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Development of verb fluency and utilization, and its importance for neuropsychology

Julio César Flores Lázaro,[1,2] Cinthya Nenetzyn Saldaña García,[3] José Marcos Ortega,[2,4,5] Eduardo Alejandro Escotto Córdova,[6] Héctor Juan Pelayo González[7]

Review article

ABSTRACT

Syntactic competence development begins between one and three years of age. An important component in this complex process is that of active verb utilization, and morphology-semantic-verb acquisition. Recent investigations have outlined the interdependence of cognitive processes during child development, for example the importance of developing executive control for verb selection (mapping) and efficient verb-utilization, as well as the importance of verb-semantics for cognitive processing. However, in both the national and the international context, studies on the fluency and lexical-semantic organization of verbs are still insufficient.

In this article, a basic review is presented of the characteristics of development in verb active utilization and fluency of verbs in preschoolers and older children. Its importance is outlined for the fields of linguistics and psycholinguistics, but especially for developmental neuropsychology.

Key words: Verbal fluency, development, executive function.

RESUMEN

El desarrollo sintáctico del lenguaje se inicia entre los dos y tres años de edad. Dentro de este complejo proceso, destaca el uso activo del verbo y de sus variantes morfológicas-semánticas. En recientes investigaciones se ha resaltado la interdependencia de los procesos cognitivos durante el desarrollo, por ejemplo la probable dependencia del desarrollo del control ejecutivo para la selección (*mapeo*) y uso efectivo de los verbos, así como la importancia de los verbos en el procesamiento cognitivo. Sin embargo, tanto en el contexto nacional como internacional, los estudios sobre la fluidez de verbos y su organización léxico-semántica durante el desarrollo aún son insuficientes.

En este artículo se presenta una revisión básica sobre las características del desarrollo en el uso y la fluidez de verbos en niños preescolares y escolares. Se destaca su importancia para el campo lingüístico y psicolingüístico, pero sobre todo para el campo de la neuropsicología del desarrollo.

Palabras clave: Fluidez verbal, desarrollo, función ejecutiva.

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INTRODUCTION

Language development in children, and in particular basic linguistic competence, occurs in a visibly accelerated way during early years: at around three years of age, children show an important lexical and grammatical competency.[1] Despite this initial competency, children characteristically have only a fraction of the semantic richness of meaning and the lexical-semantic and grammatical relationships of words. During the enrichment of linguistic representations, children frequently make errors of evocation for various reasons: they do not know the appropriate form of the word, their representations are incomplete, or they are in the process of creating maps for the representations of words within the lexicon.[2]

The predictive capacity and efficient use of verbs (morphology and semantics) requires a prolonged period of development (until the start of adolescence), although it has been described how from around 28 months, children are capable of determining the syntactic relationships in which verbs occur (for example, verbs with two arguments: *Pedro pushed Lupita*, or with a single argument: *he sleeps*). Equally, they can also utilize the order of the elements of the sentence (the subject-verb-object relationship) to extract the role of the agent implied in the verb, as one of the primary procedures of acquisition.[3] However, it has been observed that

[1] HPI-INMEGEN, National Health Institutions, Mexico.
[2] Postgraduate - National Autonomous University of Mexico (UNAM).
[3] Faculty of Human Communication. Autonomous University of Mexico State.
[4] Audiology and Phoniatry Service, General Hospital of Mexico.
[5] Postgraduate - National Autonomous University of Puebla (BUAP), Mexico.
[6] Faculty of Higher Education, Zaragoza - UNAM.
[7] Faculty of Psychology, Postgraduate BUAP.

Correspondence: José Marcos Ortega. Hospital General de México, CCINHS-Secretaría de Salud. México. E-mail: jmarcos1000@hotmail.com

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children at four years old still tend to spontaneously generate lexical innovations (such as *cutter* for an object that cuts). Even before resorting to this, a significantly high number of children tend to employ already-existing words to indicate an action or function. It is thought that using this strategy represents a simple cognitive solution and one that is more economical than generating a new word. Another frequently-occurring phenomenon is resorting to a syntactic description (through a phrase). It is believed that children perceive the necessity to use a verb in the noun or name of the object they are presented with and, because their morphological development is still not sufficiently competent, they resort to the most easily available syntactic means. The form prior to that expected is in the infinitive: first *cut*, and then *cutter*[1]

High frequency verbs are common in spontaneous speech at preschool age (run, jump, walk), which become the prototypes for larger significant categories.[4]

NAMING OF ACTIONS AND EVENTS AT PRESCHOOL STAGE

Towards three years of age, children can start to be observed relating an object with the actions or functions it performs in a verbally competent manner, and verb tenses start to appear. Development from the *Holophrase* is particularly interesting: this is the expression of a whole phrase from the use of one word. It is considered that progressive cognitive and linguistic development will allow the child to be able to analyze the sequence of events and assign linguistic resources in a specific and sequential way.[5] In this way, they go from the nominal phrase (use of the subject or object as a verb) and the predicative phrase, towards the construction of minimally-structured sentences (specifically marking each subject or object).

The process of verb acquisition is more prolonged and complex than that for nouns.[6] For example, at five years of age, children have still not achieved the capacity to express infinitive verbs consistently, more often using the third person form.[7] Efficient use of verbs is more complex than that for other linguistic categories (such as nouns), given that if a verb and its constellation of arguments is learned, it is not possible to generalize that learning to other verbs.[8,9] In children between three and five, performance in verb-naming tasks has shown to be less efficient that for nouns, which is attributed to the underlying differences in the representation and semantic organization of both categories and to the different way in which they are acquired.[8]

As well as semantic organization, it is relevant to explore the underlying morphological competency during childhood: the grammatical form expressed (from the verbs that the child knows) in an isolated way, or accompanied by arguments. The structural paradigm of a Spanish verb can be summarized as root, thematic vowel, morpheme I, and morpheme II; morpheme I possesses tense, aspect, and modality; and morpheme II represents the person and the number.[10] Given the complexity of the verbal morphology of Spanish, it is expected that the first grammatically simple forms accompanied with an argument will appear between the ages of six and ten (*Maria kicks the ball*). When the naming of an action is abstracted in the infinitive modality, it is possible to observe a predominance of verbs in the infinitive (kick).[9]

Masterson, Drukes, and Galiene[8] studied children aged three to six by means of the *Objects and Actions Naming Battery*,[11] and found that the process of verb acquisition comes after acquisition of nouns (better competency of nouns). Towards the age of five, a significant increase begins to be observed in competency with verbs; however, if reaction times are taken into account as well as the success rate, important differences in performance are still shown in favor of nouns. Reaction times are interpreted as a search process, with an important effect of selectivity-competency between the various options available and/or the construction of an alternative.

In a naming study using sheets of figures in black and white (presented by computer) on children aged five and six years, D'Amico, Devescovi, and Bates[7] found that compared to a group of adults, children of this age showed 92% agreement with the lexical naming of objects; however, they showed only 52% agreement in the naming of actions. The children characteristically gave concrete names (beg vs. ask for money), used short phrases in place of simple verbs like adults, and tended to describe scenarios in context. When comparing items where there were similarities in the description, differences were found in reaction times for naming actions (the children showed greater latency), but no significant differences were found in naming objects. The authors considered that the use of verbs requires a wider and more complex space for decision and cognitive selection (*mapping*): various forms/alternatives to describe the same event.

Multiple *vs*. specific domain focuses set out an important interaction between various cognitive processes during development.[12] In this way, it is proposed that the use of verb tenses also requires the development of a basic comprehension of time and events that happen seasonally. Towards four years of age, the use of verb tenses improves substantially, although these tenses make reference to immediate and short-term events.[2] Currently, emphasis is made on the interaction of cognitive development in time management, and a reciprocal influence in the acquisition of language; the capacity to establish predictive relationships is progressively developed throughout childhood.[13]

SEMANTIC ORGANIZATION OF VERBS

Some authors have proposed that verbs make up a semantic network that is less differentiated than nouns (in the form of a *general matrix*), in which the phenomenon of "intentionali-

ty" would be the primary binding point for these elements.[14] It is proposed that the borders between the categories of verbs which belong to different semantic fields would be more diffuse than those of nouns,[8] because of which the lexical and morphological generalization, as well as the process of conformation of semantic networks for verbs is more difficult to establish than for other elements such as nouns. This is because verbs differ in the number and type of arguments (roles of participation) that they require: intransitive verbs require just one argument (*the child sleeps*), and transitives require a subject and an object (*Pedro kicked the ball*). The argument of verbs can even be identified in the infinitive form: one argument, *to yawn*; two arguments, *to love*, *to kick*; three arguments, *to put*, *to give*.

Masterson et al.[8] also propose that verbs do not possess a hierarchical order between their categories, which is characteristic of substantives. The organization would have a "flat" representation (without supra/subordinate hierarchies), a general matrix organized on the basis of its arguments: presence or absence of an instrument ("to hammer"), an object ("to place"), a direction ("to move to"), etc. During development, children must form semantic representations of verbs and learn the rules that tie those representations to propositional structures.[15]

Propositional structures can vary, but the semantic representation of the verb does vary because of that; that is constructed on hearing the word in use and linking it with its concept. It is therefore correct to state that events conceptualize themselves.[15] In terms of their semantic representation, it has been proposed that verbs could be classified into two types: movement, concrete verbs (which include a vast set of perceptual and motor associations), and verbs of cognition, or abstract verbs (which include a variety of propositional information and lack the set of perceptive and motor associations). In spite of the relevance which implicates the verb in the development of expressive language,16 the semantic organization of verbs is still an unexplored area, because of which the characteristics of said organization in childhood or adulthood is unknown.[8]

The *Embodied Cognition Framework* has been proposed for the study of this area, which has already been applied to the process of naming actions.[17] This model sets out how the lexical representation of verbs has two modalities: one is motor (sensory-motor) and the other is semantic. This focus allows the study of whether the majority of verbs stems from sensory-motor representations and show an evolution towards semantics (a concrete-abstract transition). Recent electrophysiology studies in adults indicate the coactivation of sensory-motor and semantic systems during the naming and processing of actions, with effects of facilitation in the processing when there is concordance, and effects of competency-blocking when there is incongruence between an action and the phrase that describes an action.[18] In the case of development, it has been described that from the age of two, it is easier for children to understand phrases which include animate subjects than inanimate subjects.[3]

Thordardottir and Weismer[19] find a repertoire of eights types of arguments in school children from five to nine years old with normal development: agent, theme, object, source, goal, beneficiary, copular complement, and object+verb+unspecified, of which the ones that almost always appear in the expression are source and object, the subject frequently being omitted if it is practically acceptable. In normal development, they also observe a variety in the use of types of arguments and argumental structures of up to four.

In verb-naming tasks, performance has shown to be less efficient than that for nouns in ages between three and five, which is attributed to the differences which underpin the semantic representation of both categories and to the distinct way in which they are acquired.[8] The semantic organization and representation of verbs are more complex than for nouns, as due to their argumental structure, they must include a semantic relationship with nouns, as well as an implicit syntactic context which determines the arguments that can surround it.[8]

COGNITIVE FUNCTIONS OF THE VERB

Verbs have a central grammatical role: they provide a link between the meaning and the structure of a sentence, establishing the transitive relationships (actions) between the elements of the sentence.[4] From a psycholinguistic perspective, it is proposed that verbs encode structures of arguments which activate frameworks of syntactic and semantic processing that go beyond the concrete naming of an action.[17] It is considered that verbs act as prototype units to synthesize categories with greater meaning, which allows a syntactic and semantic simplification with minimal loss of information.[4] It has also been found that even in preschool children, verbs that are already known allow them to infer the meaning of other words.[3]

NEUROPSYCHOLOGY OF VERB FLUENCY

Even in natural contexts, verbs derive from and develop within syntactic and pragmatic processing.[8] Some authors in the field of cognition, particularly developmental neuropsychology, propose that approaching the verb as a unit of cognitive processing, and as a measure of neuropsychological-executive function, is extremely useful in assessing prefrontal executive-cortex control, and can also be useful from the psycholinguistic context.[4,20,21] As well as arguments, another characteristic to take into account is a high codependency of inflections, because of which the particular morphological-syntactic context where they are used is an important factor. Due to this, it is proposed that the capacity underlying

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the possibility to search out, analyze, and select the suitable verb form has a high component of executive control.[22]

Interest in the cerebral organization of verbs is very recent compared to the study of the cerebral organization of language.[23] Verbs are recognized as grammatically distinct categories in all languages, and learning verbs follows a different pattern during acquisition.[8,24] In brain damage, this category clearly dissociates from nouns in naming recovery, reading, and writing tasks.[25-27] Verbs present a different cerebral organization to nouns. Very recent studies (with functional neuroimaging) have found that the perceptual processes of actions (seeing someone run) and the semantic correlate (what "run" means) are found to be represented by networks in different regions of the brain. It has also been found that the perception of actions activates the premotor regions bilaterally, but the comprehension of phrases which imply physical actions only activates the left premotor regions.[28]

Within the framework of the *Embodied Cognition Model*, it is proposed that conceptual knowledge is not amodal; it is developed in sensory-motor systems which participate during conceptual processing. These pattern systems are reactivated during perception and action. Based on this model, distinctive cerebral correlates have been found for five types of verbal information: action (primary and premotor cortex), movement (temporal-occipital cortex), contact (intraparietal sulcus and inferior parietal lobule), change of state (ventral temporal cortex), and tools of use (temporal, parietal, and frontal regions).[29]

Holland et al.[20] studied verb fluency in 33 subjects aged seven to 18 years with functional neuroimaging, and found (bilateral) activation in Broca's area and in the homologous region of the right hemisphere, but with a tendency towards lateralization to the left hemisphere from childhood. They also discovered that as age increased, this lateralization increased even more towards the left hemisphere, and particularly focused on the posterior portions of the inferior frontal gyrus (Broca's area). They also found that the number of activation points (active pixels) in the right PFC reduced with age. Similar results were found by Wood et al.[30] in 48 children and 17 adults. Szaflarski, Hoolland, Schmithorst, and Byars[31] found that even from five years of age, this same cerebral region-verbal fluency relationship was found.

The progressive left lateralization would relate to acquisition-complexification processes (primarily influenced by academic and environmental experiences). It has been proposed that the left frontal participation would imply the activation of abstract (and not sensory-perceptive) representations of actions.[28] By means of cognitive development, linguistic representations require more "abstract" and semantically organized cerebral networks (of the primarily left, prefrontal cortex) due to which, towards the end of adolescence, and in particular in adult subjects, the cerebral correlates are distinct to those in children.[32]

EXECUTIVE CONTROL IN VERBAL FLUENCY

Verb recovery does not only involve a morphological and grammatical process; it also involves an important participation of executive function. In verb fluency tasks, it has been found that the options to choose/select verbs involve an executive and attentional component which is greater than that of other paradigms belonging to the category of verbal fluency –phonological and semantic.[30] As such, a measure of clinical assessment of frontal damage during the assessment of executive function has been considered.[33,34]

It is considered that when a verb is processed, it simultaneously coactivates the whole variety of arguments that it possesses.[35-37] Therefore, a verb with multiple arguments will take longer to be processed than a verb with only one;[19] in other words, the greater the argumentative richness in a verb, the greater the options (coactivations) to analyze and select (selectivity in recovery). This brings with it a greater processing cost (greater and longer-lasting use of cognitive resources); and therefore more time taken to carry out the tasks. This executive cost in the processing of a verb would include precision in searching, use of strategies, updating information, and the production of elements in a given time. All of these aspects are linked to the prefrontal cortex[38] and specifically the premotor region and Broca's area.[21,39]

During the execution of verbal fluency paradigms, and in particular when changes must be made between categories of representations which are competing for their recovery, there is a functional mechanism called "switching" which underpins the task and which is associated with activity in the left inferior frontal gyrus.[40] In areas of verbal fluency in Spanish-speaking children, a significant relationship between inhibitory control and the formation of semantically-related clusters of words has been observed. The interpretation given to this relationship is that in an evocation considered cognitively irregular due to presenting periods of production with periods of silence, the intervention of executive functions allows the formation of clusters.[41] In the case of verbal fluency, variations in performance directly correlate with executive function.[42]

Efficiency of use and executive development (executive control)

In the field of executive functions, it has been demonstrated that children possess knowledge and cognitive skills that are very often not used spontaneously or voluntarily, given that the capacity to recruit and select the best cognitive resources (in this case, argumentative) requires a more prolonged development. This phenomenon is called the knowing-knowing/doing dissociation.[13,43] As their executive competency (mapping and selection) improves, so children present greater capacity to take advantage of the best form of their

cognitive repertoire; this capacity primarily depends on the development of executive functions.[44]

CONCRETE-ABSTRACT DEVELOPMENT

The number of verbs produced in one minute increases in a linear way during development and does not stop increasing throughout childhood, in young people who attend university.[33,45] However, the type of emission that is produced also changes with age. Ávila[46] found that when Mexican children in the third grade of elementary school describe their activities in writing, they use verbs with concrete references in 90% of cases, whereas almost 60% of children in the sixth grade use abstract-type verbs. Coincidently, a very similar progress (concrete-abstract) has been found in Mexican children in semantic categorization tasks.[47] These results indicate that during development, as well as a statistically significant increase in productivity (number of verbs emitted), which would reflect a measure of executive control (selectivity in the evocation-actualization of the representations), a cognitive-qualitative change is expected in the type of verb (concrete vs. abstract) and in the morphological-semantic richness of the verbs produced. This would reflect a measure that is more cognitive-psycholinguistic, and above all, more clinically sensitive.

CLINICAL APPLICATION

In the field of neuropsychology, it has been determined that the naming of objects implies a neurocognitive process that is less complex than the naming of actions; this is because access to the lexical label of an object has a more direct relationship and less semantic competency than the selection of the adequate verbal form.[7,14,22] It has been found that children with specific language disorder have greater difficulties in naming actions than objects,[8,48] correctly determining verbal inflection, use of particles, complementation, incidental learning of new verbs, and using verbs with argumentative complexity–verbs with three or more arguments.[20] Furthermore, various studies on adult patients with Broca's aphasia have shown that the production of verbs is difficult in relation to the number of arguments that each verb requires.[49]

Baron, Erickson, Ahronovich, Baker, and Litman[50] found that in children aged three born with low birth weight and prematurely (<26 weeks of gestation), performance in verbal fluency was below the control group (born to term and with a normal weight). Replication of these results has been found in other studies with similar groups, and it has therefore been suggested that fluency of verbs can be an early predictor of executive dysfunction/difficulties with fluency of language during childhood.[50]

Fluency of verbs has also been used as part of the neurophysiological assessment instruments for children with cranioencephalic trauma,[51] and a significantly lower performance has been observed with respect to the control group. Production of verbs is also seen to be affected in the case of children with simple partial epilepsy. Measuring the fluency of three types of verbs (auxiliary, copular, and non-infinitive) and comparing performance with a control group, the production of auxiliary verbs was seen to be limited corresponding with a telegraphic style.[52]

In children with Muscular Dystrophy, a narration was observed that was qualitatively inferior to the control group with normal development, consistent with a low number of verbs and complete sentences. The above suggests that the reduced production of sentences is due to a selective problem in the generation of the argumental structure of the verb.[53] Differences in narration have also been observed in a population of children who have difficulties in language development, given that more complex verbal forms appear in conversation than in narration tasks.[54]

Children with Language Disorder have been found to present delay or modification in use of verb forms,[16] a greater use of verbs with non-specific meanings (to do, to be),[54] less variety in the type of arguments which accompany the verb and in the number of arguments they structure in a sentence,[19] substitution in verb tenses, person, less variety in the use of verb aspect (modality),[55-57] latency in verb naming tasks,[8,48] as well as less precision in verb naming (actions) with respect to nouns (objects).[48]

When comparing two cases with prefrontal-dorsolateral damage in two 12 year-old adolescents, one with right damage and the other with left, Pérez Morales, Bittencourt Chastinet, and Flores Lázaro[58] describe that for the case with left prefrontal damage, the possibility of updating the verb in the infinitive form is lost. In other words, it was extracted from its arguments, because of which the task is carried out with the presence of phrases. In contrast, the case with right prefrontal damage showed marginal performance for the generation of verbs in the infinitive form. The above indicates that differences could be found in lateralization as early as the beginning of adolescence, with a greater contribution of the left prefrontal cortex for the generation of verbs as individual linguistic units.

Evidence from functional neuroimaging added to clinical evidence allows the proposal that verb fluency can be a more sensitive measure of frontal dysfunction;[26,34,45,59] but in spite of this, it is still not widely disseminated.

In spite of the dependence of the executive function system for performance in verbal fluency tests already having been identified, this relationship has not been sufficiently specified.[22] In the literature, it has been described that the component of fluency that is most developed in childhood is switching from one category to another. This capacity requires other more basic ones, such as strategic searching, monitor-

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ing, and flexibility. It has also been described that the optimal comprehension of passive sentences (when it is not clear that the subject is the agent of the action described by the verb) presupposes the development of the capacity for cognitive flexibility, which will allow for the exercise of an analysis of reversibility of the linguistic elements exposed. This capacity begins to be competent at around six-seven years of age.[60]

From the clinical perspective, the importance of having sensitive clinical instruments which identify children with language disorders has been indicated. For this reason, verbal fluency tests could represent a very important cognitive and clinical field of development for child neuropsychology. They would allow the semantic organization of verbs, their types, and their form etc to be characterized in childhood.[6]1 Notwithstanding that verbal fluency tasks are recognized as a part of clinical measures in the assessment of executive function, their inclusion in Executive Function Assessment Batteries is very recent.[59] The linear value of the increase in the number of verbs produced in one minute from childhood through to adolescence indicates that this measure of lexical availability can be an important marker in neuropsychological and psycholinguistic development,[47] taking into account that the maximum verbal-argumentative competency reaches right through to adolescence.[19]

CONCLUSIONS

In spite of the relevance implied by the use of the verb in the expressive language development, linguistic and psycholinguistic characteristics of verb fluency are areas that are insufficiently explored.[8,60] Characterization studies during normal development allow for knowledge of the basic particularities of this phenomenon and subsequently, the early identification of difficulties. The specific difficulties in the field of morphology and verbal semantics would therefore be highlighted, which would allow for greater intervention-rehabilitation in the various alterations of neurodevelopment that go hand in hand with language difficulties. The executive control that underpins efficient verb production can be a sensitive measure of "subtle" (but cognitively relevant) neurodevelopmental difficulties (masked or subclinical) that are not detected by conventional assessment measures.

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