International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Development of the Hindi Diagnostic Articulation Test (Hdat): A Three-Phase Study of Word Familiarity, Speech-Sound Acquisition, Phonological Patterns, and Stimulability in Hindi-Speaking Children

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ABSTRACT

Assessment of speech-sound production should reflect the phonetic inventory, familiar vocabulary, and dialectal patterns of the child's language. Objective: To develop a picture-supported diagnostic articulation test for Modern Standard Hindi and describe developmental patterns among Hindi-speaking children. Methods: The three-phase investigation comprised identification of target vowels, consonants, and picturable words (Phase I); word-familiarity and picture-appropriateness ratings by 10 teachers (Phase II); and assessment of 100 typically developing Hindi-speaking children aged 3 years to 7 years 12 months, with 20 children in each of five age groups (Phase III). Sound acquisition was operationally defined as correct production by at least 75% of children in any two of three tested word positions. Results: The initial stimulus-development records identify 31 vowel words and 256 consonant words; a separate summary lists 263 consonant candidates, requiring reconciliation against the original item register. Following item review, the final test comprised 13 vowel-target and 100 consonant-target words. Bilabial, dental, and velar sounds generally showed earlier accurate production, whereas retroflex flaps, selected sibilants, and composite consonant sequences demonstrated later or more variable performance. Phonological error patterns, stimulability, and dialectal variants were also examined. Conclusion: HDAT offers a structured, linguistically informed approach to eliciting and analyzing Hindi speech sounds. Further representative sampling and psychometric evaluation are necessary before establishing generalizable normative cutoffs or definitive diagnostic accuracy.

Keywords: Hindi; articulation; phonological processes; speech sound acquisition; picture naming; stimulability; dialectal variation; HDAT.

1. Introduction

Articulation is the coordinated adjustment of speech structures and the vocal tract to produce perceptually meaningful phonemes. Development of intelligible speech involves phonetic maturation, phonological representation, motor planning and acquisition of language-specific contrasts. Children commonly simplify adult targets during development; such patterns must be distinguished from persistent speech-

sound difficulties. Assessment therefore benefits from both sound-by-sound accuracy measures and analysis of phonological processes.

Modern Standard Hindi exhibits distinctive contrasts in aspiration, dental and retroflex articulation, and consonant sequences. Vocabulary familiarity and visual clarity can also influence elicited responses. Consequently, articulation measures developed for English cannot be presumed to have equivalent linguistic or developmental applicability among Hindi-speaking children. Earlier investigations of Hindi photo-articulation and phonological development provide a foundation for language-specific assessment (Ranjan, 1999; Santosh, 2001; Rahul, 2006; Bhatt et al., 2014).

The Hindi Diagnostic Articulation Test (HDAT) was developed to integrate targeted word elicitation, developmental speech-sound analysis, phonological error classification, stimulability assessment, and recognition of dialectal alternatives. This study describes the development procedures and articulatory findings obtained across the specified age groups.

2. Aim and objectives

The principal aim was to develop and undertake preliminary standardization of an articulation and phonology assessment for Hindi-speaking children. The objectives were to (i) identify relevant Hindi vowels and consonants; (ii) construct an age-appropriate inventory of familiar, picturable words; (iii) improve teacher awareness of childhood speech and language difficulties; (iv) examine speech-sound accuracy and phonological error patterns between 3 years and 7 years 12 months; (v) assess stimulability; and (vi) identify dialectal word variations. The present investigation provides descriptive developmental evidence rather than a complete psychometric standardization.

3. Materials and methods

3.1 Design and setting

This cross-sectional developmental investigation was conducted in Lucknow, Uttar Pradesh, in three sequential phases. Classroom teachers contributed familiarity and image-suitability judgments, followed by assessment of children recruited from different areas of the city. Dates of recruitment, ethics committee approval details, consent documentation, and an a priori sample-size calculation are not available in the current study record.

3.2 Phase I: identification of sounds and construction of stimuli

Ten vowels of Modern Standard Hindi and a set of 36 consonant targets were selected using linguistic literature and school-level Hindi learning materials. Candidate words were intended to be simple, meaningful, commonly recognizable, bi- or trisyllabic and pictureable, with the target consonant represented, wherever linguistically feasible, in initial, medial and final positions. Words with repeated occurrences of the target sound and strongly localized referents were excluded. Naturalistic colored flashcards were prepared in A5 format, emphasizing clarity, sharpness and contrast.

Velar and palatal nasal consonants /ŋ/ and /ɲ/ were excluded because of limited suitable vocabulary, whereas the composite forms /kṣ/, /tr/, and /gj/ were included because of their representation in school-level Hindi instruction. The sound /f/ was accepted as a realization corresponding to /ph/ in relevant speech varieties. The initial item-development tally was 31 vowel and 256 consonant words, although another research summary indicates 263 consonant candidates. The original word inventory should be consulted to resolve the discrepancy; the intermediate selection records also identify 39 vowel and 163 consonant candidates at a separate screening stage.

3.3 Phase II: familiarity and picture appropriateness

Ten teachers (two each from LKG, UKG, Classes I, II and III) at one randomly selected school in Lucknow assessed the familiarity of candidate words and the appropriateness of corresponding pictures. Before rating, the teachers received an explanation of childhood speech and language difficulties. The three-point scoring scheme was 1 = highly familiar/highly appropriate, 2 = moderately familiar/moderately appropriate, and 3 = unfamiliar/inappropriate. For each sound and eligible position, the most familiar candidate and the most appropriate picture were selected; unsuitable pictures were to be replaced.

Rating	Word familiarity	Picture appropriateness
1	Highly familiar	Highly appropriate
2	Moderately familiar	Moderately appropriate
3	Unfamiliar	Inappropriate

3.4 Phase III: participant selection and administration

A total of 100 native Hindi-speaking children were assessed, with 20 in each age band. Children attended school and were described as coming from middle- or upper-middle-class educated households. Inclusion criteria specified no reported developmental, behavioral, structural, neurological, sensory, speech/language or treatment history affecting performance, normal oral peripheral structures, and reportedly normal bilateral hearing and vision. No independent audiometric or vision-screening protocol is described.

Group	Age range	n
I	3 years–3 years 12 months	20
II	4 years–4 years 12 months	20
III	5 years–5 years 12 months	20
IV	6 years–6 years 12 months	20
V	7 years–7 years 12 months	20
Total	-	100

Each child was shown a picture and prompted to produce its target name. When spontaneous naming failed, a verbal cue was supplied; if the word still could not be retrieved, an auditory model was provided for imitation. Responses were registered on a scoring sheet. Alternative lexical labels used in the child's community or dialect were recorded rather than automatically scored as erroneous. Stimulability was examined at word level and described as improvement with auditory-visual modeling and/or placement cues.

3.5 Outcome definitions and analysis

Correct production of target speech sounds was summarized using age-group percentages. A sound was classified as acquired when at least 75% of children produced it accurately in any two of three applicable word positions. The analysis was descriptive; individual item denominators, confidence intervals, dispersion estimates, and inferential test statistics were not available for calculation. Stimulability outcomes were interpreted qualitatively rather than as a composite numerical score.

4. Results

4.1 Stimulus selection

Following teacher ratings of word familiarity and pictorial appropriateness, the final HDAT stimulus inventory contained 13 vowel-target and 100 consonant-target words. Variability in ratings demonstrated that visually clear illustrations do not necessarily evoke familiar lexical labels. Selection therefore considered the child's likely vocabulary alongside phonetic coverage, particularly for relatively uncommon or Sanskritized words.

4.2 Articulation across five age groups

Tabled percentages summarize correct production of selected speech sounds across the five age groups. The results describe the investigated sample and should not be interpreted as nationally representative age-of-acquisition norms.

Velar stops

Sound	3y	4y	5y	6y	7y
k	75%	90%	95%	100%	100%
kʰ	75%	90%	95%	100%	100%
g	75%	90%	95%	100%	100%
gʰ	75%	95%	95%	100%	100%

Palatal affricates

Sound	3y	4y	5y	6y	7y
c	95%	95%	95%	100%	100%
cʰ	90%	90%	100%	100%	100%
ɟ	95%	95%	100%	100%	100%
ɟʰ	85%	90%	100%	100%	100%

Retroflex stops, flaps and nasal

Sound	3y	4y	5y	6y	7y
ʈ	55%	70%	65%	95%	100%
ʈʰ	55%	70%	70%	95%	100%
ɖ	65%	65%	70%	95%	100%
ɖʰ	65%	55%	70%	95%	100%
ɽ	5%	35%	60%	90%	100%
ɽʰ	5%	35%	60%	85%	100%
ɳ	30%	40%	75%	95%	100%

Dental stops and nasal

Sound	3y	4y	5y	6y	7y
t̪	100%	100%	100%	100%	100%
t̪ʰ	80%	100%	100%	100%	100%
d̪	95%	100%	100%	100%	100%
d̪ʰ	85%	90%	95%	100%	100%

n	100%	100%	100%	100%	100%

Bilabial and related consonant targets

Sound	3y	4y	5y	6y	7y
p	100%	100%	100%	100%	100%
f	100%	100%	100%	100%	100%
b	100%	100%	100%	100%	100%
bʰ	100%	100%	100%	100%	100%
m	100%	100%	100%	100%	100%

Approximants and /h/

Sound	3y	4y	5y	6y	7y
j	85%	80%	100%	100%	100%
r	45%	80%	80%	100%	100%
l	95%	100%	100%	100%	100%
ʋ	100%	100%	100%	100%	100%
h	85%	95%	95%	100%	100%

Sibilants and composite characters

Sound	3y	4y	5y	6y	7y
s	90%	90%	95%	100%	100%
ʃ	20%	45%	60%	80%	90%
ʂ	0%	5%	25%	40%	25%
kʂə	0%	25%	35%	55%	55%
ʈrə	0%	45%	50%	100%	100%
gjə	30%	60%	80%	100%	100%

All four velar stops /k, kʰ, g, gʰ/ attained at least 75% correct production in the youngest group and reached 100% by the 6-year age band. Dental /t̪, n/ and the bilabial and related consonant targets also showed high accuracy at younger ages. In contrast, the retroflex flaps /ɽ, ɽʰ/ were produced correctly by only 5% of the youngest group, followed by marked improvement across successive age bands. Correct production of /ʂ/ remained 25% in the oldest group and /kʂ/ reached 55% in the two oldest groups. These patterns merit cautious interpretation because lexical frequency, phonetic context, and dialectal differences may affect performance. Non-monotonic values across age groups are possible in a cross-sectional sample.

4.3 Phonological processes

Several phonological error processes were identified during the assessments. Their observed age spans are summarized below. The age range for metathesis could not be established reliably from the available consolidated record and is therefore not assigned a specific interval.

Process	Reported age range
/r/ substitution	3 years–5 years 12 months
Velar fronting	3 years–5 years 12 months

Final consonant deletion	3 years–5 years 12 months
Cluster reduction	3 years–7 years 12 months
Retroflex fronting	3 years–6 years 12 months
Deaspiration	3 years–5 years 12 months
Palatalization	3 years–5 years 12 months
Metathesis	Age interval not reliably established

4.4 Stimulability

Stimulability was evaluated by asking children to imitate target words following an auditory-visual model, supplemented when necessary by articulatory placement cues. Children aged up to 4 years 12 months frequently required placement cues beyond auditory-visual imitation, whereas many children aged 6 years and above corrected productions with imitation and cueing. These clinical observations were qualitative, and predictive validity or treatment-response estimates were not calculated.

4.5 Dialectal variation

Dialect-related lexical and phonetic variants were identified for words such as thali, dhaga, gai, jibh, gobhi, chaku, kadhai, aankh, pyaz, dabba, safed, and barf. Forms such as /ʈhɑl/ for /ʈhɑli/, /ɟibhi/ for /ɟibh/, and /ʈɑgɑ/ for /ɖhɑgɑ/ illustrate that an apparent omission, addition, or substitution may reflect a legitimate regional usage. Accurate clinical interpretation therefore requires attention to the child's habitual speech community.

4.6 Graphical analysis of age-wise articulation findings

Figures 1–3 illustrate the percentages of children producing selected targets correctly across the five age groups (n = 20 per age group). The curves summarize cross-sectional differences and should not be interpreted as longitudinal developmental trajectories or adjusted population estimates.

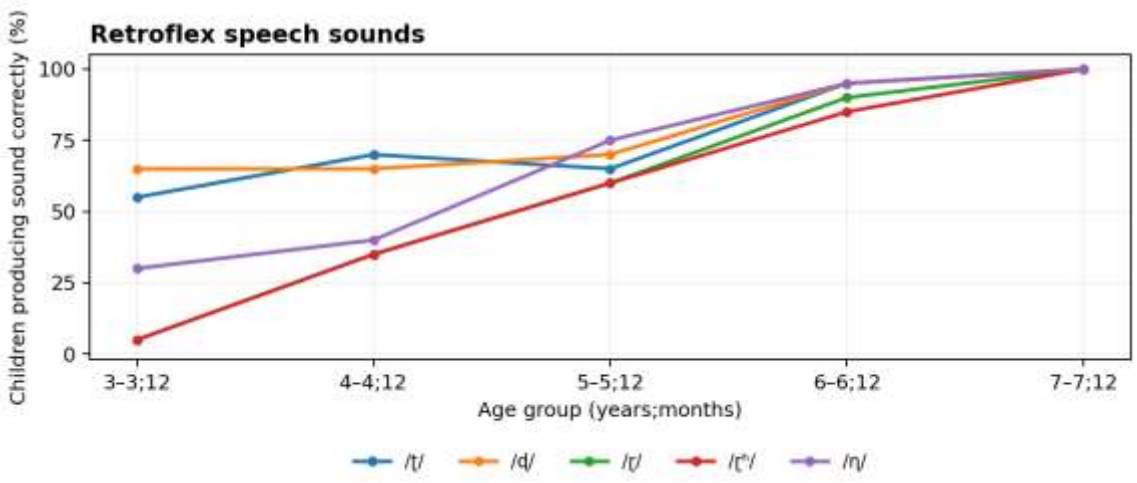


Figure 1. Correct articulation of selected retroflex speech sounds across five age groups.

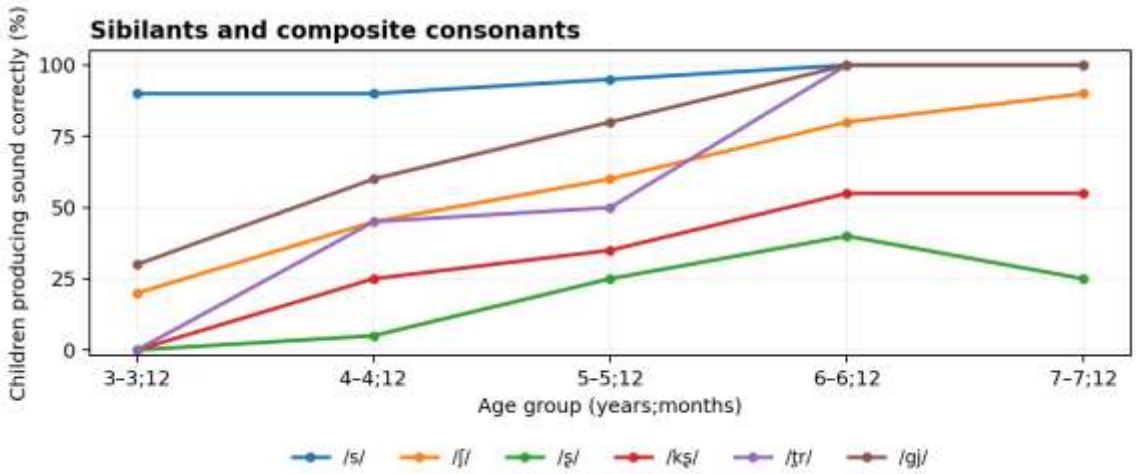


Figure 2. Age-specific production of sibilants and composite sequences, highlighting residual variability.

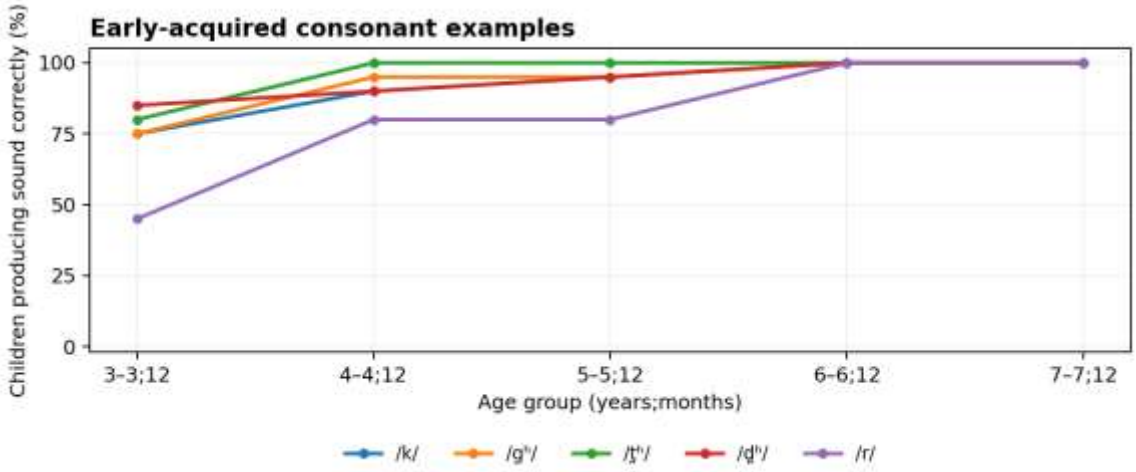


Figure 3. Age-wise production accuracy for selected velar, dental, and rhotic speech sounds.

4.7 Summary of salient developmental contrasts

Among children aged 3–3;12, /ɽ/ and /ɽʰ/ were produced correctly by 5%, compared with 100% accuracy for the bilabial targets examined. By ages 7–7;12, both retroflex flaps reached 100% accuracy, while /ʂ/ remained at 25% and /kʂ/ at 55%. Differences may be influenced by articulatory complexity, occurrence frequency, phonetic position, and dialect, although these factors were not independently quantified.

Target	Age 3–3;12	Age 7–7;12
Retroflex flap /ɽ/	5%	100%
Retroflex flap /ɽʰ/	5%	100%
Palatal fricative /ʃ/	20%	90%
Retroflex fricative /ʂ/	0%	25%
Composite /kʂ/	0%	55%
Dental /t̪/	100%	100%

5. Discussion

5.1 Language-sensitive construction of articulation stimuli

The research design addresses a major cause of measurement error in developmental assessment: an unfamiliar stimulus can underestimate expressive naming even when the target speech sound is available in the child's repertoire. Teacher judgments of word familiarity and picture suitability provide a preliminary content-screening process. The contrast between ratings for some familiar everyday items and specialized vocabulary suggests that lexical access and age-appropriateness must be controlled when selecting items for diagnostic use.

5.2 Developmental differences and interpretation of the 75% threshold

Many stop and nasal categories exhibited high correct-production rates at younger ages, whereas retroflex flaps, certain sibilants, and composite sequences showed more extended or variable acquisition patterns. The 75% criterion was defined operationally for this study. Without sex-stratified estimates, confidence intervals, item-level reliability, or independent regional replication, these results should be understood as age-associated patterns within the sample rather than universal Hindi acquisition thresholds.

5.3 Phonological patterns and clinical decision-making

Observed processes such as velar fronting, deaspiration, retroflex fronting and cluster reduction can help clinicians characterize how a child's productions differ systematically from adult targets. The notably persistent cluster-reduction window in this sample reinforces the need to consider task difficulty and sound-sequence frequency. An HDAT assessment can structure subsequent phonetic probing, connected-speech sampling, and treatment target selection, but should not operate as a stand-alone diagnosis.

5.4 Stimulability and dialectal competence

An imitation-based probe has practical value because correct production after modeling may reveal latent articulatory capacity. Still, clinical prognosis cannot be inferred quantitatively from the present dataset. Likewise, the documented regional variants demonstrate why a standardized Hindi target should not erase legitimate home-language differences; clinicians must distinguish dialect-sensitive variation from disorder.

5.5 Development contribution and translational potential

HDAT was developed by Dr. Ankita Kumari through a sequence of linguistic and clinical procedures: selection of target speech sounds, development of candidate words, preparation of A5 picture stimuli, teacher assessment of familiarity and image suitability, administration to children, phonological error analysis, and refinement of the final item list. These steps constitute the test-development methodology. The history of development may additionally be supported by dated instruments, original scoring sheets, analysis records, and related publications.

6. Limitations and future research

The sample comprised 100 school-attending children in Lucknow from comparatively restricted educational and socioeconomic backgrounds, which limits generalizability. Teacher ratings were obtained from 10 educators at a single school. Test–retest reliability, inter-rater agreement, internal consistency, diagnostic sensitivity and specificity, blinded assessment, formal audiometric verification, and comprehensive normative distributions were not established in the present analysis. An inconsistency in the recorded number of initial consonant candidate words also requires reconciliation. Further studies should broaden geographic and socioeconomic representation, evaluate word-position effects, assess

reliability and validity, and test discrimination between typical development and clinically diagnosed speech-sound disorders.

7. Conclusion

The Hindi Diagnostic Articulation Test represents a structured attempt to develop linguistically appropriate picture-based articulation materials for Hindi-speaking children aged 3–7 years 12 months. Its three phases combine sound selection, ratings of familiarity and pictorial suitability, and descriptive developmental testing in 100 children. The study provides preliminary age-related articulation patterns, phonological-process observations, stimulability information and a reminder of dialectal diversity. HDAT may support organized clinical assessment and research, but broader standardization and diagnostic validation remain necessary before universal normative claims can be made.

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