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The role of imageability in noun and verb acquisition in children with Down syndrome and their peers with typical development

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Abstract
Our main objective was to analyze the role of imageability in relation to the age of acquisition (AoA) of nouns and verbs in Spanish-speaking children with Down syndrome (DS) and their peers with typical development (TD). The AoA of nouns and verbs was determined using the MacArthur-Bates CDIs adapted to the profile of children with DS. The AoA was analyzed using a linear mixed-effect model, including factors of imageability, group, and word class, and controlling for word frequency and word length. This analysis showed that high imaginable and short words were acquired early. Children with DS acquired the words later than TD peers. An interaction between imageability and group indicated that the effect of imageability was greater in the DS group. We discuss this effect considering DS children's phonological memory difficulties. The overall results confirm the role that imageability and word length play in lexical acquisition, an effect that goes beyond word class.

Introduction

The role of imageability in noun and verb acquisition in children with Down syndrome and their peers with typical development

Down syndrome (DS) is a neurodevelopmental disorder and the main non-inherited genetic cause of intellectual disability (Fidler & Nadel, 2007; Galdzicki & Siarey, 2003), with language being one of the most impaired domains of functioning considering the level of cognitive development (Abbeduto et al., 2007; Chapman, 1995). However, not all components of language are equally affected; most studies on individuals with DS have found that compared to their morphosyntactic abilities, vocabulary is a strength (see review by Galeote et al., 2011). Some studies have even shown that their lexical comprehension exceeds nonverbal cognitive levels, this being the case for adolescents, young adults (Chapman, 2006), and children (Galeote et al., 2011) with DS. However, little research

has been conducted on their acquisition of different classes of words (nouns, adjectives, verbs, for example).

The main objective of the present study was to examine the role of imageability in noun and verb acquisition in children with DS and children with typical development (TD). Furthermore, as Galeote et al. (2018) pointed out, studying the acquisition of different classes of words is important for both theory (to understand the mechanisms that children use when learning words) and practice (to improve assessment and intervention methods). To our knowledge, no studies have specifically examined the association between imageability and noun and verb learning in children with DS or in Spanish-speaking children with TD. The study of imageability, which thus far has been very limited, is relevant to understand its relationship with the lexical development of children with DS.

To establish a clear justification for our study, we will begin by considering (1) the debate about noun and verb acquisition in developmental linguistics, (2) the acquisition of nouns and verbs in children with DS, and (3) the role that imageability plays in the learning of these classes of words.

Nouns are learned before verbs

The study of noun and verb acquisition has generated an intense debate about the order in which these classes of words are acquired (for a summary of this debate, see Waxman et al., 2013; Galeote et al., 2018). In a pioneering study, Gentner (1982) proposed that in early vocabularies, nouns are acquired before verbs because the majority of nouns refer to concrete objects that are relatively permanent/stable, coherent, and tangible. By contrast, verbs and other predicate words reflect relational meaning (relationship between objects or events) and have a less transparent relationship to the perceptual world. More specifically, Gentner (1982) and Gentner and Boroditsky (2001) claimed that to learn verbs and other relational terms (including some nouns), children must discover which aspects of the situation (semantic components) form part of their meaning. Moreover, whereas objects are stable in time and space, actions are fleeting and are performed by different actors. Consequently, word-referent mapping could be easier for concrete nouns than for verbs (Gentner, 2006). From this perspective, the early advantage of nouns over verbs would be a universal feature of human language, resulting from fundamental differences in the concepts that these word classes tend to name.

Although various studies have supported this universalist view, with a noun bias present in distinctly different languages, studies conducted primarily in Asian languages, such as Korean and Mandarin, appear to challenge this proposal (see a review in Galeote et al., 2018). These results can be interpreted as reflecting the structural features of these languages. For example, Korean is an SOV (subject-object-verb) language, so verbs occupy a salient position. Subjects and objects are also often omitted, which favors a higher frequency of verbs in children's input. Because of this, the early noun advantage might be a consequence of the characteristics of the language being learned: noun-friendly vs. verb-friendly languages (Waxman et al., 2013). It should be noted, however, that other authors have found that the verb advantage is less marked or even absent in these languages (e.g., Au et al., 1994, for Korean; Tardif et al., 1999, for Mandarin). Furthermore, experimental studies on the acquisition of new nouns and verbs in these languages have found that the former are learned more quickly and more easily (see, for example, Imai et al., 2008).

The acquisition of nouns and verbs in children with Down syndrome

Gillham (1990) and Miller (1999) identified considerable similarities between children with DS and children with TD in relation to the acquisition of different word classes. For example, nouns appeared early in the vocabularies of both groups. More recent studies involving Italian-speaking children with DS and their peers with TD (Bello et al., 2014; Zampini & D'Odorico, 2011, 2012) likewise found that nouns appeared before predicates in both groups of children. The fact that these studies used different methodologies (spontaneous language in Zampini & D'Odorico, 2011; Italian version of the MacArthur-Bates Communicative Development Inventories (CDIs) in Zampini & D'Odorico, 2012; and Italian CDIs and a structured test of lexical comprehension and production in Bello et al., 2014) provides convergent evidence for this finding.

In Spanish, a language that shares many structural features with Italian, two recent studies (Checa et al., 2016; Galeote et al., 2018) were carried out with the same sample of participants: 108 Spanish-speaking children with DS and 108 children with TD with a mental age (MA) of 9 to 29 months, grouped by different lexical levels. Information about vocabulary was obtained using the CDIs adapted to the language development profile of children with DS (hereinafter, the CDI-Down; see Method section). The two studies differed in the vocabulary measure used: absolute percentages (i.e., the percentage of nouns/verbs produced by each child in relation to their vocabulary size) vs. relative percentages (e.g., the percentage of nouns/verbs in relation to the total number of nouns/verbs that appear in the CDIs) (see Galeote et al., 2018 for a justification of the two measures). Compared with children with TD, the children with DS in the study by Checa et al. (2016; measure = absolute percentages) produced more nouns, while the children with DS in the study by Galeote et al. (2018; measure = relative percentages) produced fewer verbs; in both cases, nouns appeared before predicates. These results support a noun bias in Spanish-speaking children (both those with DS and those with TD) and corroborate the findings in Italian children with DS.

Acquisition of nouns and verbs: The role of imageability

The concept of imageability refers to the ease with which a word gives rise to a mental image or sensory experience (Paivio et al., 1968). Thus, words such as "apple" are typically rated as higher in imageability than words such as "hope" (Paivio et al., 1968). One factor related to imageability is concreteness, defined as the degree to which words refer to objects, persons, places, or things that can be experienced by the senses (Paivio et al., 1968) or, in other words, as the ability to see, hear, and touch something (Bird et al., 2001). However, as several authors point out (Bird et al., 2001; Kousta et al., 2011; Paivio et al., 1968), there are clear differences between both factors, such that a word can be highly concrete but low in imageability or vice versa. Thus, although related, the dimensions of imageability and concreteness are different constructs (Kousta et al., 2011; McDonough et al., 2011). Additionally, several studies have demonstrated the facilitatory effect of imageability in various linguistic processes (word naming, lexical decision, word recognition memory, etc.) in both typical and clinical populations (see Rofes et al., 2018). Hence, imageability might also play an important role in early noun and verb learning.

As we noted in the previous section, research appears to support a noun bias in early vocabularies. However, as Ma et al. (2009) point out some nouns like "idea" or "uncle" are learned after verbs such as "eat" or "drink." Ma et al. (2009) refer to this as the "verb learning paradox." One factor that might explain this paradox is the degree of imageability

of words (Ma et al., 2009; McDonough et al., 2011). More specifically, McDonough et al. (2011) suggest that the earlier learning of nouns is due to their greater imageability.

The first studies (e.g., Gilhooly & Logie, 1980; Masterson & Druks, 1998) on the role of imageability in early lexical development were based on adult age of acquisition (AoA) estimates; that is, adults were asked to remember when they first started to produce a word. A serious limitation of these studies, among others, is the questionable accuracy of adults' retrospective memory of AoA (Ma et al., 2009). One way of avoiding these problems is to use AoA scores obtained from parental reports (Ma et al., 2009; McDonough et al., 2011).

Several studies in languages with quite different characteristics (McDonough et al., 2011, for English; Hao et al., 2015; Ma et al., 2009, for Chinese; Hansen, 2017, for Norwegian; Smolík, 2019, for Czech) have studied the relationship between imageability and AoA using the corresponding MacArthur-Bates Communicative Development Inventories (CDIs) for their language. In all these studies, nouns were more imaginable than verbs. In addition, imageability was more powerful than grammatical category (noun vs. verb) in predicting the AoA; this result could explain the earlier acquisition of nouns compared to verbs (Hansen, 2017; Smolík, 2019). Furthermore, in McDonough et al.'s study (2011), the predictive power of imageability was greater than that of frequency, while in Hao et al.'s (2015) and Smolík's (2019) studies, it made a significant unique contribution to predicting AoA. Meanwhile, Ma et al. (2009) found that Chinese children's verbs are more imageable than English children's verbs which could explain not only the cross-linguistic noun bias but also the relative advantage verbs seem to have in the vocabularies of Chinese children; the effect found in this study was independent of frequency.

All these studies show that imageability contributes to lexical learning. This is because words with high imageability denote objects or actions that tend to be perceptually salient and accessible, and easier to represent or retrieve (Golinkoff & Hirsh-Pasek, 2006; Maguire et al., 2006). Smolík and Křiž (2015) suggest that the representation of highly imageable words in working memory may be more robust or efficient. Thus, imageability might play a role in the storage and processing of words in the mental lexicon.

The present study

Checa et al. (2016) and Galeote et al. (2018), despite using different vocabulary measures, found a noun bias in Spanish-speaking children with TD and children with DS. However, the two groups of children in both studies also produced verbs from an early age. According to McDonough et al. (2011), a possible explanation for this result could be that early acquired words are more imageable, independent of their word class. Thus, our main objective here was to analyze the role of imageability in relation to the AoA of nouns and verbs in Spanish-speaking children with DS and their peers with TD.

A secondary aim of the present study was to test whether imageability played a greater role in children with DS than in children with TD. As already noted, in comparison with children with TD, the children with DS in the study by Checa et al. (2016) produced more nouns, while the children with DS in Galeote et al.'s (2018) study produced fewer verbs. These results suggest that imageability may play a greater role in children with DS. In other words, if children with DS learn nouns with less difficulty than verbs, the greater imaginability of nouns may facilitate their learning. In the case of verbs, their lesser imageability, the problems the DS population have with morphosyntax, and the complexity of verb morphology in Spanish could make it more difficult to learn them.

Before investigating the role of imageability, it was also necessary to determine whether, as in other languages, the nouns that appear in the early vocabularies of Spanish-speaking children with DS and children with TD are more imageable than verbs since this would help to validate the role of imageability cross-linguistically and its relationship with the noun bias. To our knowledge, this topic has yet to be studied in Spanish-speaking children.

Ma et al. (2009) and McDonough et al. (2011) also examined the role of word use frequency to determine whether imageability accounted for the AoA of nouns and verbs independently of this variable. To this end, they used frequency data from the CHILDES corpora (MacWhinney, 2000) of child-directed speech (CDS). To our knowledge, there are no CDS corpora in Spanish for children with DS, and frequency data based on written language may not be ideal when working with children (Goodman et al., 2008; Hansen, 2017). Considering the aforementioned, in order to control for word frequency on the acquisition of the nouns and verbs employed in our study, we decided to utilize word frequencies from EsPal (Duchon et al., 2013), which is an adult written corpus (see Smolík, 2019; Hansen, 2017, for a similar approach). EsPal comprises data from written texts (300 million tokens) as well as subtitles data from movies and television episodes (460 million tokens). For our study, we considered the movie subtitle database as it better reflects spoken language.

Considering previous research (Hansen, 2017; Hao et al., 2015), we also opted to control word length, which is a significant linguistic factor during the initial stages of vocabulary learning. Several studies have demonstrated that short words are acquired earlier (Maekawa & Storkel, 2006; Waterson, 1978), and Maekawa and Storkel (2006) propose word length as one of the earliest and most consistent predictors of expressive vocabulary learning. According to these authors, word length impacts the memory processes required to retain the phonological form during initial word acquisition. The fact that children with DS exhibit impairments in verbal short-term memory (Baddeley & Jarrold, 2007; Næss et al., 2011) could potentially make it more challenging for them to learn longer words.

In summary, the present study aims to answer the following questions:

1. Are nouns more imageable than verbs in the early vocabularies of Spanish-speaking children?
2. Does imageability predict the AoA of words in the early vocabularies of Spanish-speaking children with DS and their peers with TD when word class (noun vs. verb), word frequency, and word length are controlled?
3. Is the role of imageability greater in children with DS than in children with TD when word class (noun vs. verb), word frequency, and word length are controlled?
4. Does the role of imageability differ between children with DS and those with TD, depending on the word class?

Method

Participants

Participants came from a larger study on language development in DS. The families of children with DS were contacted through early intervention units (infant stimulation centers) and Down syndrome parent associations from different cities in Spain. Children with TD were recruited through private and public childcare centers in Malaga and

Madrid (Spain). Informed consent was obtained from the participants' families. Formal approval by an ethical review board is not required for this type of research in Spain. Nevertheless, the research follows the ethical guidelines of the Spanish Psychological Society.

The selection criterion for participants with DS was cytogenetic documentation of trisomy 21 (children with mosaicism and translocations were excluded). Children with DS and those with TD were all required to have a MA of between 8 and 29 months and a monolingual Spanish background. Exclusion criteria for both groups of children were the presence of neurosensory deficits (ensuring especially that visual and auditory skills were normal or corrected-to-normal) and/or psychopathological disorders. These criteria were checked through information provided by caregivers and therapists. From the DS group, five children were excluded due to mosaicism, two for translocation, one for a diagnosis of autism spectrum disorder, and 25 for not meeting the MA criterion. Regarding the TD group, three children were excluded for having a MA above 29 months, and three others because they had a bilingual background.

The final sample consisted of 192 children with DS and 192 with TD. All the children were individually matched on gender and MA (the criterion was that the MA of each pair could not differ by more than 9 days). In addition, when possible, children were matched on birth order and/or the mother's educational level. Specifically, 65 children (33.85 %) were matched on the mother's educational level, 38 (19.79 %) on birth order, and 42 (21.87 %) on both factors. All the children with DS had received regular therapy from birth. MA was assessed in both groups of children using the Brunet-Lézine Psychomotor Development Scale-Revised (Josse, 1997). This scale assesses the development of children aged 1-30 months across four domains: postural control and motor function; adaptation to objects; language; and social relationships. As the number of children was small for some individual months of MA, these were grouped into two-month intervals. The MAs and chronological ages (CAs) of participating children are shown in Table 1.

With respect to the educational level of mothers of children with DS, 28.65% had completed compulsory secondary studies, 25.52% a Spanish baccalaureate, 17.19% technical and further education, and 28.12% a bachelor's degree (information about education was not provided by one mother, 0.52%). Regarding the educational level of mothers of children with TD, 31.77% had completed compulsory secondary studies, 24.48% a Spanish baccalaureate, 14.58% technical and further education, and 27.83% a bachelor's degree (information about education was not provided by four mothers, 2.08%). A chi-square analysis showed nonsignificant differences between the two samples ($\chi 2 = 2.600$, df 4, $p < .627$).

Measure of Age of Acquisition

The AoA was obtained from the CDI-Down, an adaptation of the MacArthur-Bates-CDIs to the profile of language development and communication in children with DS (Galeote et al., 2006, 2016). Despite the changes introduced, the adaptation adheres to shared standards and procedures that make it comparable to the original CDIs, containing its major structure categories. Thus, the CDI-Down consists of the three sections featured in the original inventories: 1. Vocabulary (words); 2. Actions and gestures; and 3. Sentences and Grammar. The validity and reliability of this adaptation for the Vocabulary section are reported in Galeote et al. (2016).

Table 1. Means and ranges for chronological age (CA) and mental age (MA) in children with DS and children with TD according to each MA level (age: months;days). The final two columns show the number of nouns and verbs acquired at each age level (AoA) on the CDI-Down

MA level	Group	Girls	Boys	Total	CA Mean (range)	MA[a] Mean (range)	Nouns[b]	Verbs[b]
8-9	DS	9	6	15	15;13 (11;12–22;00)	8;27 (8–9;24)	0	0
	TD	9	6	15	8;8 (5;27–12;12)	9;06 (8;06–9;27)	0	0
10-11	DS	9	7	16	18;04 (13;21–24;11)	10;22 (10–11;24)	0	0
	TD	9	7	16	10;20 (8;7–14;6)	10;24 (10–11;24)	0	0
12-13	DS	7	9	16	21;18 (13;7–29;1)	12;26 (12–13;21)	0	0
	TD	7	9	16	13;7 (11;6–16;18)	12;26 (12–13;27)	0	0
14-15	DS	4	12	16	24;18 (16;27–35;21)	14;21 (14–15;27)	1	0
	TD	4	12	16	15;1 (12;18–17;22)	14;21 (13;24–15;27)	0	0
16-17	DS	10	5	15	27;9 (17;25–38;25)	16;28 (16–17;27)	0	0
	TD	10	5	15	15;28 (13;21–20;13)	16;29 (16;3–17;27)	1	0
18-19	DS	12	10	22	32;2 (23;25–42;4)	18;28 (18;06–19;27)	1	0
	TD	12	10	22	18;5 (15;2–20;12)	18;28 (17;27–19;27)	2	0
20-21	DS	8	16	24	52;26 (20;29–51;29)	20;29 (20–21;27)	3	0
	TD	8	16	24	21;8 (16;1–30;9)	20;28 (19;27–21;27)	3	0
22-23	DS	8	13	21	43;7 (27–68;12)	23;9 (22;9–23;27)	4	0
	TD	8	13	21	23;7 (19;11–31;7)	23;1 (22;3–23;27)	19	0
24-25	DS	9	8	17	43;13 (30;27-62;12)	24;25 (24–25;24)	52	6
	TD	9	8	17	24;12 (20;16–29;25)	24;27 (24–25;29)	88	31
26-27	DS	9	7	16	55;5 (39–71;1)	26;21 (26–27;18)	162	37
	TD	9	7	16	25;26 (22;17–30;24)	26;20 (25;24–27;18)	79	24
28-29	DS	7	7	14	60 (49;18-68;19)	28;20 (28;6–29;12)	29	39
	TD	7	7	14	29;8 (24;24–33;13)	28;20 (28;6–29;12)	60	27
TOTAL	DS	92	100	192	36;16 (11;12–71;1)	19;2 (8–29;12)	252	82
	TD	92	100	192	18;26 (5;27–33;13)	19;1 (8;6–29;12)	252	82

[a]Mental age was assessed using the Brunet-Lézine Psychomotor Development Scale-Revised (Josse, 1997).
[b]Number of nouns and verbs produced by at least 50% of the children at each age interval.

One of the features of the CDI-Down is that the two original forms of the CDIs are combined into a single inventory that assesses the whole age range (from 8 to 30 months). This is justified because the CA of children with DS usually doubles their MA, so compared to children with TD, children with DS would have a wider experience of the world which may create opportunities for more diverse vocabulary exposure and learning (Chapman, 1995; Grela, 2002, 2003).

The vocabulary checklist of the CDI-Down comprises 651 words divided into 21 categories (a complete list of the words included in the CDI-Down is available for download

at: http://webpersonal.uma.es/~mgaleote/6100CDI-DOWN.htm). As with the original CDIs, parents mark the words their children understand, produce, and/or gesture. In the present study, we only considered words produced in the oral modality. Following Caselli et al. (1999), the words from the vocabulary checklist were grouped into four classes: social words, nouns, predicates (verbs and qualities and states), and closed-class words. Only nouns and verbs (400 words in total: 305 nouns and 95 verbs) were considered here. The same inventory was administered to the parents of children with TD since the vocabulary section in its oral modality is similar to other CDIs developed for these children in Spanish (see Jackson-Maldonado et al., 2005; López Ornat et al., 2005).

Interviews were held with the parents of the participating children, either face to face or in small groups (up to five parents), to explain the aim of our research (to study the language development of children with DS), the details of the inventory, and the content of the different sections and to go through some items in more detail. All inventories were checked individually when collected to make sure that parents had filled them out correctly and completely.

According to Fenson et al. (1994), the AoA of a word may be defined as the month at which at least 50% of children are reported to produce this word. As our participants were grouped into two-month intervals of MA, we considered the upper bound in each case (e.g., for the interval 8-9 months, we considered 9). Following previous studies (e.g., Goodman et al., 2008; Hansen, 2017), we excluded 66 words (53 nouns and 13 verbs) that never reached the threshold in children with DS (13), in children with TD (22), or both groups (31). Therefore, a total of 334 words (252 nouns and 82 verbs) were considered in the analysis of AoA. This AoA was computed using the raw scores, not the standardized ones; this allowed us to compare both populations even when the instrument is not standardized for toddlers with typical development.

Although it would be preferable to have a more even distribution of nouns and verbs in the sample, we opted not to adjust it due to three reasons, all of which have been previously mentioned by McDonough et al. (2011). First, the case ratio for each category in a binary variable should not exceed 9:1 (Rummel, 1970, cited in McDonough et al., 2011). In our study, the ratio stands at 3.07:1. Second, reducing the sample size could potentially impact the statistical power of the statistical analysis. Third, the proportionality in the sample mirrors the observed distribution in the population – that is, a greater percentage of nouns compared to verbs in the vocabularies of young children.

Measures of imageability

Imageability ratings were obtained from the Spanish EsPal database (Duchon et al., 2013) for each CDI-Down word for which we obtained AoA data. Only words that fully matched the EsPal database were considered. The EsPal database is an open-access collection based on an extensible set of data sources, and it contains subjective ratings for measures such as imageability. In the EsPal development study, average ratings of imageability (from 1 = hard to imagine to 7 = easy to imagine) were elicited from at least 30 respondents (undergraduate students) for 6400 words (mainly nouns and verbs).

Of the 252 nouns and 82 verbs with AoA in the CDI-Down, 58 nouns and 10 verbs (68 words) do not appear in the EsPal database. In general, these were very common words in interactions with babies, such as bib, porridge, diaper, etc. Imageability ratings for these 68 words were obtained from a sample of 80 Spanish-speaking adults (*Mean CA* = 31.01 years, range = 18 to 58) who participated voluntarily. Of the 80 participants,

44 were undergraduates at the Speech and Language Therapy Faculty and 36 were secondary school teachers. All were recruited in the centers they attended.

Participants followed the standard instructions for evaluating imageability described by Paivio et al. (1968). Specifically, they were asked to rate how easy it is to form a mental sensory image of the word's referent on a scale from 1 (hard to imagine) to 7 (easy to imagine). The instructions and stimulus words were printed in a booklet that was given to each participant. The researcher also read out the instructions before participants started responding.

To test whether our participants' imaginability ratings were similar to the imaginability ratings that appeared in the EsPal database, we examined our participants' imaginability ratings on a subset of 45 words (33 nouns, and 12 verbs) included in the EsPal database. We performed a mixed ANOVA 2 x 2 using Data source (EsPal database, our participants) as the between-subjects factor and Word Class (noun vs. verb) as the within-subjects factor. There was no significant main effect for Data source, and nor was there an interaction between Data source and Word Class. The only factor that was significant was Word Class ($F(1, 43) = 57.25$, $p<0.01$, $\eta^2_{partial} = .571$): overall, nouns ($M = 6.03$, $SD = 0.13$) received higher imageability ratings than verbs ($M = 4.06$, $SD = 0.22$). These findings suggest that the imageability ratings from our participants and the imageability ratings from EsPal are similar.

Data analyses

All statistical analyses were performed in R v4.1.1 (R Core Team, 2020). To provide information about differences in word class in Spanish (Research question 1), we performed a binomial regression using Word Class (verb, noun) as a dependent variable. The independent variables were Imageability, Word length, and Frequency.

To explore the relationship between study variables and AoA, we performed a linear mixed-effect model using the package *lme4* (Bates et al., 2015). As previously stated, this is the first research exploring the correlation between imageability and the AoA of nouns and verbs in Spanish speakers with or without DS. Thus, we selected the fixed factors based on model comparison using the function *anova*.

For the model comparison, we created a reference model, including the intercept of AoA, the control variables Word length and Frequency, and the random factor Item (all words). Then, factors and interactions between Imageability, Group, and Word Class were included hierarchically. We included the factor Imageability first because this factor was our main focus of study (Research question 2), and we hypothesized that imageability would help early word learning in both groups. Then, we added the factor and interaction with Group because we hypothesized that the DS group would rely more on imageability to learn words (Research question 3). Finally, we added the factor and interaction with Words Class because we hypothesized that imageability would enhance verb acquisition, particularly in people with DS (Research question 4). If one factor did not significantly increase the fit of the model, we assumed that this factor was not relevant to the AoA. Thus, we only explored the factors with the best fit, but these factors were controlled by Word length, which is a relevant variable for the AoA.

In all the analyses, the categorical variables Group and Word Class were dummy coded using the DS group and the verbs as a baseline, respectively. In the regression analysis, the continuous variables AoA, Imageability, and Word length were centered and scaled to improve the convergence of the models. For imageability, we took the average value of

Table 2. Mean and standard deviation / range (in brackets) for imageability, word length and age of acquisition for CDI-Down nouns (n = 252) and verbs (n = 82) in children with DS and children with TD

Word class	Imageability[a]	Word length[b]	Age of acquisition[c]	
			Children with TD	Children with DS
Nouns	6.24 (0.45, 4.39–7.00)	5.75 (1.62, 3–12)	26.30 (2.10, 17–29)	26.60 (1.63, 15–29)
Verbs	4.93 (0.89, 2.01–6.43)	5.41 (1.11, 2–9)	26.90 (1.69, 25–29)	27.80 (1.25, 25–29)
Overall	5.92 (0.81, 2.01–7.00)	5.66 (1.52, 2–12)	26.45 (2.02, 17–29)	26.90 (1.62, 15–29)

[a]The values for imageability are based on a 7-point scale
[b]Word length was counted in phonemes
[c]The unit of AoA is the child's mental age.

imageability across raters for each word. The measure of word length was the number of phonemes in each word (Hansen, 2017). The frequency was taken from the EsPal database (Duchon et al., 2013), and we used the raw frequencies of movie subtitles since it is the measure that better reflects spoken language.

Results

Descriptive statistics for all variables are reported in Table 2, separately for verbs and nouns, and both collapsed. Descriptively, on average, imageability seems higher in nouns than in verbs. Moreover, children with DS have slightly higher AoAs than those with TD; the higher variability produced by the sample selection is evident. Finally, the word length in phonemes is quite similar across part-of-speech categories.

Table 3 shows statistics of the binomial model exploring nouns and verbs in terms of imageability, frequency, and word length (Research question 1). The results revealed that nouns are more imaginable than verbs ($p < 0.001$). Any other main effect or interactions were not statistically significant; this model explains approximately 46% of the variance ($R^2 = 0.467$).

We performed a linear mixed-effect model to explore the relationship between study variables and AoA. Table 4 shows the complete statistical values for the model comparison. The model comparison showed that the factor Imageability (Research question 2) significantly increases the fit of the model with respect to the intercept model ($p < 0.001$), suggesting that this factor is important in explaining the AoA. Similarly, adding the factor Group significantly increases the fit of the model ($p < 0.001$), indicating that the imageability and group modulate AoA (Research question 3). For both, research questions 2 and 3, word class, word frequency, and word length were controlled. Nevertheless, the inclusion of the factor Word Class did not increase the fit of the model ($p < 0.161$), suggesting that the word class did not explain our data (Research question 4).

Table 5 shows the statistical values of the model with the best fit, including the factor Imageability and Group and controlling by Word length (Research questions 2 and 3). We also added Word Class as a control variable. The results showed a significant negative slope of the Imageability factor ($p = 0.002$), indicating that early-acquired words are more imaginable. There was also a significant negative slope in the factor Group ($p < 0.001$), suggesting that the DS group acquired the words later than the TD group. Finally, the significant interaction between Group and Imageability had a positive slope ($p = 0.019$).

Table 3. Best fitted model

Fixed factor	B	SE	Z	P
Intercept	1.681	0.206	8.141	**<0.001**
Imageability	2.433	0.279	8.704	**<0.001**
Frequency	0.228	0.238	0.957	0.339
Length	0.221	0.200	1.104	0.270

Formula: Words Class $\sim$ Imageability* Length SE, standard error. Bold values indicate significant effects.

Table 4. Model comparison IN

Model	N	AIC	R^2	Ln(L)	X2	df	p
Reference model	5	1741.7	0.024	−865.85			
Imageability	6	1715.3	0.087	−851.63	28.441	1	**<0.01**
Imageability*Group	9	1687.4	0.113	−834.69	33.886	3	**<0.01**
Group*Imageability* WordClass	12	1689.5	0.116	−832.72	3.93	3	0.269

Note. The reference model includes the intercept and the control variables: Frequency and Word length. Bold values represent significant comparisons. Models were fitted using the lmer function from the lme4 packages in R. N, number of parameters; AIC, Akaike information criterion; Ln(L), log-likelihood. Dependent variable: age of acquisition. The random factor in all models was the intercept of the word item. The R^2 is the *pseudo* R^2 computed only for the fixed factors.

Table 5. Best fitted model

Fixed factor	β	SE	df	t	P
Intercept	0.322	0.122	357.264	2.632	0.008
Imageability	−0.241	0.07	414.822	−3.411	<0.001
Group	−0.247	0.047	331	−5.166	<0.001
WordClass	−0.268	0.147	330.999	−1.818	0.069
Frequency	−0.088	0.05	330.999	−1.736	0.083
Length	0.163	0.047	330.999	3.423	<0.001
Imageability:Group	0.109	0.047	331	2.283	0.023

Formula: AoA $\sim$ Imageability × Group + Length + WordClass + (1|Item) SE, standard error; df, degrees of freedom. Bold values indicate significant effects.

This implies a notable association between imageability and the DS group when compared to the TD group. The stronger relationship in the DS group as opposed to the TD group suggests that the imageability factor might be a bigger driving factor in the DS group (see Figure 1).

Regarding the control variables, Word length was significant, and the positive slope revealed that short words are acquired earlier than long words. However, neither Word Class nor Frequency were significant suggesting that these variables were not associated with the AoA. This full model has a total $R^2 = 0.619$; the main part of the explained variance corresponds to the random effects ($R^2 = 0.513$), and the fixed effects only explained 10% of the variance ($R^2 = 0.106$).
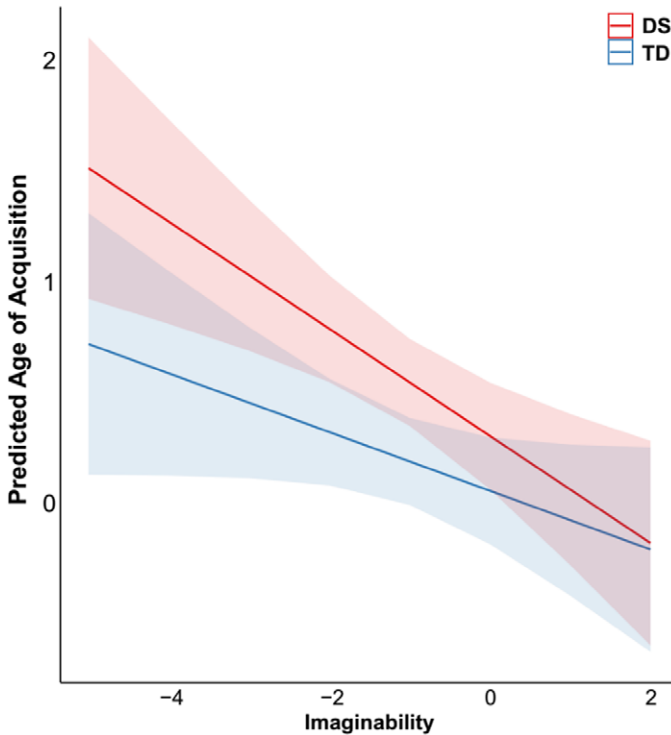
Figure 1. Interaction between Group and Imageability.
Note. Age of acquisition as a function of the imageability of words by each group: Down syndrome (DS) and typical development (TD). Predicted values were computed using the best-fitted model including Group and Imageability as fixed factors. Word Length, Word Class, and Frequency were used as control variables, and Word Item as the random factor.

Discussion

The present research explored three main questions: (1) Does imageability predict the AoA of words in the early vocabularies of Spanish-speaking children with DS and their peers with TD above and beyond word class (noun vs verb), word frequency, and word length? (RQ2) (2) Is the role of imageability greater in children with DS than in children with TD when word class, noun frequency, and word length are controlled? (RQ3) and (3) Does the role of imageability differ between children with DS and those with TD, depending on word class? (RQ4). Additionally, we investigated whether, as in other languages, the nouns that appear in the early vocabularies of Spanish-speaking children with DS and children with TD are more imageable than verbs (RQ1).

Are nouns more imageable than verbs in the early vocabularies of Spanish-speaking children?

For the words considered in our study (252 nouns and 82 verbs), the binomial regression results showed that imageability positively predicted nouns, explaining 46% of the variance. This result indicated that early acquired nouns are more imaginable than verbs in Spanish,

similar to previous works in other languages with typically developing young children (Hansen, 2017; Hao et al., 2015; Ma et al., 2009; McDonough et al., 2011; Smolík, 2019).

Although our results show that, in general, nouns are more imaginable than verbs, some verbs are more imaginable than nouns (as seen in Table 2). As Sidhu et al. (2016) pointed out, there is evidence that action verbs activate sensorial and motor regions of the brain, which suggests that sensorimotor information is important to the meaning of verbs. Thus, the role of imageability goes beyond grammatical class.

Does imageability predict the AoA of words in the early vocabularies of Spanish-speaking children with DS and their peers with TD when word class, word frequency, and word length are controlled?

The results of the linear mixed-effect model showed that words with greater imageability are acquired earlier independently of their grammatical class. This result is similar to that reported in previous studies regarding the relationship between imageability and AoA in different languages (Hansen, 2017; Hao et al., 2015; Ma et al., 2009; McDonough et al., 2011; Smolík, 2019); the result also extended this knowledge to children with DS. This result could also explain the "verb learning paradox" (Ma et al., 2009). Moreover, as pointed out by Smolík (2019), in the vocabulary of children younger than 30 months, which consists mainly of object names and common concrete actions, imageability predicts AoA; this implies that the effect of imageability is not a simple distinction between concrete and abstract labels.

Why are high-imageability words learned earlier than low-imageability words? Two aspects are often mentioned in the literature in regard to this question: (1) the type of objects and actions labeled by high imageability words and their consequences for (2) how they are stored, processed, and retrieved. Regarding the first point, objects and actions labeled by words with high imageability are thought to be perceptually salient and accessible (Golinkoff & Hirsh-Pasek, 2006; Maguire et al., 2006) or as indicated by McDonough et al. (2011), easily perceived (in any modality) as separate and distinct. In word learning research, perceptual saliency is operationalized by considering color, brightness, motion, size, and consistency of objects (see Wildt et al., 2019).

For example, Pruden et al. (2006) considered salient objects that were brightly colored and could either make a noise or move vs. boring objects (dull color, with neither motion nor noise). Usually, the visual complexity (number of parts) is also considered (Venker et al., 2022). Although these aspects are generally applied to nouns, differences in perceptual salience among verbs also exist. For example, action verbs are more salient and observable than verbs denoting abstract processes (Ma et al., 2009) and, as previously indicated, activate sensorial and motor brain regions related to sensory-motor information (Sidhu et al., 2016). Peters and Borovsky (2019) found that perceptual semantic features are associated with early lexical acquisition in TD toddlers. The authors argued that the perceptual saliency of these features facilitates the integration of these words in semantic memory. This work is directly linked with the second element of our explanation.

These object characteristics and actions that name words with high imageability are easier to represent and retrieve (Golinkoff & Hirsh-Pasek, 2006; Maguire et al., 2006). Research in psycholinguistics considers that imageability is related to the number of semantic features that form a concept. Therefore, the concepts of high-imageability vs. low-imageability words are linked to many more semantic features (Boukadi et al., 2016) and more straightforward conceptual representations (Gillette et al., 1999).

The high number of semantic features of high-imageability words also plays a role in word recognition processes. These words could produce the activation of richer semantic representations, which cause the activation of orthographic/phonological representations that facilitate word recognition (Connell & Lynott, 2016). Cortese and Schock (2013) found that participants made faster and more accurate decisions when reading aloud high-imageability than low-imageability words, indicating that the semantic activation of more imaginable words influences the generation of a phonological code. Although these results were found in adults, it is possible that the mechanisms proposed for processing effects might also contribute to acquisition (Smolík & Křiž, 2015, p. 459) since toddlers have a complex semantic system early in development (Arias-Trejo et al., 2021).

On the other hand, high-imageability words could have a direct impact on the representations of words in verbal working memory. Nishiyama (2013) explored in adults without memory problems how imageability and frequency contribute to verbal working memory performance. In a series of experiments that manipulated the effect of semantic information (imageability) vs. lexical-phonological (frequency), it was found that semantic information contributed to verbal working memory performance without mediation from lexical-phonological information. As indicated in the Introduction, Smolík and Křiž (2015) suggested that the representation of highly imageable words in working memory may be more robust or efficient. Thus, imageability might play a role in the processing of words recovered from the mental lexicon during communication processes. Moreover, Smolík and Křiž (2015, p. 460) stated that the role of imageability upon processing could be more pronounced in children with limited working memory than in adults.

Our analysis also controlled for word length; particularly, this variable revealed that shorter words are acquired earlier, which converges with recent studies that have also analyzed the imageability variable (Hansen, 2017; Hao et al., 2015). As stated previously, this result may be associated with the possibility that word length influences the memory processes necessary to retain the phonological form at the outset of word learning. As indicated by Maekawa and Storkel (2006), when infants learn a new word, they need to maintain the phonological form in working memory to associate it with its referent and create a lexical and semantic representation in long-term memory. Since short words are better remembered, word length influences working memory performance.

In our model, the frequency variable did not yield significant results. This finding contrasts with previous studies (e.g., Ma et al., 2009; McDonough et al., 2011) where frequency made a unique contribution to AoA. However, it is important to note that in our study, we used frequencies from a movie subtitle database, while previous studies (e.g., Ma et al., 2009; McDonough et al., 2011) relied on frequencies based on Child-Directed Speech (CDS). Although frequencies based on movie subtitle databases may better reflect spoken language, they may not be appropriate in relation to CDS. In this regard, Hansen (2017) employed CDS frequencies versus adult frequencies based on internet texts, including blogs and forum discussions. Only the former demonstrated predictive value for AoA (see also Goodman et al., 2008).

In sum, our results suggest that imageability and word length predicted the AoA independently of whether a word was a noun or a verb and indicate that children with DS and children with TD tend to acquire more imageable words than those with fewer phonemes earlier.

Is the role of imageability greater in children with DS than in children with TD?

To our knowledge, no previous studies have analyzed the relationship between imageability and AoA in children with DS. The findings from this study revealed a stronger association between imageability and children with DS than in those with TD (RQ3). This effect was independent of word class (noun or verb) (RQ4). As mentioned earlier, the role of imageability on AoA might be associated with the perceptual features of objects and their correspondences with semantic memory and verbal working memory. We stated that a possible explanation could be related to the verbal short-term memory impairments of people with DS (Baddeley & Jarrold, 2007; Næss et al., 2011). Previous work has shown that, in comparison with children with TD, those with DS have a similar effect of perceptual saliency (measured as the shape-color dissimilarity) on word learning (Angulo-Chavira et al., 2022). Similarly, children with DS seem to have a relatively preserved semantic memory because they have similar perceptual and associative priming effects as children with TD (Barrón-Martínez & Arias-Trejo, 2020; Barrón-Martínez et al., 2020).

The problems in working memory in DS do not seem to be the consequence of general memory deficit, auditory problems (common in this population), or motor problems when producing speech (Jarrold et al., 2002), but rather, as Baddeley and Jarrold (2007) pointed out, these difficulties may be due to a reduced capacity for phonological storage. As indicated previously, imageability seems to favor storage, retrieval, and information processing. In addition, it could have a more concrete effect on working memory performance, favoring the establishment of the link between a word and its referent. Word length might also be associated with the memory processes that correspond with lexical learning. In our study, there were observed similarities between children with DS and their peers with TD: both groups appeared to acquire shorter words earlier, which could suggest a parallel utilization of this mechanism.

Variables that predict the AoA of words

Our study suggests that imageability and word length predict the AoA of nouns and verbs in Spanish children with DS and their peers with TD. It should also be noted that the contribution they make is modest, and a considerable amount of variance remains unaccounted for by these variables. Similar findings are reported in the studies reviewed (Hao et al., 2015; Ma et al., 2009; McDonough et al., 2011; Smolík, 2019; Thill & Twomey, 2016), although, in some of them, the explained variance is not reported (e.g., Hansen, 2017). For example, Hao et al. (2015) found that word frequency, word length, imageability, and word class (nouns and verbs) only explained 27.3% of the variance in the AoA of words in Mandarin-speaking children.

These studies suggest that the most considered variables only explain a small part of the variance in the AoA of words. In this respect, and as Hansen (2017. p. 221) notes, "the answer to the question 'What makes a word easy to acquire?' is compositional." This highlights the importance of examining other factors, not only linguistic but also semantic/conceptual and pragmatic, which might account for AoA. It also seems necessary to analyze the interrelationship between these factors, and attempt to isolate the unique contribution of each one: a difficult task as many of them are highly correlated. For example, highly imageable nouns are shorter than nouns low in imageability (Reilly & Kean, 2007), and frequent words tend to be shorter than infrequent words (Dell'Acqua et al., 2000). Nevertheless, and as Hansen (2017) points out, this approach would not only

help to clarify the individual contribution of each factor but might also, as noted by Ambridge et al. (2015, as cited by Hansen, 2017), enable us to identify the mechanism or mechanisms underlying the learning process. A similar argument is made by Song et al. (2018). It is also important to consider children's developmental level, since the effect of a given variable may vary across different levels (Hollich et al., 2000; Pruden et al., 2006).

A further point to consider is that we should not overlook semantic and syntactic complexity differences between nouns and verbs. From a semantic point of view, learning verbs requires detecting the semantic components that define them (Gentner, 2006; Tomasello, 1995), some of which are complex (cause, possession, etc.). From a syntactic point of view, verbs require different numbers of arguments, and in Spanish, as in many other Indo-European languages, they are usually marked for tense, aspect, mood, number, and person. Thus, as noted by Bastiaanse et al. (2016. pp. 1223-24), "Verbs have lower imageability than nouns, but that does not mean that verbs are necessarily more difficult than nouns because of imageability." In our view, the differences in complexity between nouns and verbs could account for an important proportion of their AoA.

Limitations

The present study does have some limitations. First, although the overall number of children who took part is high, the numbers at the different levels of MA are quite low. This aspect is difficult to address since sample recruitment is almost invariably a problem when working with populations that have some disorder. Second, and as in most studies on this topic, our data are cross-sectional. Although these data are useful in revealing developmental patterns, it is impossible to access intra-individual changes. Third, like other similar studies, our imageability ratings were obtained from adults. Consequently, their appraisals may not capture the effect of the variables normally used as predictors of AoA (e.g., imageability, concreteness, emotional valence, etc.) in young children (Hansen, 2017; Thill & Twomey, 2016). As Thill and Twomey (2016) point out, it is necessary for developmental analysis to use child-centric ratings of the different predictors of AoA. Fourth, in their research about word recognition, Connell and Lynott (2012; see also Dymarska et al., 2023) indicate that the imageability construct is heavily biased towards vision, although it applies to any sensory modality. Fifth, the frequencies in our study were sourced from a movie subtitle database as opposed to frequencies based on Child-Directed Speech, which were employed in other studies (e.g., Ma et al., 2009; McDonough et al., 2011). While the subtitle-based frequencies may more accurately represent spoken language, their suitability for comparison with Child-Directed Speech is questionable (Goodman et al., 2008; Hansen, 2017). Thus, Child-Directed Speech frequencies would probably be much more appropriate. A final limitation, no less important, is that the correlational methodology used in our study prevents us from establishing causal relationships between variables.

Conclusions

Our results suggest that children with TD and those with DS learn more imageable words earlier. We propose that the association between imageability and AoA may be linked with the processing, recovery, and representation of information in verbal working memory. Hence, the observed correlation of imageability is stronger in our participants with DS, a population known to have notable working memory impairments. It's

important to highlight, as far as we're aware, that this is the first research to particularly scrutinize the association of this variable with noun and verb learning in children with DS or Spanish-speaking children with TD.

It is important to recognize that the variables included in our study only explained a small proportion of the variance in the AoA of nouns and verbs; this highlights the importance of examining other factors outside linguistic ones, such as semantic/conceptual and pragmatic factors, since they might also account for AoA. Finally, considering all these aspects could help identify the mechanism(s) that underlie the lexical learning process, and understanding them would also be crucial to improve intervention strategies.

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