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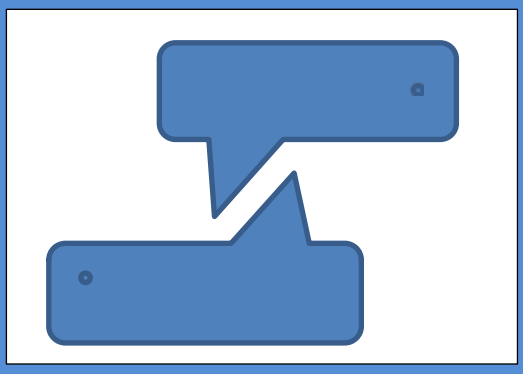

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Editorial

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Three measures often used in language samples analysis

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Abstract

Clinicians analyze spontaneous speech samples in order to examine language abilities in normal and language-impaired children. Mean length of utterance (MLU), Developmental sentence score (DSS) and Index of Productive Syntax (IPSyn) are three measures often used in language analysis. The main purpose of this paper is to review available (in Iran) research in which these three measures were used for analyzing language samples. The articles via Science direct, Medline, and Google scholar as motor engines between 1973 and 2013 were reviewed by use of MLU, DSS, IPSyn, as the keywords. High significant correlation between chronological age and MLU, DSS and IPSyn in normal children was reported. The results showed that MLUs, DSS and IPSyn total scores of linguistically normal children were better than language-impaired children. The findings revealed that DSS and IPSyn are appropriate indicators of syntactic and morphological structures in language samples. MLU is a gross index of grammatical development and unreliable measure beyond Brown's stage V. MLU can be used as a tool for measuring grammatical development before producing complex sentences.

Keywords: Speech, Language sample, syntax, Morphology, MLU, DSS, IPSyn.

1. Introduction

Gathering of language development data in children is commonly done through two different ways: sampling spontaneous speech (natural observation), and administering structured tests or experimental interventions (Owens, 2001). Analyzing morphology and syntax production is the most frequent reason of speech sample analysis. If we really want to know how children produce language structures, the best way is to sample it when produced in natural communication (Paul, 2007). Three numerical measures that have been often used for analyzing language samples are Mean Length Utterance (MLU; Brown, 1973), Developmental Sentence Score (DSS; Lee, 1974) and Index of Productive Syntax (IPSyn; Scarborough, 1990) (Ball et al., 2008).

MLU is used to measure syntax development in children. In general 50 to 100 utterances are sufficient for speech sampling. Each utterance is analyzed by the number of the morphemes. To determine the speaker's MLU,

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the total morphemes is divided by the total number of utterances. Length of utterance counted by number of morphemes is a proper index for determining grammatical complexity of an utterance (Hoof, 2009). Brown (1973) published the results of his longitudinal study of spontaneous speech of three American English language children and popularized the use of morphemes counting as a simple index of grammatical development. The children's spontaneous speech was recorded two hours per month while they were talking with their parents. He then presented five stages for syntactic development. He found a strong correlation between MLU and chronological age.

Lee (1974) studied speech samples of 200 children from the age of 2 to 5 years old and provided a standard method known as Developmental Sentence Score (DSS). This quantitative method was developed for evaluating grammatical standard rules in spontaneous speech. DSS is composed of two components: Developmental Sentence Type (DST) and Developmental Sentence Score (DSS). DST is used to categorize one-word utterances, two-word combinations, and multi-word constructions which are imperfect; while, DSS is used for complete sentences with subject and object. Lee and Canter (1971) proposed the first version of the Developmental Sentence Score. This version has eight grammatical categories: Indefinite pronouns, personal pronouns, main verbs, secondary verbs, negatives, conjunctions, interrogative reversals, and WH-questions. For grammatical forms of each grammatical group with consequent development some points were determined, in a way that later grammatical forms received higher points than earlier grammatical forms. DSS is calculated by using a sample of 50 complete sentences. The sum of scores of at least 50 complete sentences of speech sample was divided by 50 to calculate DSS. This computation was done in 3-5-year-old children.

Index of Productive Syntax (IPSyn) is a grammatical measure which was developed by Scarborough (1990). It shows the individual differences in language acquisition. Scarborough (1990) studies speech samples of 15 children at the age of 24, 30, 36, 42 and 48 months longitudinally and gathered 75 speech samples. Fifty six syntactic structures from noun phrase, verb phrase, questions and negations, and sentence structure subcategories were selected and coded in a transcript of 100 children's utterances, before the IPSyn paper was made. Production of two samples for each structure was needed to calculate the maximum IPSyn. The comparison between the mean of Index of Productive Syntax and mean length of utterance in each age proved the reliability of Index of Productive Syntax. So it can be concluded that Index of Productive Syntax is an appropriate instrument for comparing and matching groups in a study.

The MLU is used by Iranian speech & Language pathologists as a measure for language sample analysis. The aim of this paper is to review articles used MLU and/or other numeric measurements for language sample analysis.

2. Methodology

In this review article, available cross-sectional studies in Pubmed, Medline, Science direct, and Google Scholar were analyzed. The following keywords were used: speech and language sample, MLU, DSS, IPSyn, Syntax, and

morphology.
The main indicator in choosing the articles was measuring morphology and syntax by mean length of utterance (MLU), Developmental Sentence Score (DSS), and Index of Productive Syntax (IPSyn). Considering the multitude of articles, we decided to review the results of the articles in which these methods were used to study morphology and syntax development in normal and language-impaired children, or considered the limitations or relationships of these indicators. There were several articles implying the use of these indicators, but we only accessed 45 abstracts and full-text articles.

3. Findings

Brown (1973) introduced mean length of utterance by a longitudinal study on three children. Further studies with larger samples proved the correlation between chronological age and mean length of utterance. de Villiers and de Villiers (1973) studied speech samples of 21 children aged 16-40 months with the purpose of analyzing the order of morpheme acquisition. The results of this study indicated that mean length of utterance cannot predict proper use of morphemes in grammar development. In Miller and Chapman's research conducted in 1981, 123 children aged 17 to 59 months were investigated. The children's speech samples were collected during unstructured play or conversation with mother. Miller and Chapman reported that despite the positive correlation between chronological age and MLU (r=0.88), children with the same age have different MLUs. Dromi and Berman (1982) examined 38 Hebrew-speaking children aged 2 to 3 years by the means of MLU calculated by the number of morphemes. They concluded that more complicated utterances do not necessarily lead to longer utterances. Scarborough et al. (1986) suggested that MLU increases about 1.2 morphemes per year from 18 months to 5 years old, but the rate of this growth declines after 42 months. Klee and Fitzgerald (1985) concluded that morphology complexity can be predicted in child's language only when MLU is higher than 3. Therefore, MLU is a gross indicator of development, and does not determine the structural complexity of grammatical competence, even in children with similar MLU. Klee et al. (1989) studied the relationship between age and MLU in 24 normal children and 24 children with specific language impairment (SLI). MLU in children with SLI was less than normal children, and the rate of MLU variation in the SLI group was also less than the control group. Klee and his colleagues believe that MLU may not be a sensitive measure of any linguistic construct other than utterance length itself. Chabon et al. (1982) evaluated MLU based on the morpheme-count in children beyond Brown's Stage V of development. The participants were 30 normal children in 3 age groups: (3;6-4;6), (5;6-6;6), and (8;6-9;6). The results indicated that MLU scores were unreliable for children beyond Brown's Stage V. That is, older children can enhance their linguistic complexity without increasing their utterance length. Ekmekçi (1985) studied the practical application of MLU in the Turkish language in one child from 1;3 to 2;4 years and calculated MLU based on the syllable-count, morpheme-count, and word-count. It was concluded that MLU can be used in analyzing language development in Turkish-speaking children.
Rondal and colleagues (1988) calculated MLU of 15 children with Down

syndrome aged 2-12 years. Despite language delay, there was a high correlation between MLU and age.

Blaker et al. (1993) investigated the validity of MLU in spontaneous speech of 87 children aged 1;6-4;9 years. They illustrated that MLU is a valid tool for measuring grammatical complexity up to 4.5 morphemes. Johnston (2001) alternated MLU calculation and analyzed 47 language samples from preschoolers. The calculation of MLU was done after removing elliptical question responses, imitative utterances, and single word Yes/No responses. Initial MLU ranged from 2.0 to 6.5, but after removing the above items, an 18 % increase in the MLU index was observed. Moreover, individual samples increased as little as 3% or as much as 19%.

Miles et al.(2006) hypothesized that using narrated picture storybooks can increase MLU in the language sample of adolescents with Down syndrome. The participants included 14 adolescents with DS and 14 normal children matched for receptive syntax narrated picture storybooks. The results showed that picture support in a narrative context increased MLU in the group with DS.

Jalilevand et al.(2012) conducted a longitudinal study on 2 Persian-speaking children (a girl, and a boy) aged 12-60 months. The spontaneous speech of these two children were recorded and analyzed. One of the purposes of this study was to calculate MLU based on the number of words and morphemes. MLU went up with increasing age in the children. This variation slope in MLU was steeper in 24-42 months. Kazemi et al. (2012) examined MLU in Persian-speaking children living in Esfahan which were 171 children aged 2;6-5;6 were included in this study. The results of this study indicated that the rate of variation after 3-3;6 years was not high, probably because of slow syntactic growth after this age. Oryadi Zanjani et al. (2006) reported MLU counted by words in 580 children aged 2-5 years and found out that it will increase by age. Oryadi Zanjani et al. (2012) used MLU based on morpheme-count to compare speech sample of school age children in two conditions: picture description and storytelling. Results showed no significant difference between these two tasks.

Developmental Sentence Score (DSS) is one of the most common methods used by speech therapists to analyze speech sample. The DSS provides both norm and criterion referenced information (Paul, 2007). Various studies illustrated that DSS provides valuable information for the clinical setting. As a case in point, Hux et al. (1993), and Kempt and Klee (1997) showed that DSS is the most common standard and analytic method used by American speech-language Pathologist.

Lee (1974) believed that the DSS of every child can be compared with normalized data. Validity and reliability of DSS were determined by Lee and Koenigsknecht in 1974. They proposed that significant difference between the DSS of different age groups proves its validity. This cross-sectional study on 200 normally developing children aged 2 to 6;11. Three to five years old children showed significant differences in syntactic structures, and increase of DSS across all age groups. The results of observing the following three aspects proved the reliability of DSS: Grammatical component differences, temporal reliability, and sentence order effect. Rondal (1978) evaluated language delay and language disorder by DSS in 14 children with Down

syndrome and 14 typically-language children matched by MLU. The results of DSS analysis showed that language-impaired children with Down syndrome had fewer syntactic skills compared to control group. Therefore, Rondal concluded that DSS can distinguish language delay from language disorder.

Tomblin and Johnson (1975) estimated reliability of DSS by the number of speech sample. They predicted that reliability goes up with increasing the volume of sample size. The reliability of DSS was 0.75 for 50 sentences. They believed that more speech sample even up to 175 sentences provided acceptable reliability.

Toronto (1976) developed Developmental Assessment of Spanish Grammar which is similar to DSS. The aim of DASG was to assess language in Spanish-speaking children with agrammatism, and to provide a therapeutic model for Spanish language structure. Six grammatical categories in this study were: indefinite pronouns and noun modifiers, personal pronouns, primary verbs, secondary verbs, conjunctions, and interrogative words. Weighted scores were assigned to groups of structures within the hierarchies and were used to score Spanish sentences that children used spontaneously in conversation with an adult. The DASG was standardized on 128 Spanish-speaking children between the ages of 3;0 and 6;11 years.

Aram and Ekelman (1983) analyzed spontaneous speech of 8 children with apraxia based on MLU and DSS. They found that although MLU was within normal limits, DSS scores were below chronological age. The main problems were found with personal pronouns and main verbs. In addition, they had omissions of third-person singular markers, and inconsistent use of regular and irregular past tense.

Kamper et al.(1995) analyzed story telling in 62 children who were 5-10 years old. They found out that MLU and DSS grew dramatically up to the age of 6 years and kept growing slowly up to 8. Hsu et al.(1996) studied 64 children ranging from 3;2 to 8;3 years of age on four separate occasions. During the first interview, a spontaneous language sample was collected and developmental sentence score was calculated. During the second and third interviews each child was asked to act out 45 complex sentences and fourth interview included acting out task and a judgment task. The hypothesis of the four grammar types and their sequential development was supported by the fact that the children belonging to each grammar type differed significantly with respect to age and DSS scores.

Reed et al.(1998) evaluated 8-17year old children and adolescents, and concluded that older children had higher DSS scores. So it can be said that DSS can be used for a bigger age range compared to MLU.

Watkins and Yairi (1999) studied spoken language abilities in 84 preschool children with stuttering. Sixty two children were recovered from stuttering, and 22 children had persistent stuttering. Their lexicon, morphology, and syntax were analyzed through 250-300 utterances in spontaneous speech. The children were divided into 3 age groups: (2-3), (3-4), and (4-5) years old. DSS was used as an indicator of morphology and syntax. The results indicated that language ability of both recovered and unrecovered children were close or higher than was expected. Ryan (2000) examined the conversational speech sample of 20 preschool children with stuttering and

20 preschool children without stuttering. The speech rate, behaviors during conversational speech, hesitations, and language complexities of both groups were analyzed and compared. Stuttered sentences had higher DSS scores (Mean = 10.9, 12.9, respectively) than fluent sentences (Mean = 7.6).

Rice et al. (2008) analyzed language data from 7 year old children with and/or without language delay at 24 months of age. The participants included 28 late talkers, and 109 children with normal history of language development. Language was comprehensively assessed at the age of 7 years. MLU and DSS were used for morphology and syntax assessment. The language performance in the first group was weaker than in children with no history of language delay. Finestack and Abbeduto (2010) compared spoken language abilities of adolescents with Fragile X syndrome and Down syndrome. These three groups were matched based on their nonverbal mental age. They were evaluated by two tools, one of which was DSS. Their speech samples were gathered in storytelling. DSS and the sentence accuracy score was obtained and compared in these three groups. There was a significant difference between the groups on these variables. This difference was not only between normal and abnormal children, but also between Down syndrome and Fragile X group. The difference was on the sentence accuracy score (sentence point). The score of 5 grammatical subcategories of sentence development, including indefinite pronouns, personal pronouns, main verbs, conjunctions, and negatives was compared in 3 groups. The score of conjunctions in normal children differed with this score in children with Down syndrome. There was also a DSS difference between male and female children with Fragile X syndrome.

Mortimer and Rvachew (2010) conducted a longitudinal study on morphology and syntax of children with speech sound disorders. Thirty seven preschool children participated in this study. MLU and Developmental Sentence score were obtained. Children were divided into 4 groups according to MLU. The first group consisted of normal children, a second group of children with speech sound disorder and normal MLU, and a third and fourth group of children with speech sound disorder and poor MLU. Some children did not have 50 utterances for calculating DSS; thus, 5 longest sentences were selected and means of DSS were calculated. Eight grammatical groups were analyzed. Results indicated that children with speech sound disorder had lower DSS and difficulty with finite verb morphology especially forth group.

The newest method for syntax evaluation based on DSS in non-English language was provided by Miyata et al. (2013) in Japanese. They called it Developmental Sentence Score for Japanese (DSSJ). They calculated DSSJ in a study of 84 normal children in age intervals of 2;8 to 5;2. They collected 100 sentences during child-adult conversation and free play. Statistical analysis showed that DSSJ and MLU were highly correlated. They introduced DSSJ as a valuable tool in researches on language acquisition.

Scarborough (1990) examined the ability of syntax production in grammatical development, and concluded that the total score of IPSyn increased by age. Scarborough (1991) used IPSyn to evaluate various groups, including normal preschool children, children and adolescents with language delay, and children and adolescents with fragile X syndrome, Down

syndrome, and autism. In this study, MLU was considered a linguistic complexity predictor. There was a highly significant correlation between MLU counted by morphemes from 1 to about 4.5 and IPSyn. This correlation became weaker when MLU went beyond 3. Therefore the correlation between MLU and IPSyn was weak in the stage of linguistic mastery. So using other tools is recommended for examining syntactic complexity in individuals with abnormal language development.

Hadley (1998) examined syntax development in 20 English-speaking children with SLI by IPSyn. They were two to three years old. Their IPSyn increased with age; however, their score was significantly less than that of normal children.

Rescorla et al. (2000) compared MLU and IPSyn in language delayed children with normal comprehension at three and four years of age. There was a significant correlation between these two measures at both ages. At 3;0, 34% of the late talkers had IPSyn above the 10th percentile, while by 4;0, 29% did so. Using MLU, 41% scored above the 10th percentile at 3;0 and 71% did so at 4;0. There was a high correlation between MLU and IPSyn at both ages for the late talkers, especially when MLU was less than 3.

Hewitt et al. (2005) compared language samples of kindergarten children (mean age 6 years) with and without SLI. The mean scores of MLU and IPSyn in children with SLI were significantly lower than normal children though not for all subtests of the IPSyn. Price et al. (2008) studied length and complexity of syntax in boys with Down Syndrome (DS), those with Fragile X Syndrome (FXS) with and without autism and normal children during conversation. The finding revealed that utterances of children with DS and FXS were shorter and simpler than the control group. Moreover, some subscales of IPSyn (noun and verb phrases, and sentence structure) had less complexity than normal children. Questions and negative forms were simpler in both deviant groups. Syntax performance in DS group was more delayed than FXS group.

Rice et al. (2006) studied three methods of grammatical evaluation (MLU, DSS, and IPSyn) in children with SLI. They gathered 124 conversational samples consisting of 39 children with SLI (age 5;0), 40 MLU-equivalent typically developing children (age 3;0), and 45 age-equivalent controls were gathered. High correlation among the MLU, DSS, and IPSyn measures were reported. In addition, they proposed that MLU is a reliable and valid index of general language development from age 3 to 10.

Baverly and Gottwald (2009) investigated the relationship between sentence complexity, childhood stuttering and grammatical development in 6 children aged 32-42 months. They used IPSyn as an indicator of grammatical development and DSS as an indicator of sentence complexity. The first 100 utterances and sentences were chosen to calculate IPSyn and DSS respectively. The utterances were grouped as fluent and dysfluent. The result indicated that the complexity of fluent and stuttered utterances were significantly different. No significant correlation was seen between grammatical development and mean complexity level of the fluent and stuttered utterances. The authors concluded that simpler sentence forms were more fluent than newly learnt forms of language.

Oetting et al. (2010) evaluated the validity of IPSyn for children speaking

African American English (AAE). Language samples of typically developing children aged 4-6 years and 6 year old children with SLI were compared. IPSyn in African American English speaking children and English speaking children were comparable. IPSyn could not detect differences between the 4- to 6-year-olds based on age, but it could not find differences between the 6-year-olds with and without SLI. The findings showed that IPSyn is a valid measure for AAE speakers, but it is not sensitive to age and cannot show clinical variations in children older than 4 years.

4. Discussion

MLU, DSS and IPSyn are 3 measures, researchers and clinicians use for morpho-syntactic analyzing of language samples. The results of all reviewed articles showed that the total scores of MLU, DSS and IPSyn of linguistically normal children are better than those of language impaired children. All these measures were highly and positively correlated with age in normal children. The defined psychometric properties of these measures are also indicated. Although there is a high correlation between MLU and chronological age in typically developing children, MLU is a valid index of development until approximately 3.0 morphemes in Brown's stage II (Klee & Fitzgerald, 1985). Klee and Fitzgerald (1985) concluded that MLU is a gross index of grammatical development. In other words, it is not a proper measurement of syntactic structure and complexity in linguistically normal children older than 3 years. It is concluded that MLU is an unreliable measure beyond Brown's stage V (Chabon et al., 1982). MLU can be used as a tool for measuring grammatical development before producing complex sentences (Klee & Fitzgerald, 1985). The other limitation of MLU is its inability to predict morpheme acquisition in grammatical development (de Villiers & de Villiers, 1973). Moreover, different children have different MLUs at the same age. In spite of these limitations, MLU is a common and valid tool used by researchers and clinicians for measuring syntax.

Lee (1974) presented DSS as a standard method for evaluating grammatical rules in children's spontaneous speech. The reliability of DSS was also proved by temporal stability, stimuli differences, and sentence sequence effect (Koenigsknecht, 1974) but later studies demonstrated its reliability in a sample size of at least 50 sentences. DSS is a valuable tool for evaluating syntax and morphology, which is normalized on 200 children. So it can be used as a norm and criterion reference in both clinical and research settings. Similar to DSS, IPSyn enables researchers or clinicians to examine syntax development in children, but it does not have normalized data. However, Scarborough (1991) showed that IPSyn can distinguish linguistic skills in children with and without language impairments. The correlation between MLU and IPSyn in language impaired children indicated that MLU cannot be an index for grammatical complexity. As a case in point, longer sentences did not necessarily result in more complex grammar in autistic children (Scarborough et al.,1991). Researchers have compared MLU with DSS and/or IPSyn to provide a more comprehensive perspective of morpho-syntactical assessment (Rice et al., 2006; Scarborough et al., 1991; Rescorla et al., 2000; Hewitt et al., 2005; and Bauerly & Gottwald, 2009). DSS has been shown to provide more morphological and syntactic information than

IPSyn since it is a standard method with more grammatical subscales. Price et al. (2008) believed that IPSyn cannot reflect syntactic properties in patients clearly, so they suggested further studies. Finestack and Abbeduto (2010) pointed out Price's results and the advantages of DSS.
Some studies that used MLU, DSS and IPSyn are in Table 1. Recently, some investigators have not used only MLU as an index for measuring of syntactic complexity.
MLU, DSS, and IPSyn are originally developed to analyze English grammar in children, so they need to be modified for other languages. MLU, compared to two other measures, is used in more languages. Some researchers calculated MLU based on words, and some others omitted one word utterances and short responses (Yes/No) from their calculation. So, MLU can be calculated in different ways.
IPSyn and DSS are less commonly used in non-English languages. DSS has been somehow adapted to Spanish and Japanese languages. DSS has been known to be invalid for African-American English, but IPSyn is a valid measure for this language.

5. Conclusion

MLU, DSS, and IPSyn are three measures of morphology and syntax in speech samples which are valid for English-language studies. Various researchers show that the total score of DSS and IPSyn are appropriate scales for morpho-syntactic structures. MLU is a useful method of measuring syntax in children who have not yet acquired complex sentences. All these scales should be adapted before they can be used in other languages.

The purpose of Study	Measurements	Investigators
The use of MLU in morphemes as a means for determining stages of language development.	MLU	Brown (1973)
Introduce a clinical procedure for estimating syntactic development.	DSS	Lee & canter (1971); Lee (1974)
The acquisition of grammatical morphemes in child speech.	MLU	de Villiers & de Villiers (1973)
Introduce of a language analysis procedure for Spanish-speaking children similar to the Developmental Sentence Scoring (DSS).	DASG(DSS)	Toronto (1976)
The relation between disfluency and linguistic variables in children.	DSS	Haynes & Hood (1977)
Comparison of length and complexity of utterance in three year old children .	MLU , DASG	Linares-Orama (1977)
Relation between age and MLU counted by morphemes.	MLU	Miller & Chapman (1981)
Comparison of syntax in children with and without Down Syndrome .	DSS	Weigel-Crump & Carole (1981)
Morpheme measurement in early language development.	MLU	Dromi & Berman (1982)

Spontaneous language samples analysis of children with developmental verbal Apraxia	MLU ,DSS	Ekelman & Aram (1983)
Comparison between age and MLU in normally developed and language impaired children	MLU	Klee & et al (1989)
Developing of a research tool to measure morphological and syntactic development.	IPSyn	Scarborough (1990)
Comparison of Length and complexity of utterance in normal and abnormal children	MLU, IPSyn	Scarborough et al (1991)
Measuring of Linguistic complexities in fluent and disfluent preschoolers	DSS	Ryan (2000)
Measuring of expressive language in late –talker children	MLU, IPSyn	Rescorla et al.(2000)
Comparison of MLU, DSS, IPSyn in normally developed and Specific language impaired children	MLU, DSS, IPSyn	Rice et al. (2006)
Evaluating of utterance length and syntactic complexity in individuals with and without language disorders.	MLU, IPSyn	Price et al. (2008)
The relation between sentence complexity, childhood stuttering and grammatical development.	DSS, IPSyn	Bauerly, Gottwald (2009)
Validity of IPSyn in African American English	IPSyn	Oetting et al. (2010)
Examining of the expressive language abilities adolescents and young adults with language disorders.	DSS	Finestack & Abbeduto (2010)
Morpho-syntactic measure for Japanese similar to DSS	DSSJ	Miyata et al. (2013)

Table 1: Some studies that used MLU, DSS and IPSyn

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