiment, suggesting that they could be working as cues to help recall.

Results showed that, repetition performance on Top-P was more accurate than repetition performance on Simple Main Clause. This was found to be true across all participant groups in the Immediate Recall condition. In the Delayed Recall with

[33] They are maximal projections, while clitics are heads.

Distractor, this phenomena is still present only in the young controls, while MCI participants and old controls found it easier to recall sentences in the Simple Main Clause condition.

Additionally, article production performance was analysed to evaluate whether there are also other impairments or not. It showed no particular phenomena in both experiments. All population performed almost at ceiling level in the Immediate Recall, whereas both MCI participants' and old controls' performance was less accurate than young controls' in the Delayed Recall with Distractor. MCI subjects showed more difficulties in recalling articles, particularly with indefinite article recalling. The common strategy among all three groups was to add an article in Zero Article sentences in the Delayed Recall with Distractor, while only old controls and MCI subjects used it in the Immediate Recall.

Our experiments had some limitations. In both experiments, some patients found the repetition task boring, while only the Delayed Recall with Distractor Experiment was too tiring for most MCI participant, who needed frequent pauses. Severe MCI participants were unable to complete the Immediate Recall Experiment, indicating that this task is not suitable for them. For these reasons, our study needs to be changed so every future MCI participant will be able to perform it.

It would be interesting to analyse language production of complex sentences in a conversational setting, since our experiments analysed them in isolation, as well as comparing complex sentence production both with other languages and with other types of dementia to see whether the same difficulties are present. In this way, speech therapists can also concentrate in rehabilitation of these structures.

Conclusion

We examined the performance of participants with Mild Cognitive Impairment (MCI) on the repetition of non-canonical sentence structures which are known to be problematic in more advanced types of dementia. Because of the cognitive decline associated with MCI, these patients are likely to be sensitive to syntactic constructions that tax memory. Our expectation of an overall decrement in performance and of difficulty in non-canonical syntactic structures were confirmed.

The two experiments reported here used identical target sentences – the first experiment was an Immediate Recall task, while the second a Delayed Recall with Distractor task. All MCI participants did different neuropsychological battery to evaluate their cognitive decline as well as the particular cognitive area claimed to be impaired by the participant himself. We decided to use a repetition task for several reasons: it does not need particular training, it is easy and it is sensitive to differences in syntactic complexity and language systems similarity. Repetition is not a passive action since it requires both comprehension of the target sentence and production of a new sentence that must be identical to the heard one. However, our test analysed repetition in isolation, i.e. in a clinical setting with prepared sentences. It would be interesting to analyse spontaneous repetition to see if syntax is affected as well.

MCI participants have shown attentional and syntactic processing difficulties, which lead to less accurate performance in their overall ability to repeat non-canonical sentences from the target sentence. Their difficulty was linked to the syntactic structure that requires both movement and resumptive pronouns. In many cases, target words were not repeated correctly and a Simple Main Clause was produced in order to avoid recalling topicalized structures. This strategy was present in all groups, however, some participants in the young control group produced a topicalized sentence instead of a Simple Main Clause, probably due to a priming effect.

Additionally, we gave a look to article production, which might be affected as syntactic structures. Unfortunately, the target sentences were too few to have a definite answer. Only in the Delayed Recall with Distractor both old controls and MCI had a lower performance than young controls. In both experiments, all groups added the article in Zero Article sentences as a strategy to make the sentences more familiar, since

Zero Article sentences are not as common as Definite and Indefinite Article sentences. This topic needs further investigation to confirm whether it is problematic in this population.

In general, our test must be improved. First of all, MCI participants found the Delayed Recall with Distractor too tiring, in fact some participants did only two of the three lists. It was not only the test length, but also the counting back. Some participants found the interference task hard, because they concentrated more on the distractor task making harder recalling the previously read sentence. Another point is that the test was inappropriate for severe MCI – they were not able to complete the Immediate Recall Experiment. Regarding old controls, some claimed that the topicalized sentences were wrong or weird. We cannot exclude that their performance was influenced by their linguistic knowledge, i.e. they unconsciously might have tried to correct the sentences.

In summary, this study was one of the firsts to analyse non-canonical sentence production performance in MCI patients. The results revealed difficulties with movement with the presence of resumptive pronouns. At the same time, we cannot confirm whether article production is impaired even though some difficulties were met. So, the experiments did not distinguish between MCI and old controls as a neuropsychological battery would, but it shows a decline in MCI performance, which could be used as a rehabilitation starting point.

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Appendix A

CONSENSO INFORMATO

Gentile partecipante,
chiediamo la sua disponibilità a partecipare ad uno studio condotto da Elisa Furlan, studentessa presso l'Università Ca' Foscari di Venezia - Dipartimento di Studi Linguistici e Culturali Comparati – e tirocinante presso la Fondazione Ospedale San Camillo IRCCS (VE).

Obiettivi, Benefici e Rischi della Ricerca

Lo scopo dello studio è di indagare i processi mentali coinvolti nella ripetizione di frasi semplici e complesse e di una breve storia. La Sua partecipazione ci aiuterà a capire meglio come funzionano i processi del linguaggio in caso di diagnosi di deterioramento cognitivo lieve. Questa è ricerca di base. La Sua partecipazione non Le porterà benefici immediati, ma potrà tuttavia aiutare i ricercatori a capire meglio gli aspetti linguistico-cognitivi nei casi di deterioramento cognitivo lieve e a sviluppare protocolli sperimentali di valutazione. Non si anticipano rischi.

Procedura e Durata

Dopo la somministrazione di un breve test per analizzare il grado di deterioramento cognitivo lieve, Le verrà chiesto di ripetere ad alta voce una lista di frasi di lunghezza variabile, contenenti nomi e verbi comuni. Durante la somministrazione del test, sono previste delle pause. Se avrà bisogno di chiarimenti, non esiti a chiedere. Può chiedere di fare pause aggiuntive in qualunque momento.

Durante la seduta la Sua voce verrà registrata per consentire di trasferire le Sue risposte su materiale cartaceo e informatizzato accessibile soltanto ai ricercatori: in ogni caso, i suoi dati personali saranno sempre separati da quelli raccolti per garantire la Sua privacy.

La durata del test è di circa un'ora incluse le pause.

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Partecipazione volontaria

La Sua partecipazione allo studio è assolutamente volontaria e può decidere in qualsiasi momento di non terminare il test o di abbandonare lo studio stesso.

Per ogni eventuale informazione o chiarimento, il medico di riferimento Francesca Meneghello (0412207516) e la sperimentatrice Elisa Furlan (3463790666) rimarranno a Sua completa disposizione.

Anonimato e confidenzialità

Le garantiamo la tutela dei dati e l'anonimato, i dati raccolti non saranno collegati in alcun modo alle sue informazioni personali.

Trattamento dei dati

I dati raccolti saranno registrati, elaborati e archiviati in forma cartacea e informatizzata per le esclusive finalità connesse con la ricerca, in forma assolutamente anonima. I dati, collettivamente raccolti, saranno soggetti ad elaborazione statistica e in questa forma, sempre assolutamente anonima, inseriti in pubblicazioni e/o congressi, convegni e seminari scientifici.

Grazie per la partecipazione!

Ai sensi del D. Lgsl. 196 del 30.06.2003, autorizzo l'Università Ca' Foscari di *Venezia e Fondazione Ospedale San Camillo IRCCS a sottoporre a trattamento i dati personali che mi riguardano per attività di ricerca. In particolare autorizzo a trattare, oltre ai dati comuni, anche i miei dati cosiddetti sensibili e a diffonderli, resi anonimi, nei limiti sopra indicati.*

Firma ________________________

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Il/La sottoscritto/a ______________________________________,

dichiara

- Di essere stato/a messo/a a conoscenza delle procedure relative all'indagine alla quale verrò sottoposto come soggetto nel progetto di ricerca dal titolo (…);
- Di essere stato/a informato/a riguardo alla finalità e gli obiettivi della ricerca in questione;
- Di aver preso visione diretta dell'ambiente e dei materiali che verranno utilizzati per la ricerca;
- Di aver ricevuto soddisfacenti assicurazioni relativamente al principio del mantenimento della riservatezza delle informazioni relative e/o scaturite dall'esame della propria persona;

Per tutti questi motivi, il/la sottoscritto/a sente di esprimere il consenso informato a partecipare alla suddetta indagine che sarà svolta presso *Fondazione Ospedale San Camillo IRCCS* fermo restando la possibilità di potersi sottrarre alla sperimentazione in qualsiasi momento, senza doverne rendere conto ad alcuno. Autorizzo inoltre, ai sensi e per gli effetti del D. Lgsl. 196 del 30.06.2003, gli sperimentatori, i docenti e i medici ad esaminare i miei dati personali, inclusi quelli relativi al mio stato di salute (dati sensibili).

Firma ________________________

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INFORMATIVA E CONSENSO AL TRATTAMENTO DEI DATI PERSONALI

Titolari del trattamento dei dati e relative finalità

Il Centro di Sperimentazione IRCCS Ospedale San Camillo – Lido di Venezia e Università Ca' Foscari Venezia tratteranno i suoi dati personali, in particolare quelli sulla sua salute, soltanto in funzione della realizzazione della sperimentazione. A tal scopo, non andrà oltre le rispettive competenze e si conformerà alle responsabilità stabilite dalle norme di buona pratica clinica (D. Lgsl. 211/2003) e dal Codice in maniera di protezione dei dati personali (D. Lgsl. 196/2003).

Il trattamento dei suoi dati personali e sanitari è essenziale per lo svolgimento della sperimentazione; se si rifiuta di fornirli, non potrà partecipare allo studio.

Natura dei dati

La responsabile dello studio o la ricercatrice che si occuperà di Lei durante la sperimentazione La identificherà attraverso un codice. I dati che la riguardano raccolti durante lo studio saranno registrati, analizzati e conservati unitamente a tale codice, alla Sua età, al sesso e alla scolarità. Soltanto la responsabile dello studio ed il personale autorizzato potrà associare questo codice al Suo nominativo.

Modalità del trattamento

I dati saranno trattati in modo sia elettronico sia cartaceo; saranno diffusi solo in forma anonima, ad esempio attraverso pubblicazioni scientifiche, statistiche, convegni scientifici, ecc… La Sua partecipazione allo studio implica che, conformemente alla legislazione sulle sperimentazioni cliniche, il Comitato Etico e le Autorità Sanitarie italiane potranno venire a conoscenza dei Suoi dati, ma sempre con modalità tali da garantire la riservatezza della Sua identità.

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Esercizio dei Suoi diritti

Può esercitare i diritti di cui all'Art. 7 del Codice in materia di protezione dei dati personali (ad esempio, accedere ai suoi dati personali, integrarli, aggiornarli, ecc…) rivolgendosi direttamente al Centro di sperimentazione dell'Ospedale San Camillo – Venezia.

Può interrompere la Sua partecipazione allo studio in qualsiasi momento senza dover fornire alcuna spiegazione. In tal caso, non verranno raccolti ulteriori dati che la riguardano, fermo restando che sarà autorizzato l'uso dei dati raccolti in precedenza in modo da non alterare l'analisi dei risultati dello studio.

Consenso

Firmando questo modulo, acconsento al trattamento dei miei dati personali nonché al loro trasferimento per le finalità dello studio, in conformità ai termini e alle condizioni specificati nell'informativa fornitami con il presente documento.

Nome e cognome del paziente

____

Firma del paziente

____

Data

____

Appendix B

SENTENCE REPETITION TASK

Item Number	Exp / Fill	Condition	Stimulus
1	Exp	Base-O	Giuliana ha regalato l'orologio a sua sorella
1	Exp	Topic-O-Clitic	L'orologio Giuliana lo ha regalato a sua sorella
1	Exp	Topic-PP	A sua sorella Giuliana ha regalato l'orologio
2	Exp	Base-O	Marco ha prestato soldi a suo figlio
2	Exp	Topic-O-Clitic	Soldi Marco ne a prestati a suo figlio
2	Exp	Topic-PP	A suo figlio Marco ha prestato soldi
3	Exp	Base-O	Maria ha raccontato una storia alla vicina
3	Exp	Topic-O-Clitic	Una storia Maria la ha raccontata alla vicina
3	Exp	Topic-PP	Alla vicina Maria ha raccontato una storia
4	Exp	Base-O	Giuseppe ha costruito tante case al mare
4	Exp	Topic-O-Clitic	Tante case Giuseppe le ha costruite al mare
4	Exp	Topic-PP	Al mare Giuseppe ha costruito tante case
5	Exp	Base-O	Davide ha portato delle sedie in terrazza
5	Exp	Topic-O-Clitic	Delle sedie Davide le ha portate in terrazza
5	Exp	Topic-PP	In terrazza Davide ha portato delle sedie
6	Exp	Base-O	Daniela ha cucito il vestito per la nipote
6	Exp	Topic-O-Clitic	Il vestito Daniela lo ha cucito per la cugina
6	Exp	Topic-PP	Per la cugina Daniela ha cucito il vestito
7	Exp	Base-O	Giorgio ha lasciato le galline in cortile
7	Exp	Topic-O-Clitic	Le galline Giorgio le ha lasciate in cortile
7	Exp	Topic-PP	In cortile Giorgio ha lasciato le galline
8	Exp	Base-O	Piero ha messo sale sulle sarde
8	Exp	Topic-O-Clitic	Sale Piero ne ha messo sulle sarde
8	Exp	Topic-PP	Sulle sarde Piero ha messo sale
9	Exp	Base-O	Galileo ha scoperto stelle col telescopio
9	Exp	Topic-O-Clitic	Stelle Galileo ne ha scoperte col telescopio
9	Exp	Topic-PP	Col telescopio Galileo ha scoperto stelle
10	Exp	Base-O	Vittorio ha scavato molti pozzi in campagna
10	Exp	Topic-O-Clitic	Molti pozzi Vittorio li ha scavati in campagna
10	Exp	Topic-PP	In campagna Vittorio ha scavato molti pozzi
11	Exp	Base-O	Carla ha lavato la camicia con l'aceto
11	Exp	Topic-O-Clitic	La camicia Carla la ha lavata con l'aceto
11	Exp	Topic-PP	Con l'aceto Carla ha lavato la camicia
12	Exp	Base-O	La maestra ha interrogato gli alunni in cortile
12	Exp	Topic-O-Clitic	Gli alunni la maestra li ha interrogati in cortile
12	Exp	Topic-PP	In cortile la maestra ha interrogato gli alunni
13	Exp	Base-O	Il cuoco ha preparato i carciofi per pranzo
13	Exp	Topic-O-Clitic	I carciofi il cuoco li ha preparati per pranzo
13	Exp	Topic-PP	Per pranzo il cuoco ha preparato i carciofi

14	Exp	Base-O	Il papà ha chiuso le finestre alle cinque
14	Exp	Topic-O-Clitic	Le finestre il papà le ha chiuse alle cinque
14	Exp	Topic-PP	Alle cinque il papà ha chiuso le finestre
15	Exp	Base-O	Paolo ha acquistato la barca per il nipote
15	Exp	Topic-O-Clitic	La barca Paolo la ha acquistata per il nipote
15	Exp	Topic-PP	Per il nipote Paolo ha acquistato la barca
16	Exp	Base-O	Ieri io ho mangiato pasta a cena
16	Exp	Topic-O-Clitic	Pasta ieri ne ho mangiata a cena
16	Exp	Topic-PP	A cena ieri ho mangiato pasta
17	Exp	Base-O	La nonna ha comprato la carne al mercato
17	Exp	Topic-O-Clitic	La carne la nonna la ha comprata al mercato
17	Exp	Topic-PP	Al mercato la nonna ha comprato la carne
18	Exp	Base-O	La bambina ha rovesciato l'olio sul pavimento
18	Exp	Topic-O-Clitic	L'olio la bambina lo ha rovesciato sul pavimento
18	Exp	Topic-PP	Sul pavimento la bambina ha rovesciato l'olio
19	Exp	Base-O	Il postino ha consegnato dei pacchi a Gianni
19	Exp	Topic-O-Clitic	Dei pacchi il postino li ha consegnati a Gianni
19	Exp	Topic-PP	A Gianni il postino a consegnato dei pacchi
20	Exp	Base-O	Il cuoco ha spalmato della crema sulla torta
20	Exp	Topic-O-Clitic	Della crema il cuoco la ha spalmata sulla torta
20	Exp	Topic-PP	Sulla torta il cuoco ha spalmato della crema
21	Exp	Base-O	Il contadino ha sparso del letame sui campi
21	Exp	Topic-O-Clitic	Del letame il contadino lo ha sparso sui campi
21	Exp	Topic-PP	Sui campi il contadino ha sparso del letame
22	Exp	Base-O	Il pescatore ha lanciato un amo in canale
22	Exp	Topic-O-Clitic	Un amo il pescatore lo ha lanciato in canale
22	Exp	Topic-PP	In canale il pescatore ha lanciato un amo
23	Exp	Base-O	Il meccanico ha spinto un furgone in strada
23	Exp	Topic-O-Clitic	Un furgone il meccanico lo ha spinto in strada
23	Exp	Topic-PP	In strada il meccanico ha spinto un furgone
24	Exp	Base-O	La mamma ha levato una coperta dal letto
24	Exp	Topic-O-Clitic	Una coperta la mamma la ha levata dal letto
24	Exp	Topic-PP	Dal letto la mamma ha levato la coperta
25	Exp	Base-O	Il giardiniere ha spruzzato acqua sulle orchidee
25	Exp	Topic-O-Clitic	Di acqua il giardienere ne ha spruzzata sulle orchidee
25	Exp	Topic-PP	Sulle orchidee il giardiniere ha spruzzato acqua
34	Fill	Fill-art	Dopo mangiato ordiniamo sempre il caffè
34	Fill	Fill-zero	Dopo mangiato ordiniamo sempre caffè
34	Fill	Fill-di+art	Dopo mangiato ordiniamo sempre del caffè
35	Fill	Fill-art	A colazione non voglio la frutta
35	Fill	Fill-zero	A colazione non voglio frutta
35	Fill	Fill-di+art	A colazione non voglio della frutta
36	Fill	Fill-art	Per passare il tempo ho raccolto le violette
36	Fill	Fill-zero	Per passare il tempo ho raccolto violette
36	Fill	Fill-di+art	Per passare il tempo ho raccolto delle violette
37	Fill	Fill-art	Se ci fosse acqua ne berrei un sorso

37	Fill	Fill-zero	Se ci fosse l'acqua ne berrei un sorso
37	Fill	Fill-di+art	Se ci fosse dell'acqua ne berrei un sorso
38	Fill	Fill-art	Vado in cantina a prendere il vino
38	Fill	Fill-zero	Vado in cantina a prendere vino
38	Fill	Fill-di+art	Vado in cantina a prendere del vino
39	Fill	Fill-art	Per le vacanze Virginia deve leggere i libri
39	Fill	Fill-zero	Per le vacanze Virginia deve leggere libri
39	Fill	Fill-di+art	Per le vacanze Virginia deve leggere dei libri
40	Fill	Fill-art	La domenica mattina Roberta piega le tovaglie
40	Fill	Fill-zero	La domenica mattina Roberta piega tovaglie
40	Fill	Fill-di+art	La domenica mattina Roberta piega delle tovaglie
41	Fill	Fill-art	A ferragosto si fanno i fuochi d'artificio
41	Fill	Fill-zero	A ferragosto si fanno fuochi d'artificio
41	Fill	Fill-di+art	A ferragosto si fanno dei fuochi d'artificio
42	Fill	Fill-art	In montagna mi piace fare le camminate
42	Fill	Fill-zero	In montagna mi piace fare camminate
42	Fill	Fill-di+art	In montagna mi piace fare delle camminate
43	Fill	Fill-art	Lorenzo conosce bene i pescatori di seppie
43	Fill	Fill-zero	Lorenzo conosce bene pescatori di seppie
43	Fill	Fill-di+art	Lorenzo conosce bene dei pescatori di seppie
44	Fill	Fill-art	Marta dipinge spesso i quadri astratti
44	Fill	Fill-zero	Marta dipinge spesso quadri astratti
44	Fill	Fill-di+art	Marta dipinge spesso dei quadri astratti
45	Fill	Fill-art	Francesco frigge il pesce appena pescato
45	Fill	Fill-zero	Francesco frigge pesce appena pescato
45	Fill	Fill-di+art	Francesco frigge del pesce appena pescato
26	Fill	Fill-Sub-Pre	Se c'è il sole vado al mare
26	Fill	Fill-Sub-Post	Vado al mare se c'è il sole
26	Fill	Fill-Sub-Post-Lex	Giada va al mare se c'è il sole
27	Fill	Sub-Pre	Entriamo quando finisce la musica
27	Fill	Fill-Sub-Post	Quando finisce la musica entriamo
27	Fill	Fill-Sub-Post-Lex	Marco entra quando finisce la musica
28	Fill	Fill-Sub-Pre	Durante il temporale è andata via la luce
28	Fill	Fill-Sub-Post	È andata via la luce durante il temporale
28	Fill	Fill-Sub-Post-SubjPre	La luce è andata via durante il temporale
29	Fill	Sub-Pre	Se suona il campanello apri la porta
29	Fill	Fill-Sub-Post	Apri la porta se suona il campanello
29	Fill	Fill-Sub-Post-Lex	Pino apre la porta se suona il campanello
30	Fill	Sub-Pre	Prima che faccia giorno il gallo canta
30	Fill	Fill-Sub-Post	Il gallo canta prima che faccia giorno
30	Fill	Fill-Sub-Post-Lex	Luigi si sveglia prima che il gallo canti
31	Fill	Fill-Sub-Post	Abbiamo cambiato la serratura senza dire niente
31	Fill	Sub-Pre	Senza dire niente abbiamo cambiato la serratura
31	Fill	Fill-Sub-Post-Lex	La vicina ha cambiato la serratura senza dire niente
32	Fill	Fill-Loc-Subj	In fondo alla strada inizia il bosco

32	Fill	Subj-Loc	Il bosco inizia in fondo alla strada
32	Fill	Fill-Loc-Subj	Alla fine della strada c'è il bosco
33	Fill	Fill-Loc-Subj	Dietro la chiesa c'è il campo da calcio
33	Fill	Fill-Subj-Loc	Il campo da calcio è dietro la chiesa
33	Fill	Fill-Loc-Subj	Dietro la chiesa trovi il campo da calcio