What predicts individual response to language treatment in bilingual children with developmental language disorder?

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We have no conflicts of interest to disclose.

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Funding: NIH-NIDCD R21DC010868 (PI: K. Kohnert) supported data collection. NIH-NIDCD R01DC019613 (PI: K. Ebert) supported manuscript writing for the authors.

Abstract

Purpose. For bilingual children with developmental language disorder (DLD), language treatment response is the degree to which an individual child progresses in both of their languages. Understanding what predicts language treatment response for an individual child can help clinicians plan treatment more effectively.

Methods. This study is a retrospective analysis of data from Ebert et al. (2014). Participants included 32 school-age Spanish-English bilingual children with DLD who completed an intensive language treatment program. Gains in Spanish and English were measured using raw test scores in each language. Predictors of language gains include language, cognitive, and demographic variables. To examine which predictors were significant, we calculated partial correlations between the potential predictors and the posttreatment language test scores, controlling for the effects of pretreatment test scores.

Results. In Spanish, several predictors correlated with the outcome measures. After controlling for pretreatment scores, English grammaticality, female sex, processing speed, age, and fluid reasoning were related to Spanish posttreatment scores. In English, correlations with individual predictors were minimal. After controlling for pretreatment scores, only one variable was associated with one English posttreatment score: English grammaticality.

Conclusions. The original study reported limited gains in Spanish compared to robust gains in English (Ebert et al., 2014). Treatment response in Spanish is more variable given the lack of environmental support for Spanish in the US. As a result, individual factors (including nonverbal cognition, pretreatment language levels, and demographic variables) influence treatment gains in Spanish. In contrast, strong environmental support for English supports a more consistent treatment response, with a smaller role for individual factors.

Developmental language disorder (DLD) is a common neurodevelopmental disorder characterized by clinically significant difficulty learning, understanding and using spoken language (Bishop et al., 2017; RADLD, 2022). Although the disorder is persistent, there is ample evidence to indicate that language treatment for children with DLD is effective (e.g., Cleave et al., 2015; Smith-Lock et al., 2013, Storkel et al., 2017). Within group studies of language treatment, however, individual children within the group vary in how much they benefit (e.g., Pawlowska et al., 2008; Smith-Lock et al., 2015). Some children may make large gains whereas others derive little to no gain from the treatment. The degree to which an individual child benefits from treatment can be called their *treatment response*. Knowing what predicts this treatment response enables clinicians to make effective predictions about an individual child's prognosis with treatment.

For bilingual children with DLD, treatment should seek to improve both of their languages. Thus, treatment *response* for bilingual children should include gains in both languages. Increasing our understanding of language treatment response in bilingual children with DLD means that clinicians will be better able to determine how much a child will likely gain in each of their languages, and ultimately to make decisions that lead to growth in both languages.

Research on the predictors of treatment response in children with DLD, particularly bilingual children, is limited to date. We seek to contribute via a retrospective analysis of individual response to treatment within a group study of Spanish-English bilingual children with DLD (Ebert et al., 2014). To frame the current study, we first provide a brief review of the existing literature on language treatment response, in both monolingual and bilingual children. In this review, we do not differentiate among language treatment programs. Ultimately, the

predictors of treatment response may vary according to the specific treatment program a child receives. However, there are not enough studies on predictors of language treatment response to consider these predictors separately by treatment program.

Predictors of language treatment response in monolingual and bilingual children

There are many possible characteristics that might predict a child's response to language treatment. For example, children with higher language skills at the beginning of treatment (i.e., less severe language deficits) may be better able to take advantage of the linguistic input in treatment and progress more rapidly; conversely, it is also possible that children who begin treatment with lower language skills (i.e., more severe deficits) have greater room for improvement and thus tend to make greater gains. Other possibilities include child sex or gender, socioeconomic status (often indexed by maternal education), articulation skills (which may influence the child's ability to produce target language forms), and age.

For monolingual children, less severe language deficits appear to facilitate faster treatment gains. In perhaps the most comprehensive study to date, Kapa et al. (2020) analyzed data from 107 monolingual English-only children (aged 4;0 to 6;4) who received Enhanced Conversational Recast treatment. Treatment targeted a specific grammatical morpheme, and individual outcomes were measured by the child's production of the morpheme on probes before and at the end of treatment. A host of possible predictors were considered in analyses: child age, sex, pretreatment language skills (including receptive vocabulary, expressive grammar, and production of the specific morpheme targeted in treatment), nonverbal IQ, articulation, and maternal education level. Of these variables, pretreatment language skills were the most influential. Children with less severe impairment in expressive grammar made greater gains from

the grammatical treatment, especially when combined with average to above average receptive vocabulary.

Other studies of English speakers are generally consistent with Kapa et al.'s (2020) findings, though the treatment programs, outcome measures, and predictors tested vary across studies. Children who began language treatment with more accurate grammatical productions (Pawlowska et al., 2008), better paragraph comprehension skills (Storkel et al., 2019), greater vocabulary and phonological awareness (Storkel et al., 2017), and expressive-only deficits (vs. receptive-expressive deficits; Boyle et al., 2009) made greater progress within their respective treatment programs. In addition, some factors have consistently failed to predict treatment response across multiple studies, including age (Boyle et al., 2009; Kapa et al., 2020; Leonard et al., 2004; Storkel et al., 2019) and gender (Kapa et al., 2020; Storkel et al., 2019; Storkel et al., 2017).

For bilingual children who first learn a home language (or L1) and later a school or community language (L2), both treatment response and pretreatment skills should be considered in each language. Pretreatment skills could facilitate gains in the same language, the other language (i.e., cross-linguistic facilitation), or both. Cross-linguistic facilitation is an established developmental phenomenon in bilinguals, meaning that there is evidence that children with stronger skills in their L1 tend to acquire their L2 more quickly (e.g., Castilla et al., 2009).

Consideration of cross-linguistic facilitation within the context of treatment for DLD has been limited, as few studies have considered individual predictors of treatment response within this population. Gutiérrez-Clellen and colleagues published companion reports on the individual predictors of growth in Spanish (Simon-Cereijido et al., 2013) and in English (Gutiérrez-Clellen et al., 2012) for 188 Spanish-English bilingual 4-year-olds who completed an academic

enrichment program in either English only or in Spanish and English. Results suggested that beginning treatment with stronger grammatical skills in the L1 (Spanish) led to greater gains in the L2, as children with higher mean length of utterance (MLU) in Spanish before treatment made significantly larger gains in English MLU. There was also evidence of within-language facilitation, with a positive relationship between pretreatment L2 vocabulary and posttreatment L2 grammar. The findings of both within-language and cross-linguistic facilitation in the literature on language treatment response in bilingual children (Bedore et al., 2020; Gutiérrez-Clellen et al., 2012; Simon-Cereijido et al., 2013) are broadly consistent with the findings from monolingual children: overall, children with stronger language skills at the start of treatment appear to progress more quickly. There has been limited consideration of other predictors of treatment response (i.e., beyond pretreatment language skills) in bilinguals with DLD.

Considering cognitive processing predictors

General perceptual and cognitive skills influence language acquisition and deficits in these skills may underlie the language deficits in children with DLD (e.g., Ebert & Kohnert, 2011; Gillam et al., 2019; Leonard et al., 2007). Therefore, it is possible that nonlinguistic cognitive skills will influence how children with DLD respond to language treatment. To date, nonverbal IQ has been the only nonlinguistic cognitive factor considered as a predictor of language treatment response (Kapa et al., 2020). However, nonverbal IQ testing, which typically measures fluid reasoning, may not capture all relevant cognitive skills. For example, Gillam et al. (2019) used a battery of cognitive processing assessments to determine which cognitive abilities predict sentence comprehension in school-age children with DLD. Factor analysis yielded three distinct cognitive abilities -- fluid reasoning, controlled attention, and controlled working memory – which all played a role in comprehending language input. Though not considered by

Gillam et al. (2019), general information processing speed may be another important cognitive factor to consider; in bilingual children with DLD, processing speed is associated with language skills (Park et al., 2020).

In short, it is possible that specific cognitive skills -- including fluid reasoning as well as processing speed, attention, and working memory -- may influence treatment response in children with DLD. In bilingual children, these general processing skills could influence response in either or both languages. Relations between specific cognitive processing skills and language treatment response have not yet been considered.

Present study

The present study explores predictors of treatment response in a group of school-age Spanish-English bilingual children with DLD who completed a language treatment program. We examine a host of potential predictors motivated by prior work, including pretreatment language skills in both the L1 and the L2, nonlinguistic cognitive skills (including measures of fluid reasoning, processing speed, working memory, and sustained selective attention), and demographic characteristics (age and sex). Because treatment response among bilingual children is an understudied area of research, we include a full set of predictors that could potentially influence outcomes including fluid reasoning, age, and sex. Prior treatment response studies in monolingual and bilingual children (e.g., Gutiérrez-Clellen et al., 2012; Kapa et al., 2020; Simon-Cereijido et al., 2013; Storkel et al., 2019) have focused on the preschool age. Our sample is relatively older (school-age) and spans a wider age range; both factors motivate considering age. Sex has been considered an important variable in the study of bilingual language acquisition specifically, with some studies showing an advantage for girls in retaining an L1 (e.g., Ebert & Reilly, 2022; Rojas & Iglesias, 2013). Finally, the theoretical support for links between language

and cognition, as well as the potential to contrast fluid reasoning with cognitive processing skills, motivates the inclusion of fluid reasoning scores.

This study examines the following research questions:

1. Which pretreatment language, cognitive, and demographic variables are associated with L1 (Spanish) gains following a language treatment program in school-age Spanish-English bilingual children with DLD?
2. Which pretreatment language, cognitive, and demographic variables are associated with L2 (English) gains following a language treatment program in school-age Spanish-English bilingual children with DLD?

Methods

This study is a retrospective analysis of deidentified data collected in Ebert et al. (2014). The original study was approved by the University of Minnesota Institutional Review Board.

Participants

The participants included in these analyses are Spanish-English bilingual children with DLD (n = 32; 7 females) who completed one of two language treatment programs originally reported in Ebert et al. (2014). All participants were receiving school-based services for language disorder; passed a hearing screening; scored within the average range on a nonverbal intelligence test; and had no other reported conditions that could cause a language disorder. Participants ranged in age from 5;6 to 12;2. They spoke Spanish ‘most’ or ‘all’ of the time at home per parent report and received school instruction in English. The characteristics of the participant sample are listed in Table 1.

Measures of Treatment Response

Assessments of L1 (Spanish) and L2 (English) were administered before and after treatment to capture change. In the present study, we selected three subtests of one standardized measure, the Clinical Evaluation of Language Fundamentals – 4th Edition (in English: CELF-4E, Semel et al., 2003 and in Spanish: CELF-4S, Wiig et al., 2006) to represent a child's treatment response. In the original study, children completed the four subtests that make up the Core Language index score. Three of these subtests are the same across all ages included in this study: Concepts & Following Directions/Conceptos y Siguiendo Direcciones, which examines the ability to follow directions of increasing length and complexity; Recalling Sentences/Recordando Oraciones, which examines the ability to repeat sentences without altering words or grammatical structures; and Formulated Sentences/Formulación de Oraciones, which examines the ability to create semantically and grammatically correct utterances within contextual constraints (including illustrations and target words). Consistent with the original treatment study (Ebert et al., 2014), we use the pretreatment and posttreatment raw scores from each of these subtests to measure change in each language. Raw scores were preferred to scaled subtest scores because bilingual children are not included in the normative sample of the CELF-4E and because there was evidence of floor effects (i.e., scaled scores of 1) in the sample.

Treatment Programs

Participants completed a treatment program offered four days per week over six weeks. Sessions were provided after school or during summer school and were conducted by a nationally certified speech-language pathologist (SLP). In the original study (Ebert et al., 2014) participants were randomly assigned to one of four conditions; in the present study, we consider outcomes from participants in the two conditions that targeted language directly: English-only language treatment (n = 17) and Spanish-English bilingual language treatment (n = 15).

In both conditions, children completed a combination of interactive activities and computer programs designed to target morphosyntactic forms, vocabulary depth (i.e., semantic features), and auditory comprehension of instructions. In the English-only condition, all activities and interactions with SLPs were conducted in English. In the Spanish-English bilingual condition, stimuli for most activities (4 of 6) were provided in Spanish, with English-only stimuli in one of the remaining activities and both Spanish and English stimuli in the other. SLPs providing bilingual treatment incorporated English into Spanish activities to make explicit cross-linguistic connections, as well as to clarify instructions and provide reinforcement.

Treatment efficacy from Ebert et al. (2014) is summarized here. At the group level. children in both English-only and bilingual conditions made gains on multiple English measures, but only children in the bilingual condition made statistically significant gains in Spanish. Results supported the importance of bilingual treatment. Nonetheless, gains were unequal across languages, with limited gains in Spanish and robust gains in English. Differential language gains reflected weaker environmental support for Spanish compared to English. In the present study, our focus is on the individual response to treatment, which can vary within the group, and the characteristics that might predict it.

Predictors of Language Treatment Response

Additional measures of L1, L2, and nonverbal cognition were administered prior to treatment and are included as predictors of treatment response in the present study.

Language. To represent a participant's overall level of skill in the L1 and the L2 using a measure independent of our measures of language change (i.e., CELF subtests), we selected a measure of grammaticality – percent grammatical utterances -- from a language sample. The

percent of grammatical utterances indexes overall grammatical skill and may be a particularly good measure of language impairment in bilingual children (Ebert & Pham, 2017).

Participants were asked to generate a narrative retell using the wordless picture book, *Frog, where are you?* (Mayer, 1969). Samples were collected separately for each language by an examiner fluent in that language. The language samples were transcribed and segmented according to the modified C-Unit conventions for the Systematic Analysis of Language Transcripts (SALT) software (Miller & Iglesias, 2012). Each utterance within the sample was judged as grammatical or ungrammatical (see Ebert & Pham, 2017) and the total number of grammatical utterances was divided by the total number of utterances in the sample to calculate the grammaticality measure.

Nonverbal cognition. One standardized measure of nonverbal cognition, the Test of Nonverbal Intelligence – 3rd Edition (TONI-3, Brown et al., 1997), was used. The TONI-3 uses a visual pattern recognition task to assess fluid reasoning skills.

We also administered three computer-based experimental tasks to measure aspects of nonverbal cognitive processing (see also Ebert et al., 2014). The first was a visual processing speed task. The child watched the screen for a red or blue circle to appear and pressed a button (corresponding to the color of the circle) as quickly as possible. The dependent variable was average response time for correct responses, in milliseconds.

The second nonverbal cognitive processing task measured auditory sustained selective attention. Children listened to a stream of auditory stimuli (environmental noises related to cars) and responded to a target noise (keys jingling) while ignoring distractor noises (engine revving, tires squealing, and car door closing). The dependent variable was *d'*, which measures the rate at which a child recognizes targets and ignores distractors.

The third nonverbal cognitive processing task measured auditory working memory. Children listened to paired sequences of tones and were asked to determine whether the pairs were the same or different. Sequences were initially 2 tones each, and then progressed in length up to 5 tones per sequence. Children were assigned a score of 0 – 4, according to the longest sequence length at which they could accurately complete the task: children who could not answer accurately (defined as 11 of 15 trials correct) with two tones per sequence received a score of 0; those who answered accurately at two tones but not at three tones received a score of 1; and scores of 2, 3, and 4 were assigned in parallel fashion.

Analyses

To explore individual factors associated with treatment response in each language, we examined correlations between predictor variables (age, gender, L1 grammaticality, L2 grammaticality, fluid reasoning as measured by TONI-3, processing speed, sustained selective attention, and working memory) and our measures of treatment progress, the three CELF-4 subtests of interest in each language. Because gain scores (i.e., the difference between posttreatment and pretreatment test scores) have been criticized for their statistical properties (such as reliability, e.g., Hedge et al., 2018), we used the posttreatment CELF scores, corrected for the associated pretreatment subtest score, as our measures of treatment progress; this approach to capturing change is also known as a residual change model and is a statistically preferred means of capturing change following intervention (Gollwitzer et al., 2014). Therefore, our analyses examined the partial correlations between predictor variables and posttreatment CELF subtest scores, controlling for the corresponding pretreatment CELF subtest score. Due to the small sample and exploratory nature of the work, we did not apply a multiple comparison correction to the partial correlations. To provide information about the magnitude of relations

among variables, we report and interpret r^2 effect sizes, which indicate the percentage of variance accounted for by the predictor.

Results

Pearson correlations between each outcome measure (i.e., each posttreatment CELF subtest score) and the corresponding pretreatment subtest score are displayed at the top of Table 2 for Spanish and Table 3 for English. All six correlations were large (r = .66 or greater), indicating strong associations between pretreatment and posttreatment scores and reinforcing the need to control for pretreatment scores in subsequent analyses.

Table 2 shows partial correlations between the predictor variables and residual change scores (i.e., each L1 posttreatment CELF subtest score, controlling for pretreatment). There were moderate correlations between at least one predictor and each L1 subtest, although the specific predictors varied by subtest. L2 grammaticality and female sex were positively associated with Conceptos y Siguiendo Direcciones outcomes, accounting for 20.7% and 15.1% of the variance in residual change on this subtest respectively. Processing speed was negatively associated with Recordando Oraciones, meaning that faster processing speed correlated with greater gains, and accounted for 16.8% of the variance in residual change. Finally, age and fluid reasoning were positively associated with Formulación de Oraciones outcomes, accounting for 21.5% and 20.6% of variance respectively.

Table 3 shows partial correlations between the predictor variables and residual change scores (i.e., each L2 posttreatment CELF subtest score, controlling for pretreatment). No predictor variables were significantly associated with Concepts & Following Directions or Formulated Sentences outcomes. There was a moderate positive correlation between L2

grammaticality and Recalling Sentences, accounting for 20.2% of variance in residual change. Tables of correlations between all variable pairs are available in Supplemental Materials.

Discussion

This study considered individual characteristics that predict response to language treatment in school-age bilingual children with DLD. We retrospectively analyzed associations between outcomes in each language and a set of predictor variables motivated by prior research. Our predictors included measures of nonlinguistic cognition, in order to examine the potential for general processing skills to influence treatment gains. We also included pretreatment measures of grammatical skill in each language, as less severe language impairments are generally associated with better treatment response in English-only monolinguals with DLD and both within- and cross-linguistic facilitation is possible in bilingual children. Sex was included as it has been associated with L1 maintenance in research on bilingualism (e.g., Ebert & Reilly, 2022; Rojas & Iglesias, 2013). Age was included because our sample was older (school-age) and spanned a wider age range than prior treatment response studies that focused on preschoolers (e.g., Gutiérrez-Clellen et al., 2012; Storkel et al., 2019).

In Spanish, we found several significant associations. The significant correlation between L2 grammaticality and Conceptos y Siguiendo Direcciones means that children who began treatment with stronger English skills made greater gains on this subtest, suggesting cross-linguistic facilitation. We also found support for the role of nonlinguistic cognitive skills, as faster processing speed was correlated with outcomes on Recordando Oraciones and stronger fluid reasoning skills were correlated with outcomes on Formulación de Oraciones. Finally, two demographic variables reached significance, indicating that older children made greater gains on one subtest and that girls made greater gains on another.

The pattern of results in English was notably different, with just one association reaching significance. The correlation between L2 grammaticality and Recalling Sentences is consistent with prior findings that less severe language deficits are associated with greater language treatment response in monolinguals (Kapa et al., 2020; Pawlowska et al., 2008; Storkel et al., 2017; Storkel et al., 2019) and that within-language facilitation occurs in bilinguals during language treatment (Gutiérrez-Clellen et al., 2012). However, the absence of other significant correlations defined the English results.

Taken together, the results show that individual predictors play a greater role in language treatment response as measured in the L1 than in the L2. It is important to consider this pattern in the context of overall gains in each language, as originally reported in Ebert et al. (2014). Gains in the L1 were notably smaller for all treatment groups than gains in the L2. For school-age children in the U.S. who speak a minority L1, social and educational environments most often promote growth in the L2, English. These powerful environmental factors influence children's language treatment response, meaning that their individual pretreatment skills and characteristics have a smaller impact. In contrast, L1 gains are less certain, and thus more likely to be influenced by individual factors. It would be premature to conclude that the specific factors that mattered in this sample will be critical for all bilingual children in language treatment. Instead, we encourage clinicians working with bilingual children to carefully attend to the maintenance of L1 skills. Our findings also encourage ongoing investigations into language treatment response in bilinguals that can lead to more specific clinical recommendations. .

Limitations and Future Directions

There are clear limitations in the evidence base for predicting language treatment response in bilingual children. To our knowledge, just a handful of studies have examined this

topic (Bedore et al., 2020; Gutiérrez-Clellen et al., 2012; Simon-Cereijido et al., 2013). Our study is limited by its retrospective nature and relatively small sample size, which precluded applying a statistical control for multiple comparisons in our analyses and also required us to combine two different language treatment conditions in analyses. Thus, this study should be considered exploratory. Nonetheless, it makes an initial contribution by highlighting how individual factors seem to play a larger role in treatment response in a minority L1, Spanish, than in the majority language, English. Additional research is needed to develop guidelines that clinicians can apply to bilingual children.

We also found evidence that nonverbal cognitive skills – specifically, fluid reasoning and processing speed – can support a stronger response to language treatment. Theoretically, such findings reinforce theories that nonverbal cognition influences language acquisition in DLD; clinically, the results suggest that clinicians should examine cognitive skills – for example, by reviewing findings from a school psychologist, or by administering measures that tap cognitive skills such as working memory -- in predicting the likely treatment response for a bilingual child with DLD. Future research should continue to examine relationships between specific areas of nonverbal cognition and language treatment response.

Acknowledgments

The data analyzed in this study was originally collected with support from NIH-NIDCD R21DC010868 awarded to K. Kohnert. Manuscript writing for the first and second authors was supported by NIH-NIDCD R01DC019613 (PI: K. Ebert). We appreciate the contributions of participants, research assistants, and other collaborators on the original study.

Data Availability Statement

The dataset analyzed during the current study is available from the corresponding author on reasonable request.

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Supplemental Materials

Table S1. Bivariate correlations among all predictor and outcome variables.

Table S2. Complete partial correlation table for predictor variables, controlling for pretreatment Conceptos y Sigiuiendo Direcciones.

Table S3. Complete partial correlation table for predictor variables, controlling for pretreatment Recordando Oraciones.

Table S4. Complete partial correlation table for predictor variables, controlling for pretreatment Formulacion de Oraciones.

Table S5. Complete partial correlation table for predictor variables, controlling for pretreatment Concepts & Following Directions.

Table S6. Complete partial correlation table for predictor variables, controlling for pretreatment Recalling Sentences.

Table S7. Complete partial correlation table for predictor variables, controlling for pretreatment formulated sentences.

Table 1.

Participant Characteristics Before Treatment.

Variable	Mean	Standard Dev.	Minimum	Maximum
Age	8;5	1;6	5;6	11;2
Fluid Reasoning	12.34	4.70	6	25
L1 CELF CD	19.50	8.92	5	36
L1 CELF RS	11.69	10.52	0	44
L1 CELF FS	10.34	7.83	0	25
L2 CELF CD	22.03	14.00	2	42
L2 CELF RS	17.25	11.09	0	45
L2 CELF FS	12.88	9.19	0	26
Processing Speed	775.90	164.64	528.84	1201.00
Sustained attention	3.42	1.19	0.75	5.23
Working memory	2.16	1.67	0	4
L1 Grammaticality	0.52	0.19	0.15	0.93
L2 Grammaticality	0.47	0.19	0.11	0.85

Note. Age is listed as years;months. Fluid reasoning was measured using the Test of Nonverbal Intelligence, 3rd edition (TONI-3, Brown et al., 1997). L1 = Spanish, L2 = English. CELF = Clinical Evaluation of Language Fundamentals, 4th edition, in English (Semel et al., 2003) and Spanish (Wiig et al., 2006). CD = Concepts & Following Directions/Conceptos & Siguiendo Direcciones from CELF-4, RS = Recalling Sentences/Recordando Oraciones from CELF-4; FS = Formulated Sentences/Formulación de Oraciones from CELF-4. TONI-3 and CELF results are listed as raw scores. Processing speed is listed in milliseconds. Sustained

attention is measured with *d'*. Working memory score is the highest level achieved on the task. L1 and L2 grammaticality are listed as the proportion of grammatical utterances in the language sample.

Table 2.

Correlations Between Predictors of Treatment Response and Spanish Language Outcomes

Variable	L1 (Spanish) Posttreatment Scores		
Predictor	CELF CD	CELF RS	CELF FS
Pretreatment score	.66***	.93***	.83***
Age	.29	.17	.46**
Sex	.39*	.20	.03
Fluid Reasoning	.20	.13	.45*
Processing Speed	-.26	-.41*	-.25
Working memory	.23	.16	-.00
Sustained Attention	.24	-.08	0.30
L1 Grammaticality	.24	.32	.09
L2 Grammaticality	.46**	.15	.30

Note. Top row displays Pearson correlations between pretreatment subtest scores and the posttreatment score on the same subtest. Remaining rows display partial correlations between each predictor variable and the posttreatment subtest score, controlling for the effects of the pretreatment score. L1 = Spanish, L2 = English. $df = 30$ for Pearson correlations and $df = 29$ for partial correlations.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3.

Correlations Between Predictors of Treatment Response and English Language Outcomes.

Variable	L2 (English) Posttreatment Scores		
Predictor	CELF CD	CELF RS	CELF FS
Pretreatment score	.91***	.92***	.95***
Age	.21	.18	-.07
Sex	-.13	.07	-.16
Fluid reasoning	-.03	.16	.16
Processing Speed	-.34	.20	.11
Working memory	.07	-.15	-.06
Sustained Attention	.22	-.11	.22
L1 Grammaticality	-.08	.13	.25
L2 Grammaticality	.02	.45*	.34

Note. Top row displays Pearson correlations between pretreatment subtest scores and the posttreatment score on the same subtest. Remaining rows display partial correlations between each predictor variable and the posttreatment subtest score, controlling for the effects of the pretreatment score. L1 = Spanish, L2 = English. $df = 30$ for Pearson correlations and $df = 29$ for partial correlations.

* $p < .05$. *** $p < .001$.

Table S1. *Bivariate Correlations Among All Variables.*

Variable	Age	Sex	Fluid Reas	Pre CSD	Post CSD	Pre RO	Post RO	Pre FO	Post FO	Pre CD	Post CD	Pre RS	Post RS	Pre FS	Post FS	PS	SSA	WM	L1 Gr
Sex	.22																		
Fluid Reas	.62***	-.09																	
Pre CSD	.59***	.00	.58**																
Post CSD	.57**	.29	.51**	.67***															
Pre RO	.27	.24	.21	.50**	.44*														
Post RO	.31	.30	.24	.62***	.55**	.93***													
Pre FO	.45**	.14	.36*	.59***	.60***	.79***	.80***												
Post FO	.61***	.13	.53**	.67***	.62***	.68***	.74***	.83***											
Pre CD	.88***	.21	.75***	.66***	.72***	.40*	.45**	.55**	.71***										
Post CD	.84***	.14	.68***	.70***	.72***	.42*	.46**	.64***	.77***	.91***									
Pre RS	.90***	.15	.64**	.68***	.64***	.43*	.50**	.54**	.67***	.87***	.87***								
Post RS	.86***	.17	.64***	.67***	.63***	.44*	.50**	.64***	.67***	.84***	.84***	.92**							
Pre FS	.87***	.30	.66***	.72***	.69***	.56**	.62***	.69***	.75***	.90***	.89***	.90***	.90***						
Post FS	.82***	.24	.66***	.66***	.71***	.51**	.55***	.73***	.75***	.87***	.886*	.83***	.87***	.95***					
PS	-.54**	-.05	-.45*	-.43*	-.46**	.10	-.06	-.08	-.21	-.47**	-.55**	-.55**	-.44*	-.46**	-.41*				
SSA	.32	-.03	.25	.05	.22	.08	.04	.19	.11	.21	.28	.30	.23	.26	.31	-.33			
WM	.24	-.23	.34	.36*	.40*	.17	.22	.18	.14	.29	.29	.411*	.32	.29	.26	-.29	.39*		
L1 Gr	-.04	.00	.17	.17	.29	.46**	.53**	.52**	.48**	.18	.13	.06	.11	.20	.26	.18	-.08	.14	
L2 Gr	.64***	.35	.52**	.26	.50**	.07	.12	.30	.41*	.66***	.60***	.64***	.73***	.62***	.67***	-.27	.22	.14	-.03

Note. *df* = 32. Female is the reference group for sex. Fluid reasoning was measured using the Test of Nonverbal Intelligence, 3rd edition (TONI-3, Brown et al., 1997). Pre- and post-treatment language scores measured using the CELF = Clinical Evaluation of Language Fundamentals, 4th edition, in English (Semel et al., 2003) and Spanish (Wiig et al., 2006). Raw scores from TONI-3 and CELF were used in analyses. Fluid reas = fluid reasoning, Pre- = pretreatment, post = posttreatment, CSD = Conceptos & Siguiendo Direcciones from CELF-4 Spanish, RO = Recordando Oraciones from CELF-4 Spanish, FO = Formulación de Oraciones from CELF-4 Spanish, CD = Concepts & Following Directions from CELF-4 English, RS = Recalling Sentences from CELF-4 English; FS = Formulated Sentences from CELF-4 English, PS = processing speed, SSA = sustained selective attention, WM = working memory, L1 Gr = Grammaticality in L1 (Spanish), L2 Gr = Grammaticality in L2 (English).

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table S2.

Partial Correlations Controlling for Pretreatment Conceptos y Sigiuiendo Direcciones.

Variable	Posttreatment CSD	Fluid reasoning	Age	Female	Processing Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid reasoning	.20							
Age	.29	.42*						
Female	.39*	-.11	.27					
Processing Speed	-.26	-.27	-.39*	-.06				
Sustained Attention	.24	.27	.36	-.03	-.34			
Working Memory	.23	.17	.04	-.25	-.16	.40*		
L1 Grammaticality	.24	.09	-.18	.00	.28	-.09	.09	
L2 Grammaticality	.46*	.47**	.63***	.36	-.18	.21	.05	-.07

Note. *df* = 29. CSD = Conceptos y Sigiuiendo Direcciones, CELF-4 Spanish.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table S3.

Partial Correlations Controlling for Pretreatment Recordando Oraciones.

Variable	Posttreatment RO	Fluid reasoning	Age	Female	Processing Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid reasoning	.13							
Age	.17	.60***						
Female	.20	-.15	.16					
Processing Speed	-.41**	-.48**	-.59***	-.08				
Sustained Attention	-.08	.24	.31	-.05	-.34			
Working Memory	.16	.31	.20	-.29	-.31	.39*		
L1 Grammaticality	.32	.09	-.19	-.12	.15	-.13	.07	
L2 Grammaticality	.15	.52**	.65***	.34	-.28	.22	.13	-.06

Note. *df* = 29, RO = Recordando Oraciones, CELF-4 Spanish.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table S6.
Partial Correlations Controlling for Pretreatment Recalling Sentences.

Variable	Posttreatment RS	Fluid reasoning	Age	Female	Proc Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid Reasoning	.16							
Age	.18	.14						
Female	.06	-.24	.18					
Proc Speed	.20	-.15	-.13	.04				
Sustained Attention	-.11	.08	.14	-.08	-.21			
Working Memory	-.15	.11	-.33	-.33	-.08	.31		
L1 Grammaticality	.13	.18	-.21	-.01	.25	-.11	.13	
L2 Grammaticality	.45*	.19	.19	.33	.13	.04	-.18	-.09

Note. df = 29. RS = Recalling Sentences, CELF-4 English.

* $p < .05$.

Table S4.

Partial Correlations Controlling for Pretreatment Formulacion de Oraciones.

Variable	Posttreatment FO	Fluid reasoning	Age	Female	Proc Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid reasoning	.45							
Age	.46**	.55						
Female	.02	-.15	.17					
Proc Speed	-.25	-.45*	-.57**	-.04				
Sustained Attention	-.08	.20	.27	-.06	-.32			
Working Memory	.00	.30	.18	-.27	-.28	.37*		
L1 Grammaticality	.09	-.02	-.37*	-.08	.26	-.22	.06	
L2 Grammaticality	.30	.46*	.59**	.32	-.26	.17	.09	-.23

Note. df = 29. FO = Formulacion de Oraciones, CELF-4 Spanish.

* $p < .05$. ** $p < .01$.

Table S5.
Partial Correlations Controlling for Pretreatment Concepts & Following Directions.

Variable	Posttreatment CFD	Fluid reasoning	Age	Female	Proc Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid reasoning	-.03							
Age	.21	-.13						
Female	-.13	-.38*	.08					
Proc Speed	-.34	-.16	-.30	.05				
Sustained Attention	.22	.14	.30	-.08	-.27			
Working Memory	.07	.19	-.04	-.31	-.18	.36		
L1 Grammaticality	-.08	.07	-.41*	-.03	.30	-.12	.10	
L2 Grammaticality	.02	.05	.18	.29	.06	.11	-.07	-.19

Note. df = 29. CFD = Concepts & Following Directions, CELF-4 English.

* $p < .05$.

Table S7.

Partial Correlations Controlling for Pretreatment Formulated Sentences.

Variable	Posttreatment FS	Fluid Reasoning	Age	Female	Proc Speed	Sustained Attention	Working Memory	L1 Grammaticality
Fluid Reasoning	.16							
Age	-.07	.12						
Female	-.16	-.40*	-.09					
Proc Speed	.11	-.22	-.32	.10				
Sustained Attention	.22	.10	.20	-.12	-.24			
Working Memory	-.06	.20	-.04	-.35	-.18	.34		
L1 Grammaticality	.24	.06	-.44*	-0.058	.31	-.14	.09	
L2 Grammaticality	.33	.19	.26	.22	.02	.08	-.06	-.19

Note. df = 29. FS = Formulated Sentences, CELF-4 English.

* $p < .05$.