

A Standardized and Validated Protocol for Primitive Reflex Assessment: Reliable Measurements Across the Lifespan for Clinical and Research Practice

Erzsébet Stephens-Sarlós

`stephens-sarlós.erzsebet@sze.hu`

Széchenyi István University <https://orcid.org/0000-0001-7723-0128>

Edmond Girasek

Széchenyi István University <https://orcid.org/0000-0002-0579-6592>

Nicole Avena

Princeton University USA <https://orcid.org/0000-0002-9166-4560>

Lorraine Boran

Dublin City University, Ireland <https://orcid.org/0000-0002-0993-0306>

Marianna Pagkratidou

Dublin City University, Ireland <https://orcid.org/0000-0002-0161-1554>

Patrick Stephens

Széchenyi István University <https://orcid.org/0009-0007-9211-0512>

Fanni Küplen

Széchenyi István University <https://orcid.org/0009-0002-4733-9813>

Angéla Somogyi

Széchenyi István University <https://orcid.org/0000-0001-7966-1159>

Richard AP Roche

Maynooth University Ireland <https://orcid.org/0000-0001-6606-4187>

Attila Szabo

Széchenyi István University <https://orcid.org/0000-0003-2788-4304>

Research Article

Keywords: cortical inhibition, inter-rater and intra-rater reliability, primitive reflexes, neurodevelopmental and neurodegenerative assessment, standardized protocol

Posted Date: March 5th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9031441/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: The authors declare no competing interests.

Abstract

Primitive and transitional reflexes reflect central nervous system development, integrity and functional status across the lifespan, yet their assessment has remained largely qualitative and non-standardized. We developed and validated a comprehensive protocol to quantify 18 primitive and transitional reflexes using a standardized three-point ordinal scale. A total of 565 participants aged 3 to 92 years were assessed, including typically developing children, healthy older adults, individuals with dementia, and those with sensorimotor integration difficulties. Inter-rater reliability ($N = 259$; weighted Cohen's $\kappa = 0.912$ to 1.000) and intra-rater reliability ($N = 306$; $\kappa = 0.912$ to 0.983) demonstrated excellent agreement, with narrow confidence intervals confirming statistical robustness. This is the first lifespan-validated reflex battery with established psychometric properties. By transforming reflex examination into a reproducible measurement framework, it enables systematic investigation of cortical inhibitory control and establishes primitive reflex profiling as a potential behavioral biomarker in neurodevelopmental and neurodegenerative research.

Introduction

Primitive and transitional reflexes, which are developmentally transient, brainstem-mediated motor responses to specific sensory inputs, represent some of the earliest functional manifestations of human central nervous system development. These stereotyped motor patterns emerge prenatally and serve essential survival functions during the neonatal period

^{1–3}. Increasing evidence suggests, however, that the timing and quality of primitive reflex integration reflect not only motor maturation but are also closely linked to the development of sensorimotor networks and higher-order cognitive functions ^{4,5}. Prolonged persistence or re-emergence of primitive reflexes beyond early childhood has been associated with a range of neurodevelopmental and neurodegenerative conditions, including attention-deficit/hyperactivity disorder (ADHD), developmental coordination disorder, and dementia ^{6–9}.

In this study, we address the current lack of a standardized approach to assessing and interpreting 18 primitive and transitional reflexes across the lifespan by establishing a systematic framework for evaluation across development and aging.

Despite their substantial clinical relevance, primitive reflexes remain markedly underrepresented in contemporary neuroscientific research. A major limitation of the field is the absence of a unified, psychometrically validated protocol for reflex assessment across the lifespan. Existing tools are largely based on subjective clinical observation and frequently lack standardized scoring criteria and formal evaluation of inter-rater reliability. These limitations substantially reduce comparability across studies and constrain the use of reflex profiles in diagnostic and longitudinal research contexts ^{10–12}. This gap is particularly problematic given that disturbances in cortical inhibitory control—central to most neurodevelopmental disorders—are rarely examined through the persistence of primitive reflexes,

despite growing evidence that such persistence is associated with alterations in GABAergic inhibitory mechanisms^{13,14}.

Several approaches to primitive reflex assessment have been proposed previously (including the Fiorentino³, Masgutova¹⁵, Goddard¹⁶, and Wang¹⁷ assessment methods); however, these frameworks largely lack empirical validation, exhibit limited reliability, and have not been integrated into established neurological or neuropsychological assessment systems^{8,18}. Moreover, existing approaches often assess only a limited selection of primitive reflexes, and the reflexes included, as well as the methods of evaluation, vary significantly between protocols. This lack of consistency in both content and methodology further limits the comparability of findings across studies and hinders the development of standardized assessment tools^{17–19}.

Here, we present a new standardized assessment protocol (Supplementary Information 1 and 2) comprising 18 primitive and transitional reflexes, validated across an age range of 3 to 92 years in a cohort of 565 participants. Both intra-rater and inter-rater reliability of the protocol were statistically confirmed. Methodologically, this represents the first initiative to operationalize reflex profiling as a quantitative assessment tool, with potential applicability in clinical diagnostics, rehabilitation settings, and neurodevelopmental research²⁰.

Methods

Human participants

Across the full sample, participant age ranged from early childhood to advanced old age (3–95 years; $N = 565$). To establish the reliability of the validation procedure, both intra-rater and inter-rater reliability analyses were conducted. The mean age in the intra-rater subsample ($N = 306$) was 13.7 years ($SD = 19.8$), whereas the inter-rater subsample ($N = 259$) had a mean age of 48.6 years ($SD = 33.4$), reflecting a broad distribution across developmental and aging stages.

Four distinct cohorts of human participants were recruited, covering early childhood through older adulthood. Group 1 consisted of 95 typically developing children aged 5–7 years (45 boys, 50 girls) with no registered sensorimotor difficulties. Group 2 comprised 164 adults aged 60–92 years (35 men, 129 women) without a clinical diagnosis of dementia. Group 3 comprised 18 adults aged 71–89 years (5 men, 13 women) diagnosed with moderate dementia. Group 4 consisted of 292 individuals aged 3–59 years (154 men, 138 women) diagnosed with sensorimotor integration–related difficulties.

Younger participants (3–18 years; Groups 1 and 4) were recruited from preschools and schools, whereas older participants (60–92 years; Groups 2 and 3) were recruited from residential eldercare facilities. Young and middle-aged adults within Group 4 were self-referred for assessment on a voluntary basis due to sensorimotor-related concerns. Participants were drawn from a geographically diverse range of settings, including the capital city, large urban centers, small towns, and rural communities. A non-

random, purposive, stratified sampling strategy was employed to ensure representation of age- and neurological-status–relevant subgroups. Exclusion criteria included orthopedic, internal medical, and neurological conditions that could interfere with the examined functions, apart from dementia in Group 3. The aim of the sampling strategy was not population-level representativeness, but rather comparability across predefined developmental and clinical subgroups and reliable identification of relevant neurofunctional patterns.

Primitive reflex assessment protocol

In this study, we employed a standardized assessment protocol comprising 18 primitive and transitional reflexes. We developed our protocol based on an extensive international literature review and formalized it into a unified testing framework (3, 4, 16, 17, 19). For each reflex, the protocol specifies the participant's standardized starting position, the precise eliciting stimulus, and the expected reflexive motor response.

For participants aged 60 years and older, the starting position for five of the reflexes was modified to maximize safety and minimize physical risk. These adaptations affected only the initial posture; the eliciting stimulus and response criteria remained unchanged, thereby ensuring comparability across age groups. Specifically, positions that would typically require an all-fours posture on the floor were adapted to support hand placement on a table. Reflexes typically elicited in a supine position were instead elicited in a standing posture. Based on preliminary pilot testing, these posture modifications did not affect reflex elicitation or expression, supporting the functional equivalence of the adapted and standard protocols across age groups. The full protocol provides detailed operational definitions for all reflexes and scoring criteria and will be made available in the Supplementary Information at the time of publication. An overview of the reflexes assessed, including their standardized starting positions, eliciting stimuli, and whether elicitation was performed bilaterally, is provided in Table 1.

Table 1

Overview of the primitive and transitional reflexes included in the standardized assessment protocol. *The table summarizes the reflexes assessed, their standardized starting positions, the eliciting stimuli used, and whether the reflexes were elicited bilaterally. Age-specific adaptations are indicated for participants aged 60 years and older, where applicable.*

Reflex name	Starting position	Eliciting stimulus (brief)	Bilateral elicitation
Asymmetric Tonic Neck Reflex	Standing	Passive head rotation to one side	Yes
Hip-Lumbar Galant Reflex	Quadruped	Drawing a blunt object on one side along the spine	Yes
Hip-Lumbar Galant Reflex 60+	Standing, leaning forward	Drawing a blunt object on one side along the spine	Yes
Symmetric Tonic Neck Reflex	Quadruped	Passive head flexion and extension	Yes
Symmetric Tonic Neck Reflex 60+	Sitting	Passive head flexion and extension	Yes
Tonic Labyrinthine Reflex Forward	Supine	Change in head position relative to gravity	Yes
Tonic Labyrinthine Reflex Forward 60+	Sitting	Change in head position relative to gravity	Yes
Tonic Labyrinthine Reflex Backward	Prone	Change in head position relative to gravity	Yes
Tonic Labyrinthine Reflex Backward 60+	Sitting	Change in head position relative to gravity	Yes
Moro Reflex	Standing	Sudden controlled head drop	Yes
Moro Reflex 60+	Sitting	Sudden controlled head drop, tilting	Yes
Parachute Reflex	Standing	Bending forward with a swinging movement	No
Palmar Grasp Reflex	Sitting	Pressure applied to the palm	Yes
Plantar Grasp Reflex	Sitting	Pressure applied to the plantar surface	Yes
Babinski Reflex	Sitting	Stroking the lateral plantar surface	Yes
Babkin Palmomental Reflex	Sitting	Firm bilateral palmar pressure, active finger movement	Yes
Rooting Reflex	Sitting	Tactile stimulation of the perioral region	Yes
Plantar Withdrawal Reflex	Sitting	Stroking along the outer edge of the sole	Yes

Reflex name	Starting position	Eliciting stimulus (brief)	Bilateral elicitation
Diving reflex	Supine	Using a cold, wet cloth to gently touch the area between the nose and the eyebrows	No
Fear Paralysis Reflex	Supine	Sudden unexpected noise stimulus	No
Snouting Reflex	Sitting	Lightly tapping or stroking the center of the upper lip, just below the nose	No
Glabellar Reflex	Sitting	Tapping the glabella	No
Perez Reflex	Quadruped	Drawing a blunt object on both sides along the spine	No
Perez Reflex 60+	Standing, leaning forward	Drawing a blunt object on both sides along the spine	No

Scoring procedure

Reflex responses were evaluated using a three-point ordinal scale: 2 = reflex fully elicitable, 1 = reflex partially elicitable, 0 = reflex not elicitable. A fourth category (score 3) was assigned exclusively when the reflex assessment could not be performed due to technical constraints or safety considerations. Scoring was performed in real time during testing, based on predefined, reflex-specific behavioral and postural criteria specified in the standardized protocol. All assessments were conducted in person. For inter-rater assessments, examiners independently evaluated reflex responses using identical scoring criteria and were blinded to each other's ratings and to any prior assessment data. For intra-rater assessments, the same examiner repeated the evaluation on the same participant at a later time point, applying the same standardized criteria and without access to their previous scores. If a response was ambiguous, the stimulus was repeated once, and the maximal observed response was recorded.

Examiner training and reliability

32 trained professionals conducted inter-rater and intra-rater reliability assessments. All examiners completed a 150-hour structured training program, including 50 hours dedicated explicitly to primitive reflex testing procedures and standardized response evaluation. Inter-rater reliability was assessed by having multiple examiners independently score the same participants. Intra-rater reliability was evaluated through repeated assessments of the same participant by the same examiner, with retest intervals ranging from 1 to 48 hours.

Testing environment

All assessments were conducted in a quiet, clean, and safe environment under standardized conditions. In residential eldercare facilities, assessments took place in designated exercise or physiotherapy rooms specifically adapted for movement-based testing. In educational settings, testing was conducted in school gymnasiums or designated medical rooms, while in clinical contexts, assessments were performed in outpatient clinics or medical examination rooms. Environmental conditions were kept within normal indoor ranges, with room temperature maintained at approximately 20–22°C and relative humidity at approximately 40–60%. Testing sessions for all age cohorts took place between 08:00 and 12:00 hours to minimize fatigue-related variability. Participants were given sufficient time to acclimatize to the environment prior to testing, and breaks were provided when necessary.

Study design

This study employed a cross-sectional, observational design to standardize and validate a lifespan-spanning protocol for assessing primitive reflexes.

Outcome measures

The primary outcome measures were ordinal reflex scores derived from standardized assessments of 18 primitive and transitional reflexes (Table 1; full protocol provided in the Supplementary Information Methods 1 and 2). Secondary outcome measures included inter-rater and intra-rater reliability metrics of the reflex scoring procedure.

Blinding

Blinding procedures differed across participant groups due to practical and ethical considerations. In the group of participants diagnosed with moderate dementia, examiners were necessarily aware of the participants' clinical status during testing. In all other participant groups, reflex testing and scoring were conducted under blind conditions, with examiners unaware of group assignment at the time of assessment. For children and adults presenting with sensorimotor-related concerns, examiners were not informed about the underlying etiology of these difficulties during testing.

Data analysis

We performed statistical analyses using IBM SPSS Statistics, version 30.0.²¹ Descriptive statistics, particularly frequency distributions, were first computed for each of the 18 primitive or transitional reflexes to assess the distribution of scores (0, 1, and 2) and the occurrence of the “cannot be examined” category (score 3). A total of 30 assessments were performed, as reflexes that could be evaluated bilaterally were scored separately for the right and left sides. Detailed assessment procedures are available in the Supplementary Information (Supplementary Methods 1 and 2).

To assess the reliability of the measurement protocol, inter-rater (N = 259) and intra-rater (N = 306) reliability were evaluated using Weighted Cohen's Kappa. This method was chosen to account for the ordinal nature of the reflex integration scale. Before the reliability analysis, observations scored as 3 ("cannot be examined") were treated as missing data to preserve the ordinal hierarchy (0–2) of the functional reflex states.

Missing values were handled using pairwise deletion; therefore, the exclusion of a non-examinable reflex for a given participant did not result in the listwise removal of that participant's entire data set. This approach maximized the retention of valid data points across the 30 individual reflex assessments. This approach ensured that the Kappa coefficients accurately reflected the degree of agreement regarding reflex inhibition. Point estimates for Kappa were interpreted according to the criteria of ²². The precision of these estimates was further validated by calculating 95% confidence intervals (CIs).

Prior to formal analysis, a rigorous quality control (QC) protocol was implemented to ensure data integrity. Initial screening included range checks to verify that all reflex scores fell within the predefined 0–3 scale, and no erroneous entries were identified. Data consistency was validated by cross-referencing participant IDs across the independent rater datasets.

A critical step in data preparation involved handling the "cannot be examined" category (score 3). These entries were identified and systematically coded as missing values for the reliability analysis to prevent the inflation of agreement due to non-clinical factors. Finally, frequency distributions were examined for each of the 18 reflex variables to ensure sufficient variance for the calculation of Cohen's Kappa, confirming that the high reliability coefficients were not artifacts of a restricted range of observations.

For the reliability analysis, no formal correction for multiple comparisons (such as Bonferroni) was applied to the Kappa coefficients. This approach was adopted because the primary objective was the point estimation of reliability for each of the 30 individual reflexes as independent measurement components, rather than hypothesis testing of a shared global null hypothesis. To address the potential for inflated error and to provide a more robust assessment than simple p-values, we reported 95% confidence intervals for all Kappa statistics. The fact that all lower bounds of these intervals remained significantly above the threshold for "almost perfect agreement" (Kappa > 0.81) further confirms that the observed reliability is not an artifact of multiple testing.

Primitive reflex assessment protocol

A standardized protocol for assessing primitive and transitional reflexes was employed to evaluate reflex integration across the lifespan. The protocol comprises 18 primitive and transitional reflexes, operationalized through 30 individual measurements, including 12 reflexes assessed bilaterally and 6 assessed centrally. The protocol was designed to enable quantitative, reproducible reflex profiling in children, adolescents, adults, and older individuals, including clinical populations. Participants were recruited across educational, community, workplace, and day-care settings to ensure representation of both neurotypical individuals and individuals with sensorimotor and/or cognitive difficulties.

Neurotypical children were recruited from mainstream kindergartens and primary schools. Individuals with sensorimotor difficulties were recruited through educational, community, and workplace settings. Older adults without a clinical diagnosis of dementia were recruited voluntarily from day-care services. Older adults with a clinical diagnosis of dementia were recruited from day-care facilities following referral and with informed consent obtained from their legal guardians.

Each reflex assessment followed a three-component standardized structure:

- (1) definition of a precise starting position,
- (2) application of a clearly specified eliciting stimulus, and
- (3) evaluation of the resulting motor or postural response using a predefined ordinal scoring system.

Starting positions included supine, prone, sitting, standing, quadruped, or supported postures, depending on the reflex assessed. Eliciting stimuli consisted of controlled passive head movements, tactile stimulation, pressure application, auditory stimuli, vestibular challenges, or postural perturbations, applied under standardized conditions. Observable response criteria were defined for each reflex to distinguish full, partial, or absent reflex expression.

Reflex responses were scored using a three-point ordinal scale:

2 = reflex fully elicitable,

1 = reflex partially elicitable,

0 = reflex inhibited (not elicitable).

Scoring was performed in real time during testing, based on predefined behavioral and postural criteria. If an initial response was ambiguous, the stimulus was repeated once, and the maximal observed response was recorded.

For participants aged 60 years and older, age-specific safety adaptations were implemented for five reflexes (Symmetrical Neck Tonic Reflex, Spinal Galant Reflex, Tonic Labyrinth Reflex Backward and Forward, Moro Reflex). These adaptations involved modification of the starting position only (e.g., from quadruped to supported sitting), while eliciting stimuli and response criteria remained unchanged, thereby preserving measurement equivalence across age groups.

A fourth category ("cannot be examined") was used exclusively when assessment was contraindicated or technically infeasible due to orthopedic limitations or safety considerations. These instances were documented but treated as missing data in subsequent analyses to preserve the ordinal structure of functional reflex states.

All assessments were conducted in a controlled, safe environment, with careful monitoring of participant comfort and stability. The protocol emphasizes natural, nonvolitional responses and explicitly instructs examiners to avoid cueing, anticipatory stabilization, or verbal prompting during stimulus application.

Complete operational definitions, reflex-specific stimulus parameters, scoring decision rules, and representative assessment examples are provided in the Supplementary Information (Supplementary Methods 1 and 2).

Safety considerations

Participant safety was prioritized throughout all testing procedures. No adverse events or safety incidents occurred during reflex assessments in any participant group. For child participants, parents or legal guardians provided written statements regarding the child's health status prior to assessment. For participants diagnosed with dementia or Alzheimer's disease, health status declarations were provided by caregivers or legal representatives responsible for the participant's care.

Data exclusion

No participants or datasets were excluded from analysis after data collection based on performance, compliance, or data quality.

Generalizability

The findings of this study are intended to inform the validity and reliability of a standardized assessment of primitive reflexes across developmental and aging populations, rather than to provide population-representative prevalence estimates.

Results

Detailed frequency distributions for the 30 individual reflex measurements, derived from assessments of 18 primitive and transitional reflexes, are presented in Tables 2 and 3. The total of 30 measurements reflects the bilateral assessment of reflexes, with left- and right-sided responses scored separately. The occurrence of the "cannot be examined" category (score 3) was minimal, indicating that the protocol could be reliably administered by assessors across the study population and that the rate of non-assessable measurements was low. The scores for the testable reflexes (0, 1, and 2) showed adequate variance across all variables, providing a robust basis for the subsequent reliability analysis. Due to space constraints, Tables 2 and 3 are provided in the Supplementary Information.

Intra-rater and Inter-rater Reliability

The reliability of the 18-reflex assessment protocol was exceptionally high across all dimensions. Owing to space constraints, the reliability statistics underlying Tables 4 and 5 are provided in the Supplementary Information.

Intra-rater reliability (N = 306) demonstrated superior consistency, with Kappa values ranging from 0.912 to 0.983. The lower bound of the 95% confidence interval (0.847) remained well above the 0.81 threshold for "almost perfect agreement".

Similarly, inter-rater reliability (N = 259), the weighted Kappa coefficients ranged from 0.912 to 1.000. Notably, even for the reflex with the lowest point estimate (Kappa = 0.985), the lower bound of the 95% confidence interval (0.972) remained well above the 0.81 threshold for "almost perfect agreement."

All calculated 95% CIs were narrow, indicating high precision in the reliability estimates. These results collectively confirm that the scoring system is highly reproducible and independent of the specific examiner or the timing of the assessment.

Discussion

In this study, we present the first lifespan-spanning, standardized, and quantitatively scored assessment protocol for primitive and transitional reflexes, validated for reliability in a large cohort ranging from early childhood to advanced old age. The exceptionally high intra- and inter-rater reliability observed across all reflexes (weighted Cohen's $\kappa > 0.91$) demonstrates that primitive reflexes, historically regarded as qualitative and examiner-dependent phenomena, can be operationalized as robust, reproducible outcome measures. This finding directly addresses a long-standing methodological limitation in the field, namely the absence of psychometrically validated tools capable of supporting systematic comparisons across studies, developmental stages, and clinical populations²³.

The high level of agreement between examiners and across repeated assessments indicates that the protocol is resilient to subjective interpretation and temporal variability. Notably, the narrow confidence intervals surrounding the reliability estimates further support the measurement system's statistical stability. Together, these results suggest that the proposed protocol provides a reliable foundation for reflex-based phenotyping in research and applied clinical settings, while future work will be required to establish diagnostic validity, including sensitivity and specificity, in clinically defined populations. This represents a substantive advance over previously proposed reflex assessment frameworks, which have largely lacked formal reliability testing and standardized scoring criteria, thereby limiting their scientific and translational utility¹¹. In validation studies, $\kappa = 1.000$ values are rare. In the present study, their occurrence is most likely attributable to the combined effects of extensive examiner training, the use of a three-point ordinal scale, and highly standardized operational definitions within the protocol.

Beyond its methodological contribution, the present work has implications for understanding neurodevelopmental and neurodegenerative processes. The persistence of primitive and transitional reflexes beyond early childhood is widely interpreted as an indicator of insufficient cortical inhibitory control²⁴. Neurophysiologically, this interpretation aligns with established models of brain maturation, in which the progressive emergence of effective GABAergic inhibition enables the suppression of brainstem-mediated motor patterns²⁵. Seminal work by Rivera and colleagues demonstrated that the

developmental upregulation of the K^+/Cl^- cotransporter KCC2 renders GABAergic transmission hyperpolarizing, a transition that is critical for functional cortical inhibition and network stabilization¹³. Disruptions to this process may therefore plausibly contribute to the persistence or re-emergence of primitive reflexes.

Consistent with this framework, previous studies have linked retained or persistent primitive reflexes to neurodevelopmental conditions characterized by altered inhibitory control, including attention-deficit/hyperactivity disorder⁹ and developmental coordination disorder²⁶. Importantly, our findings extend the relevance of reflex profiling beyond childhood by demonstrating the reliable and practical administration of standardized assessment in older adults, including individuals with moderate dementia. The reappearance of primitive reflexes in later life has traditionally been conceptualized as a “release phenomenon,” reflecting the breakdown of cortical control over subcortical motor circuits. The present protocol provides, for the first time, a quantitative tool capable of capturing such changes systematically across the lifespan²⁷.

The availability of a standardized, reliable reflex assessment opens several new avenues for future research. First, reflex profiles may serve as candidate behavioral biomarkers of inhibitory network integrity, complementing neuroimaging and electrophysiological measures⁵. Second, longitudinal application of the protocol could enable the monitoring of neurodevelopmental trajectories in at-risk populations, potentially facilitating earlier detection of atypical cortical maturation²⁸. Third, in aging and neurodegeneration, repeated reflex profiling may offer a low-cost, non-invasive means of tracking disease progression or treatment response, particularly in contexts where advanced imaging is impractical²⁹.

Limitations

Several limitations of the present study should be acknowledged. First, the cross-sectional, observational design precludes inferences regarding intra-individual developmental or degenerative trajectories of primitive reflex integration. Consequently, temporal stability, sensitivity to change, and causal relationships cannot be established. Longitudinal designs will be required to determine within-subject trajectories and to assess whether the protocol captures true developmental or pathological change over time.

Second, although the protocol demonstrated exceptionally high inter- and intra-rater reliability, the current validation primarily addressed measurement reproducibility rather than predictive, criterion, or construct validity. The extent to which reflex profiling predicts or relates to cognitive performance, functional outcomes, or neurobiological markers remains to be determined. Future longitudinal and multimodal studies integrating behavioral, neuroimaging, and neurochemical measures will be necessary to establish clinical and mechanistic relevance.

Third, the purposive, stratified sampling strategy, while appropriate for ensuring representation across relevant developmental and clinical subgroups, limits population-level generalizability. As a result, prevalence estimates and epidemiological inferences cannot be drawn from the present sample. Replication in population-based cohorts will be required to assess external validity.

Fourth, age-specific adaptations to starting positions were implemented for older participants to ensure safety and feasibility. Although pilot testing suggested functional equivalence across age groups, subtle biomechanical or postural influences on reflex expression cannot be entirely excluded and may have introduced systematic variance.

Fifth, reflex responses were scored using a three-point ordinal scale to maximize inter-rater reliability and standardized administration. While this approach supports consistent clinical implementation, it may limit sensitivity to subtle, fine-grained variations in reflex expression relative to instrumented, kinematic, or continuous measurement approaches.

Finally, complete examiner blinding to clinical status was not possible in participants with dementia. Although high reliability estimates suggest minimal systematic bias, the potential influence of contextual or expectancy effects cannot be fully excluded.

Conclusion

This study establishes the first psychometrically validated protocol for assessing primitive reflexes across the human lifespan, transforming reflex examination from qualitative clinical observation into a standardized quantitative measurement. The protocol demonstrates exceptional reproducibility (weighted $\kappa > 0.91$), supporting its use not only in research settings but also as a robust clinical assessment tool.

By enabling systematic profiling of primitive reflex patterns from early childhood through advanced age, including in individuals with neurodevelopmental and neurodegenerative conditions, this method provides a clinically actionable framework for identifying atypical sensorimotor and inhibitory control profiles. The availability of a standardized and reliable reflex assessment has direct implications for clinical screening, longitudinal monitoring, and treatment evaluation in disorders characterized by altered cortical inhibition, including developmental and dementing conditions.

Beyond its immediate clinical utility, this approach establishes a methodological foundation for integrative studies linking reflex persistence to cortical inhibitory control, functional outcomes, and underlying neurobiological mechanisms. By bridging developmental and degenerative neuroscience, this protocol facilitates future integration with neuroimaging, neurochemical, and behavioral biomarkers, thereby advancing both translational research and evidence-based clinical practice.

Significance statement

Primitive reflexes are fundamental indicators of early brain organization, yet they remain largely absent from contemporary quantitative neuroscience due to the lack of standardized, reliable assessment tools. Here, we introduce the first lifespan-spanning, quantitatively scored protocol for assessing primitive reflexes, validated for reliability from early childhood through advanced old age. By demonstrating exceptionally high intra- and inter-rater reliability across a large, heterogeneous cohort, this work establishes primitive reflex profiling as a reproducible, objective measurement framework.

The availability of a standardized reflex assessment enables systematic investigation of inhibitory network maturation, neurodevelopmental vulnerability, and age-related loss of cortical control. Beyond its research utility, this protocol has translational potential by transforming reflex examination from subjective bedside observation into a more objective and standardized measurement approach. This creates a foundation for future studies aimed at improving clinical screening, longitudinal monitoring, and treatment evaluation in neurodevelopmental and neurodegenerative disorders characterized by altered inhibitory control, contingent on further diagnostic validation.

More broadly, this protocol provides a foundation for incorporating primitive reflexes into biomarker-oriented research, longitudinal neurodevelopmental monitoring, and the study of neurodegenerative processes across the human lifespan. By bridging developmental and degenerative neuroscience with standardized measurement, this work advances mechanistic understanding and supports the future development of evidence-based clinical applications.

Declarations

Data Availability Statement

To promote transparency and reproducibility, all operational definitions, scoring criteria, and assessment procedures are included in the Supplementary Information. The authors are committed to making the protocol openly accessible for research use. De-identified datasets and analysis scripts are available from the corresponding author upon reasonable request.

Additional Information

This manuscript is not under consideration elsewhere and has not been previously published. No prior editorial discussions regarding this work have taken place with *Scientific Reports*.

Competing Interests statement

The authors declare no competing interests

Ethical approval

Ethical approval was granted by the Scientific Ethics Committee of Széchenyi István University (approval code: SZE/ETT-17/2025), and written informed consent was obtained from all participants or their legal guardians in accordance with the Declaration of Helsinki.

AI Usage

AI-based tools (ChatGPT 5.2, OpenAI) were used exclusively for language editing and stylistic refinement; the authors take full responsibility for the scientific content and integrity of the manuscript.

Funding statement

The author received no funding for this work.

Author Contributions

N.A.: Writing – review & editing.

Acknowledgements

We thank the colleagues who participated in the training program, acquired the standardized protocol for primitive reflex assessment, and conducted the testing. We are grateful to the students who assisted with data recording. We also thank Dr. Róbert Kányai for his valuable support in the statistical analysis of the data. Finally, we sincerely acknowledge the children and adults who volunteered to participate in the primitive reflex assessments.

References

1. Harjpal P, Kovala RK, Qureshi MI (2023) Promoting Survival and Primitive Reflexes to Prevent Brain Imbalance in Premature Infants: A Scoping Review of New Insights by Physiotherapists on Developmental Disorders. *Cureus* 15:e43757. 10.7759/cureus.43757
2. F., B. M. K. *Fejlődésneurológia*. (Medicia, (2014)
3. Fiorentino MR (1981) *Reflex Testing Methods for Evaluating C.N.S. Development*
4. Bod M (2019) in *Gyermek Neurológia* Ch. 4., 73–100Medicina
5. Gerry Leisman RM (2025) Evaluating Primitive Reflexes in Early Childhood as a Potential Biomarker for Developmental Disabilities. *J Paediatr Child Health* 61. <https://doi.org/10.1111/jpc.70053>
6. Altunkalem Seydi K et al (2024) The standard assessment of global everyday activities is a valid and reliable scale to assess both physical and cognitive functionality in Turkish older adults. *Appl Neuropsychol Adult* 1–7. 10.1080/23279095.2024.2420252

7. Bob P, Konicarova J, Raboch J (2021) Disinhibition of Primitive Reflexes in Attention Deficit and Hyperactivity Disorder: Insight Into Specific Mechanisms in Girls and Boys. *Front Psychiatry* 12:430685. 10.3389/fpsy.2021.430685
8. Gieysztor EZ, Choinska AM, Paprocka-Borowicz M (2018) Persistence of primitive reflexes and associated motor problems in healthy preschool children. *Arch Med Sci* 14:167–173. 10.5114/aoms.2016.60503
9. Meng Wang JY, Kim H-D (2023) Angelita Bautista Cruz Attention deficit hyperactivity disorder is associated with (a)symmetric tonic neck primitive reflexes: a systematic review and meta-analysis. *Frontiers Psychiatry* Jul 714:1175974. 10.3389/fpsy.2023.1175974
10. Pecuch A et al (2020) Primitive Reflex Activity in Relation to the Sensory Profile in Healthy Preschool Children. *Int J Environ Res Public Health* 17. 10.3390/ijerph17218210
11. Zafeiriou DI (2004) Primitive reflexes and postural reactions in the neurodevelopmental examination. *Pediatr Neurol* 31:1–8. 10.1016/j.pediatrneurol.2004.01.012
12. Zafeiriou DI, Pavlou E (2004) Images in clinical medicine. Hypoglossal-nerve palsy. *N Engl J Med* 350:e4. 10.1056/ENEJMicm020058
13. Rivera C et al (1999) The K⁺/Cl⁻ co-transporter KCC2 renders GABA hyperpolarizing during neuronal maturation. *Nature* 397:251–255. 10.1038/16697
14. Laliberte AM, Farah C, Steiner KR, Tariq O, Bui TV (2021) Changes in Sensorimotor Connectivity to dl3 Interneurons in Relation to the Postnatal Maturation of Grasping. *Front Neural Circuits* 15:768235. 10.3389/fncir.2021.768235
15. Masgutova S (ed) (2011) (ed MNRI Institute). Warsaw, Poland
16. Goddard Blythe S (2012) *Assessing Neuromotor Readiness for Learning*. Wiley-Blackwell
17. Wang M et al (2025) Development of the children's primitive reflex integration assessment scale. *Front Psychol* 16:1495990. 10.3389/fpsyg.2025.1495990
18. Jeff Sigafoos LR, Mark F, O'Reilly, Giulio E (2021) Lancioni Persistence of Primitive Reflexes in Developmental Disorders. *Curr Dev Disord Rep* 8:98–105. <https://doi.org/10.1007/s40474-021-00232-2>
19. al., B. e. The Masgutova Neurosensorimotor Reflex Integration (MNRI®): A Scoping Review. *Open J Occup Therapy* 10(4), 1–16, <https://doi.org/10.15453/2168-6408.1927> (2022)
20. al., H. e. Evaluation of neuromotor function in infancy – a systematic review of available assessment tools. *Dev Med Child Neurol* 29, 4 (2008)
21. IBM SPSS Statistics for Windows (2023) Version 30.0 v. Version 30.0. IBM Corporation, Armonk, NY
22. Landis JR, Koch GG (1977) The Measurement of Observer Agreement for Categorical Data. *Biometrics* 33:159–174. <https://www.jstor.org/stable/2529310>
23. Eric M, Chin AH, Peter A, Blasco ML, Leppert WA, Jennejahn (2025) Amy Jo Merchant Newmeyer, John Michael Falligant, Louis P. Hagopian. *Capute and Accardo's Neurodevelopmental Disabilities in Infancy and Childhood* Ch. Developmental testing for the physician. Pages. Academic, pp 125–174

24. Cainelli E, Vedovelli L, Bisiacchi P (2014) The mother–child interface: A neurobiological metamorphosis. *Neuroscience* Volume 561, 22 November, Pages 92–106.
<https://doi.org/10.1016/j.neuroscience.2024.10.027>
25. Melillo R, Gerry Leisman YM-F, Chinchilla-Acosta M (2023) Calixto Machado, Ty Melillo, Eli Carmeli
The Relationship between Retained Primitive Reflexes and Hemispheric Connectivity in Autism
Spectrum Disorders. *Brain Sci* 13:1147. <https://doi.org/10.3390/brainsci13081147>
26. Marinov E, Staneva TS (2015) Primitive Reflexes of Children with Developmental Coordination
Disorder. *Yale Rev Educ Sci* VI:616
27. Stephens-Sarlos E et al (2025) Relationship between primitive reflexes, functional fitness, handgrip
strength, and physical activity in older adults aged 65 and over. *Physiol Rep* 13:e70229.
[10.14814/phy2.70229](https://doi.org/10.14814/phy2.70229)
28. Hadders-Algra M (2021) Early Diagnostics and Early Intervention in Neurodevelopmental Disorders-
Age-Dependent Challenges and Opportunities. *J Clin Med* 10. [10.3390/jcm10040861](https://doi.org/10.3390/jcm10040861)
29. Matias-Guiu JA, Fernández-Matarrubia MNC-MM, Moreno-Ramos T, Valles-Salgado M, Porta-Etessam
J, Carreras JL, Matias-Guiu J (2015) Topography of primitive reflexes in dementia: an F-18
fluorodeoxyglucose positron emission tomography study. *Eur J Neurol* 22:1201–1207.
<https://doi.org/10.1111/ene.12726>Digital

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMethod1StandardizedPrimitiveReflexExaminationProtocolallagegroupsENPublic.pdf](#)
- [SupplementaryMethod2StandardizedPrimitiveReflexExaminationProtocol60ENPublic.pdf](#)