

DEVELOPMENT OF OROFACIAL PRAXIS OF CHILDREN FROM 4 TO 8 YEARS OF AGE¹

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Summary.—Orofacial praxis is the ability to plan and execute movements or sequences of voluntary movements, meaningful or not, using the muscles of the pharyngo-buccofacial system or the orofacial region. An original test was developed, the Orofacial Praxis Test, consisting of 36 gestures, 24 single and 12 complex, elicited through verbal and imitative request. The test was administered to 93 normally developing Italian children ages 4 to 8 yr. to assess development of orofacial praxis. Analysis showed a progressive development of the orofacial praxic ability by type of gesture and examiner's request: (1) the imitation modality is more facilitating than a verbal request modality, especially for children ages 4 or 5 years; (2) a consistent mastery of sequences of gestures and oververbal movements is in place by age 6 years. The analysis of the orofacial region may be helpful in identifying persistent speech difficulties and developmental coordination disorders.

Orofacial praxis is the ability to plan and execute movements or sequences of voluntary movements, meaningful or not, using the muscles of the pharyngo-buccofacial system or the orofacial region (De Renzi, Pieczuro, & Vignolo, 1966; Denckla & Roeltgen, 1992; Dewey, 1995). Regardless of body region, the praxic ability is considered a learned function which depends on the maturation of the motor system interacting with the outer world and usually shows a normal development between the ages of 2 to 12 years (Henderson & Sudgen, 1992; Dewey, 1993, 1995). At age 12 years, children should present with a fully developed motor ability and be able to produce fine, efficient, and coordinated movements towards a significant action.

Test Development

In the literature, only a few studies have been focused on the development of orofacial praxis abilities. In a study of limb and orofacial praxic development, Baldi and Pignet (1985) tested a developmental scale of praxic ability on a sample of 1,185 Italian children ages 5 to 7 years. The scale assessed imitation of meaningful movements using the muscles of the face and the upper limbs and consisted of 10 focused transitive motor acts, entailing use of an object and 10 of intransitive motor acts with no objects

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involved, which were exclusively imitated. Analysis showed that praxic imitation (blinking, whistling, blowing up cheeks, blowing a balloon, etc.) markedly evolves between ages 5 to 6 years and less between ages 6 to 7 years. In this latter time frame, the child reinforces the knowledge acquired in the previous years. According to the authors the frequent trial-and-error behaviours by children 5 years of age suggest that those children are engaged in devising suitable motor programs. However, such behaviours significantly decrease at age 6 years and are replaced by more complex, preplanned motor programs. According to Baldi and Pignet, the more mature motor program is not complete before age 7 years as at this age imitation is based on perceptual-figurative gesture imitations rather than conceptual imitation. More recently, Dewey (1993) studied the development of the ability to execute six orofacial gestures (whistling, coughing, chewing, smelling a flower, drinking, and blinking) in 102 children ages 6 to 11 years (68 boys and 34 girls, whose mean age was 8 yr., 5 mo.). Of these, 51 children were normally developing, while the other 51 children had received a diagnosis of Developmental Coordination Disorder according to DSM-IV criteria (American Psychiatric Association, 1994). Children were asked to produce gestures upon verbal request and upon imitation. Both groups showed a gradual increase in gesturing with age and a facilitation of the imitation task compared with gesturing upon verbal command at all ages.

The Nepsy neuropsychological battery, created by Korkman, Kirk, and Kemp (1998), is a standardized task to assess the development of rhythmic oromotor coordination, based on a sample of 1,000 American children ages 3 to 12 years (*M* age: 7 yr., 5 mo.) divided into groups of 100 children for each age year (50 boys, 50 girls). On the Oromotor Sequences task, the child is asked to repeat 8 sequences of two or three sounds (e.g., "tick tock, tick tock"; "puh tuh kuh, puh tuh kuh") and 6 tongue twisters (e.g., "put the pepper beads in the paper bag"; "red leather, yellow leather") for a total of 14 items. The child is asked to repeat the sequence or the tongue twister five consecutive times. According to the authors, children with oromotor planning difficulties making articulatory errors varying in type and number across the test sessions could present with an articulatory disorder due to dyspraxia or verbal apraxia. Often, these oromotor difficulties are associated with difficulties in the execution of limb motor sequences and fine movements of the fingers.

Unfortunately, the studies by Baldi and Pignet (1985), and Dewey (1993) present with two limitations: the limited number of items administered to children (6 gestures in Dewey's study and 10 in Bale and Pignet's study), and the limited types of task-related gestures (nonmeaningful gestures and sequences of movements were not included). Korkman, *et al.* (1998) developed and validated a more complete measure of orofacial praxis on a wide

sample of normal children and on several clinical groups. However, this measure is normed for English-speaking child populations and cannot be administered to children speaking other languages. In the literature there is no battery for the assessment of oral praxic development in children or related disorders (either developmental or acquired).

To overcome partially limitations of the reviewed studies the Orofacial Praxis Test was developed to contribute to a more apt assessment of orofacial abilities in clinical settings. This test is language independent and has been normed for Italian children ages 4 to 8 years. It has been developed on the basis of an unpublished test by Vargha-Khadem, Watkins, Alcock, Fletcher, and Passingham (1995) and Watkins, Dronkers, and Vargha-Khadem (2002), and Watkins, Vargha-Khadem, Ashburner, Passingham, Connelly, Friston, Frackowiak, Mishkin, and Gadian (2002). This test allows the assessment of difficulties in the execution of movements (e.g., whistling or blowing a kiss) and sequences of movements (e.g., opening and closing one's mouth) using the orofacial muscles, making a distinction between type of gesture (oroverbal praxic movement, orofacial praxis movement, sequences of movements, parallel movements) and type of request (verbal and imitation-al). The Orofacial Praxis Test shows some similarities with the Screening Test for Developmental Apraxia of Speech-Second Edition (Blakely, 2000). However, while the latter is mainly used for the diagnosis of developmental apraxia of speech, the Orofacial Praxis Test is more general in design and aim and can therefore be used for the screening of a large number of disorders affecting motor coordination at various levels.

METHOD

Subjects

This study included 108 healthy Italian children (61 boys, 47 girls) between 4.0 and 8.1 yr. of age, from middle class background. Of these 47 children attended the first two grades of primary school, while the other 61 children attended kindergarten. The children were divided into four age groups: 4:0–4:11 yr.; 5:0–5:11 yr.; 6:0–6:11 yr.; 7:0–8:1 yr. (Table 1).

TABLE 1
DESCRIPTION OF THE SAMPLE OF 93 ITALIAN CHILDREN

Age (yr., mo.)	Age		<i>n</i>		<i>n</i>
	<i>M</i>	<i>SD</i>	Boys	Girls	
4:0–4:11	4:5	:3	8	10	18
5:0–5:11	5:6	:3	19	7	26
6:0–6:11	6:4	:3	13	8	21
7:0–8:1	7:5	:3	14	14	28
Total			54	39	93

The Orofacial Praxis Test

This test comprises a number of tasks for the production of voluntary movements in the orofacial region. Movements (gestures) are grouped into three categories: (1) single postures, comprising (a) verbal praxic movements for the production of a sound, e.g., meowing, and (b) orofacial praxic movements with no sound production, e.g., showing one's tongue; (2) sequences of two or three movements, e.g., opening one's mouth and showing the tongue; (3) parallel movements consisting of two or three actions to be performed concurrently, e.g., closing one's eyes and opening one's mouth. The test comprises 36 items (Table 2) grouped into 12 verbal praxic movements, 12 orofacial praxic movements, 6 sequences of movements, and 6 parallel movements.

TABLE 2
ITEMS OF THE OROFACIAL PRAXIS TEST

1a. Verbal Praxis	1b. Orofacial Praxis
Meowing	Showing the tongue
Bleating	Clenching the teeth
The train's noise	Biting lower lip
Saying "a" with mouth open	Blowing
Coughing	Blowing the cheeks
Clearing the voice	Touching the cheek with tongue
Clicking the tongue	Smiling
Blowing a raspberry	Yawning
Asking for silence ("shhh")	Biting the tongue with the teeth
Humming a tone	Breathing in through the nose
Whistling	Raising the eyebrows
Blowing a kiss	Blinking
2. Sequence	3. Parallel Movement
Opening and closing the mouth	Closing the eyes and opening the mouth
Showing the tongue and closing the mouth	Closing the teeth and raising eyebrows
Blowing cheeks and blowing with the nose	Biting the tongue and closing the eyes
Showing the teeth, opening the mouth and closing the eyes	Closing the eyes, closing the mouth and saying "Mm-mm"
Blowing, biting the lower lip and blowing cheeks	Opening the mouth, protruding the tongue and saying "aab"
Showing the tongue, touching the cheek with the tongue and blowing a kiss	Closing the eyes, closing the mouth and breathing in through the nose

The examiner, a trained psychologist, introduced each type of gesture with specific instructions and an example. When introducing verbal praxic movements, the examiner told the child "I will ask you to make some movements with your mouth in order to produce some sounds. For example, mew like a cat." When introducing orofacial praxic movements, the examiner told the child "I will ask you to make some movements with your

mouth or your eyes. For example, open your mouth/close your eyes.” When introducing sequences of movements, the examiner told the child “I will ask you to make some movements one after the other. For example, open your mouth and then close your eyes.” When introducing parallel movements, the examiner told the child “I will ask you to make some movements at the same time. For example, open your mouth and close your eyes at the same time.”

Procedure

Each child attended a single session of 45 min. and was administered a neuropsychological screening and the Orofacial Praxis Test. The screening served to exclude children with cognitive, linguistic, and motor difficulties, school-related difficulties, sensory and perceptual impairments, or children exposed to other languages besides Italian. The neuropsychological screening included the following tests, Coloured Progressive Matrices (Raven, 1984), The Bird Nest Story (Fabbro, 1999; Tavano, De Fabritiis, & Fabbro, 2005), Imitating Hand Positions (Korkman, *et al.*, 1998), MT Reading Tests (Cornoldi, Colpo, & Gruppo MT, 1998) for primary school children, or the Visual Analysis and Fixation Tests of the PRCR-2 Battery (Cornoldi & Gruppo MT, 1999) for children attending kindergarten. All children in the sample performing lower than 2 *SDs* below the mean on one test or lower than 1 *SD* below the mean for age on two or more tests were excluded, according to the indications in the ICD-10 (Kemali, Maj, Catalano, Giordano, & Sacca, 1992). A total of 15 children (13.8%) (3 children age 4 yr., 3 children age 5 yr., 4 children age 6 yr., and 5 children age 7 or 8 yr.) were excluded from the original sample of 108 children. The final group whose scores were analyzed included 93 children.

Gestures were requested first verbally and then as imitations. As for the categories, the presentation order remained unchanged throughout: each child performed first the easier gestures (single postures), then sequences and parallel movements. Within each category of movements, two randomized presentation orders were used, the even-numbered order in which the child performed first even-numbered items and then odd-numbered items, and the odd-numbered order in which the child performed first odd-numbered items and then even-numbered items. Therefore, 50.5% of the children followed the even-numbered order, and 49.5% of the children performed the odd-numbered order.

A child's performance on the Orofacial Praxis Test was video recorded and evaluated by two independent judges, both trained psychologists. The first judge coded all 93 performances. Afterwards, another trained judge blind to the study objectives coded the performances of 10 children. The intraclass correlation coefficient was calculated for each dependent variable.

For verbal praxis, the following coefficients were obtained: orofacial praxis $\rho = .95$, verbal praxis $\rho = .93$, sequence $\rho = .53$, parallel movement $\rho = .99$. The coefficient for total verbal request scores was .86. For imitational praxies, the following coefficients were obtained: orofacial praxis $\rho = .99$, verbal praxis $\rho = .96$, sequence $\rho = .92$, parallel movement $\rho = .99$. The coefficient for total trials on imitation was .91.

Coding was as follows. When the gesture was correctly produced or imitated, the item was scored 1; when the gesture was incorrectly produced or imitated or was not performed, the item was scored 0. The test may be used by both psychologists and speech pathologists after a brief training on administration and coding.

RESULTS

Descriptive statistics were calculated, and analyses of variance were applied to collected data. Table 3 shows the means and the standard deviations for each age group in the two request conditions.

TABLE 3
MEANS AND STANDARD DEVIATIONS OF 93 CHILDREN AGES 4 TO 7 OR 8 YEARS FOR
TWO REQUEST CONDITIONS: VERBAL REQUEST AND IMITATION

Age (yr.:mo.)	Request Condition			
	Verbal Request (max = 36)		Imitation (max = 36)	
	M	SD	M	SD
4:0-4:11	28.29	2.49	32.53	1.80
5:0-5:11	28.00	2.59	32.57	1.92
6:0-6:11	30.84	2.79	33.94	1.26
7:0-8:1	33.28	1.65	35.14	1.14

A 4×2 (Age \times Request condition) analysis of variance was performed to assess the effects of age and the request condition on gesture performance of children ages 4 to 7 or 8 years (7 or 8 = children age 7:0 to 8:1). Significant factors were age ($F_{3,90} = 23.69$, $p < .01$) and Request condition ($F_{1,90} = 313.46$, $p < .01$) as well as the interaction between these factors ($F_{3,90} = 8.73$, $p < .01$). Obtained means show that younger children had more difficulty in executing verbal requests, probably because they were still developing relevant verbal comprehension skills. A Newman-Keuls *post hoc* analysis on the main effect of age shows that children ages 4 and 5 years scored significantly lower than children ages 6 to 7 or 8 years ($p < .001$). A further Newman-Keuls *post hoc* analysis for the main effect of the request condition shows that for all age groups, performance in response to imitation was better than that to verbal request. To assess the effect of gesture type, one-way analyses of variance were performed for each group of children in the two request conditions. Table 4 shows the results obtained by each age group for the different

TABLE 4
MEANS AND STANDARD DEVIATIONS OBTAINED BY 93 CHILDREN AGES 4 TO 7 OR 8 YEARS
FOR FOUR GESTURE CATEGORIES BY VERBAL AND IMITATION REQUEST CONDITION

Age (yr.:mo.)	Request Condition	Verbal Praxis*		Orofacial Praxis*		Sequences†		Parallel Movements†	
		M	SD	M	SD	M	SD	M	SD
4:0-4:11	Verbal	8.58	1.93	10.82	0.88	3.41	1.41	5.47	0.87
	Imitation	10.70	1.21	11.52	0.71	4.47	1.28	5.82	0.39
5:0-5:11	Verbal	9.42	1.36	11.03	0.96	3.42	1.52	5.07	0.84
	Imitation	11.11	0.76	11.46	0.76	4.42	1.23	5.57	0.57
6:0-6:11	Verbal	9.63	1.60	11.36	0.68	4.57	1.50	5.47	0.77
	Imitation	11.15	0.89	11.63	0.59	5.52	0.51	5.73	0.45
7:0-8:1	Verbal	10.39	1.19	11.64	0.48	5.42	0.83	5.89	0.31
	Imitation	11.71	0.53	11.78	0.41	5.75	0.58	5.96	0.19

*max = 12. †max = 6.

gesture types. Children age 4 years showed differences in gesture performance both in the verbal request condition ($F_{3,51} = 43.83$, $p < .0001$) and upon imitation ($F_{3,51} = 7.82$, $p < .0002$). In both conditions, these children performed equally well the parallel movements and orofacial praxic movements, which were the easiest to perform. Upon verbal request, verbal praxic items were performed less accurately than parallel movements ($p < .001$) and orofacial praxic items ($p < .001$), while the latter were performed better than sequences of movements ($p < .0001$), which were the most complex to perform. Orofacial praxic items were performed better than verbal praxic items ($p < .05$) and sequences ($p < .001$), and parallel movements were imitated significantly better than sequences ($p < .001$). The group of children age 5 years showed differences related to gesture type and request condition: verbal request ($F_{3,75} = 23.27$, $p < .0001$) and imitation ($F_{3,75} = 17.07$, $p < .0001$). In both request conditions, sequences and verbal praxic items were more difficult to

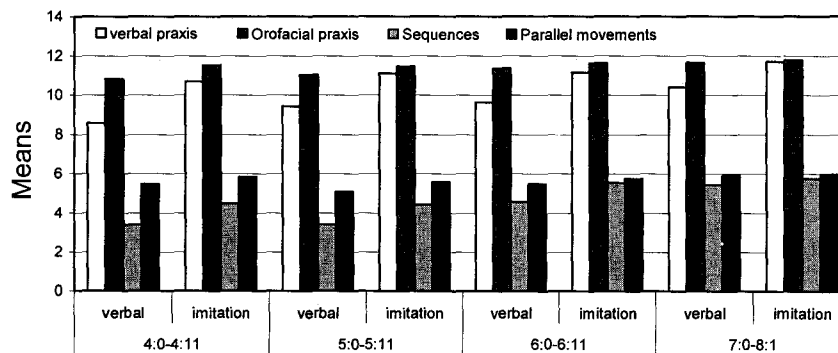


FIG. 1. Means and standard deviations obtained by 93 children ages 4 to 7 or 8 years for four gestures

perform than orofacial praxic items ($p < .0001$) and parallel movements ($p < .01$). However, at this age a difference in performance patterns was observed. Compared with younger children, children age 5 years performed equally well on verbal and orofacial movements and parallel movements. At age 6 and 7 or 8 years, children performed all gesture types upon imitation with the same accuracy, while some differences were still observed in the verbal request condition (for age 6 years $F_{3,63} = 6.59$, $p < .0001$, and for age 7 or 8 years $F_{3,81} = 1.85$, $p < .001$). The two age groups did not differ on orofacial praxic items and parallel movements. The same does not apply for sequences of movements and verbal praxic items. On the verbal request task, children age 6 years had more difficulties in producing sequences of gestures versus orofacial praxic items ($p < .02$) and parallel movements ($p < .005$). Similarly, a difference was noted between verbal and orofacial praxic items ($p < .02$) and parallel movements ($p < .02$), the latter being better performed. At age 7 or 8 years, a difference was observed between orofacial praxic items and parallel movements ($p < .01$), the latter being better performed. Children had more difficulties in performing verbal praxic items than orofacial praxic items ($p < .0002$) and parallel movements ($p < .0001$).

DISCUSSION

This work has confirmed that performing voluntary orofacial movements improves with age. In point of fact, children ages 4 and 5 years scored significantly lower than children ages 6 and 7 or 8 years. This finding is in line with previous studies by Baldi and Pignet (1985) and Dewey (1993). Like for other neurolinguistic and neuropsychological functions, the age of 6 years seems to be a critical time for awareness in performance of cognitive tasks (Rothbart & Posner, 2001; Tavano, *et al.*, 2005).

Another finding from this study is the higher competence of all age groups in the execution of orofacial gestures upon imitation versus upon verbal request, as observed earlier by Dewey (1993). This was significantly more evident in children of 4 and 5 years. It is known from many studies that the acquisition of neuropsychological skills by children privileges the imitational channel, while verbal control of behavior shows slower development (Locke, 1995). In language acquisition, imitational aspects markedly precede explicit learning of lexical or grammatical components (Ellis, 1994). Another relevant finding is the understanding by children ages 4 and 5 years of complex verbal requests. It is, indeed, known that grammatical comprehension is complete about 8 years (Chilosi & Cipriani, 1995) and, at this age, development of working memory skills has matured (Gathercole & Baddeley, 1995).

With regard to gesture categories, on imitation tasks children ages 4 and 5 years had more difficulties in performing sequences and verbal praxic

items. In contrast, no significant differences were found across gesture categories between children ages 6 and 7 or 8 years. It is thus possible that sequences and verbal praxic items are among the most difficult gestures to perform and are not completely acquired until the age of 6 years. This could be related to the greater difficulty of younger children in planning sequences of movements or concurrently planning a motor act and a vocalization in verbal praxic items. In the verbal request condition, sequences are the most difficult tasks for all age groups. Not even the children ages 7 or 8 years correctly performed sequences for all instructions. Similarly, all age groups had difficulty performing verbal praxic items upon verbal request, while orofacial praxis items and parallel movements were easier to produce.

Development of orofacial praxis is impaired in a series of disorders, among which are Developmental Coordination Disorder, Oral Dyspraxia, and Developmental Apraxia of Speech (Dewey, 1995; Shriberg, Aram, & Kwiatkowski, 1997). The difference between Oral Dyspraxia and Developmental Apraxia of Speech is still a debated issue. In Dewey's study (1995), Oral Dyspraxia is defined as a group of difficulties mainly related to orobuccofacial movements which can have a significant effect on verbal production. The main symptoms for diagnosis of Developmental Apraxia of Speech are (1) severe clumsiness and effortful production for a part of, or all phonemes (behavior by trial and error), (2) inability to produce isolated phonemes voluntarily or sequences of phonemes that are properly produced on other occasions, and (3) inability to produce isolated oral movements or automatically available sequences of movements upon request (Maassen, 2002). From a developmental perspective for the aforementioned pictures the literature shows a high frequency of disorders affecting the execution of a single gesture and coordination of orofacial and facial gestures. For example, there can be a dissociation between automatic and voluntary execution of focused actions, e.g., a child can find it difficult to whistle upon the examiner's request but can blow out a candle with no difficulty. Furthermore, a high comorbidity with the Developmental Disorder of Motor Function (Kemali, *et al.*, 1992) or Developmental Coordination Disorder (American Psychiatric Association, 1994) was also observed. Persistence of the deficit over time can make it resistant to rehabilitation, with ensuing worsening of language delay (Yoss & Darley, 1974; McCabe, Rosenthal, & McLeod, 1998; Maassen, 2002; Marquardt, Sussman, Snow, & Jacks, 2002; Nijland, Maassen, Van Der Meulen, Gabreels, Kraaimat, & Schreuder, 2002; Nijland, Maassen, Van Der Meulen, Gabreels, Kraaimat, & Schreuder, 2003).

In this perspective, the Orofacial Praxis Test can be used as a clinical screening for oropraxic difficulties in the case of Developmental Coordination Disorder and difficulties related to Oral Dyspraxia. Furthermore, the analysis of video recordings can contribute to defining the functional profile

typical of Developmental Apraxia of Speech (Bishop, Price, Dale, & Plomin, 2003). Furthermore, research using the Orofacial Praxis Test may also help explain the relationships between Developmental Language Disorders, Oral Dyspraxia, Developmental Apraxia of Speech, and Developmental Coordination Disorders, for which appropriate in-depth investigations of specific motor region abilities are still lacking. According to the unitary model proposed by Roy and Square (1985), there is only one mechanism underlying motor execution independent of the body segment involved in movement. This hypothesis relies on the fact that oral, verbal, and limb-related praxic disorders are often associated and the quality of errors made by children is similar. In contrast, according to Raade, Rothi, and Heilman's (1991) unitary model, there are two independent motor systems, one of which subserves limb movement while the other subserves orofacial movements, given dissociations observed between limb apraxia and orofacial apraxia. Prichard, Tekieli, and Kozup (1979) and Aram and Horwitz (1983) observed, for example, that children with Developmental Apraxia of Speech performed tasks of verbal and oral sequences inadequately, while they did not show any difficulties on tasks requiring production of single gestures with the limbs or sequences of nonverbal gestures. Similarly, two Italian studies (Sabbadini, Migliorini, Ceretti, Guerra, Piattelli, Massara, Villa, & Volpe, 1975; Sabbadini, Bonini, Neri, & Piattelli, 1978) defined oral dyspraxia as "dyspraxia of the lips, tongue, and velum," i.e., children cannot move the tongue, blow kisses, or whistle, while limb praxic movements are performed adequately. At present, neither of the two models explains the nature of the mechanism(s) which subserves praxic ability.

The differences in methods across the mentioned studies can partly account for the different results obtained in the assessment of praxic abilities and thus for the lack of theoretical agreement. To this end, it is very important to use a test, such as the one presented, which allows description of the type and severity of orofacial praxic deficits of children, their evolution over time, and the possible relationships with upper limb praxic movements and general movement development. The subdivision of executing movements on request vs imitation is useful in the differential diagnosis of children with orofacial praxis deficits with or without speech difficulties.

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