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Construct validation of a multidimensional measure of perceptual–motor integration in young children

Küçük çocuklarda algısal-motor entegrasyonun çok boyutlu bir ölçeğinin yapı geçerliği

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ABSTRACT

Aim: Perceptual and praxis skills are fundamental to adaptive functioning in early childhood. The aim of this study was to develop and examine the psychometric properties of the Perception and Praxis Scale (PPS), designed to assess sensory–motor integration across four domains: somatosensory, vestibular, visual, and motor planning.

Methods: Data were collected from parents of 496 typically developing children aged 2–6 years. Sample adequacy and factorability were confirmed using the Kaiser–Meyer–Olkin measure and Bartlett's test of sphericity. Construct validity was examined through exploratory factor analysis and confirmatory factor analysis. Reliability analyses included internal consistency, test–retest reliability, and item discrimination. Additional construct validity evidence was examined using composite reliability, average variance extracted, maximum shared variance, and heterotrait–monotrait ratios.

Results: EFA revealed a four-factor structure accounting for 59.8% of the total variance, with factor loadings ranging from .46 to .83. CFA supported this structure and demonstrated acceptable to good model fit ($\chi^2(1,028) = 2,210.20$, $\chi^2/df = 2.15$, CFI = .94, TLI = .93, RMSEA = .047, SRMR = .049). Internal consistency coefficients were high ($\alpha = .86–.95$; $\omega = .87–.95$), and four-week test–retest reliability was excellent (ICC = .89, 95% CI [.84–.93]). All items showed strong discriminative power between the upper and lower 27% groups ($p < .001$).

Conclusion: The PPS is a psychometrically robust instrument for assessing distinct yet related aspects of perceptual and praxis functioning, offering a culturally sensitive and time-efficient means to identify developmental differences and monitor progress in early childhood.

Keywords*:* child; motor skills; perception; psychomotor performance

ÖZ

***Amaç*:** Algı ve praksi becerileri, erken çocukluk döneminde uyum sağlayıcı işlevselliğin temel bileşenlerindendir. Bu çalışmanın amacı, somatosensoryal, vestibüler, görsel ve motor planlama alanlarını kapsayan Algı ve Praksi Ölçeği'nin (A&PÖ) geliştirilmesi ve psikometrik özelliklerinin incelenmesidir.

Yöntem: Çalışma verileri, 2–6 yaş aralığında tipik gelişim gösteren 496 çocuğun ebeveynlerinden elde edilmiştir. Örneklemin faktör analizine uygunluğu Kaiser–Meyer–Olkin ve Bartlett küresellik testi ile doğrulanmıştır. Ölçeğin yapı geçerliği açımlayıcı faktör analizi ve doğrulayıcı faktör analizi ile değerlendirilmiştir. Güvenirlik analizleri kapsamında iç tutarlılık, test–tekrar test güvenirliği ve madde ayırt ediciliği incelenmiştir. Ayrıca birleşim güvenirliği, ortalama açıklanan varyans, maksimum ortak varyans ve heterotrait–monotrait oranı hesaplanarak ek yapı geçerliği kanıtları elde edilmiştir.

Bulgular: AFA sonuçları, toplam varyansın %59.8'ini açıklayan dört faktörlü bir yapı ortaya koymuştur (faktör yükleri = .46–.83). DFA sonuçları bu yapıyı doğrulamış ve kabul edilebilir–iyi uyum indeksleri göstermiştir ($\chi^2(1,028) = 2,210.20$, $\chi^2/df = 2.15$, CFI = .94, TLI = .93, RMSEA = .047, SRMR = .049). Ölçeğin iç tutarlılığı yüksek bulunmuştur ($\alpha = .86–.95$; $\omega = .87–.95$) ve dört haftalık test–tekrar test güvenirliği mükemmel düzeydedir (ICC = .89, %95 GA [.84–.93]). Tüm maddeler üst ve alt %27'lik gruplar arasında anlamlı ayırt edicilik göstermiştir ($p < .001$).

Sonuçlar: PPS, algı ve praksi işlevlerini güvenilir ve geçerli biçimde değerlendiren, erken çocukluk dönemine uygun, kültürel olarak duyarlı ve uygulaması pratik bir ölçme aracıdır.

Anahtar kelimeler*:* algı; çocuk; motor beceriler; psikomotor performans

Introduction

Perception and praxis together form the foundation of purposeful action in early childhood, developing progressively as children learn to interpret sensory information and transform it into contextually appropriate movement (Ayres, 1972; Bundy & Lane, 2020). Within sensory integration theory, praxis is conceptualized as a higher-order process that involves ideation, motor planning, sequencing, and execution of novel actions, and it depends on the effective integration of sensory registration, discrimination, body scheme, and sensorimotor feedback (Ayres, 1972; Bundy & Lane, 2020; Schaaf & Mailloux, 2015). When this process functions efficiently, children typically demonstrate more coordinated play, postural control, and adaptive problem-solving abilities in daily routines (Case-Smith & O'Brien, 2015; Schaaf & Mailloux, 2015). Difficulties in perception or motor planning, however, may negatively affect participation, independence, and engagement in everyday occupations over time (Blank et al., 2019; Miller et al., 2007). Therefore, understanding perceptual–motor functioning during early childhood is important for both developmental assessment and clinical decision-making, because these skills represent core components of adaptive behavior and functional performance (Blank et al., 2019; Case-Smith & O'Brien, 2015).

Recent studies suggest that perceptual–motor functioning is not a unitary construct but reflects the integration of multiple

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sensory and motor systems. The somatosensory, vestibular, and visual systems develop through partly distinct but interacting pathways, contributing to body awareness, postural control, spatial orientation, balance, and coordinated action (Bundy & Lane, 2020; Ferri et al., 2017; Schaaf & Mailloux, 2015). This interaction is particularly relevant during early childhood, when sensorimotor experiences support the gradual organization of body schema, bilateral coordination, visual–motor control, and adaptive responses to environmental demands (Libertus & Violi, 2016; Wilson et al., 2017). As children mature, these sensory–motor processes become increasingly linked with broader cognitive and social functions, including imitation, action planning, and participation in play and self-care activities (Diamond, 2020).

Developmental neuroscience further indicates that parietal and frontal brain regions gradually become specialized for planning, imitation, and visuomotor control throughout childhood (Diamond, 2020; Moriguchi, 2022). Accordingly, praxis is now understood as a multidimensional process emerging from the interaction of sensory, motor, and cognitive systems rather than as a purely motor function (Buxbaum, 2017). This multidimensional perspective highlights the importance of assessing perceptual and praxis abilities across multiple domains instead of relying solely on isolated measures of motor performance (Blank et al., 2019).

Despite these theoretical advances, assessing perception and praxis in natural contexts remains challenging. Many standardized motor assessments provide valuable information about performance capacity, but they often depend on structured testing conditions, examiner observation, and task-specific motor output, which may limit their sensitivity to everyday functional behaviors (Blank et al., 2019; Case-Smith & O'Brien, 2015). Parent- and caregiver-report measures can provide complementary information by capturing how sensory–motor behaviors appear across home, school, and community routines (Dunn, 2001). However, existing instruments generally focus either on sensory processing patterns or on motor coordination difficulties, whereas relatively few tools examine sensory-based perceptual processes and praxis-related behaviors within a single multidimensional framework (Blank et al., 2019; Dunn, 2001). This limitation is especially important in preschool-aged children, because subtle perceptual–motor difficulties may appear first as everyday problems in postural organization, imitation, bilateral coordination, tool use, or movement planning rather than as clear deficits on formal motor tasks (Blank et al., 2019; Case-Smith & O'Brien, 2015).

New psychometric approaches provide opportunities to develop multidimensional instruments that integrate theoretical constructs with empirical evidence (Boateng et al., 2018; DeVellis & Thorpe, 2021). Current standards for measurement development emphasize the importance of defining the target construct clearly, generating theoretically grounded items, evaluating content validity, examining dimensionality, and reporting reliability and validity evidence transparently (Boateng et al., 2018; Mokkink et al., 2010; Terwee et al., 2007). Exploratory and confirmatory factor analyses are particularly useful when examining constructs that are conceptually related yet distinct, as is the case for perceptual–motor functioning (Costello & Osborne, 2005; Tabachnick & Fidell, 2019). Using these complementary methods allows scale development to remain consistent with theoretical models while ensuring that the resulting structure is supported by empirical data (Boateng et al., 2018; DeVellis & Thorpe, 2021). Reliability indicators, including internal consistency and test–retest stability, further establish whether a measure can be used confidently in both clinical and research settings (Koo & Li, 2016; Terwee et al., 2007).

Given the limited availability of multidimensional caregiver-report instruments that comprehensively assess perceptual and praxis functioning in early childhood, there is a need for a psychometrically sound measure that captures these abilities within everyday contexts. Such a measure may support early identification of perceptual–motor difficulties, guide intervention planning, and provide a practical method for monitoring developmental progress (Blank et al., 2019; Boateng et al., 2018; Mokkink et al., 2010).

With this in mind, the present study focused on developing and validating the Perception and Praxis Scale (PPS), a caregiver-report instrument designed to assess perceptual–motor functioning in everyday life. The scale was organized around four theoretically derived domains: somatosensory perception, vestibular perception, visual perception, and motor planning/praxis. Expert feedback was incorporated throughout item development, and the resulting structure was evaluated in a large sample of typically developing children. The primary aim of this study was to examine the construct validity and reliability of the PPS and to determine whether the proposed multidimensional structure adequately represents perceptual–motor functioning in early childhood.

Methods

Research design

This study used a cross-sectional design to develop and validate the PPS, a caregiver-report scale designed to assess sensory–motor perception and praxis in young children. The development process followed established recommendations for scale development and validation (Boateng et al., 2018; DeVellis & Thorpe, 2021). The study was conducted in three sequential phases: (1) item generation and content validation, (2) exploratory factor analysis (EFA), and (3) confirmatory factor analysis (CFA) and reliability testing. Item development was informed by theoretical models of sensory integration and expert feedback. The resulting item pool was subsequently evaluated using EFA to identify the underlying factor structure, followed by CFA and reliability analyses to examine construct validity and measurement stability.

Participants

The sample included 496 caregivers of typically developing children between 2 and 6 years old ($M = 4.3$, $SD = 1.2$). Caregivers were recruited from preschools and pediatric therapy centers in Istanbul and nearby districts between May and October 2025. Inclusion criteria required children to be within the target age range and have no known neurological, developmental, or sensory diagnosis. Of the children, 51.4% were boys and 48.6% were girls.

For psychometric analyses, the total sample was randomly divided into two equal groups: an EFA subsample ($n = 248$) and a CFA subsample ($n = 248$). This division is consistent with commonly recommended participant-to-item ratios for factor analysis (Costello & Osborne, 2005).

To evaluate temporal stability, a test–retest subsample of 80 caregivers from the main study sample completed the PPS a second time after a four-week interval. This procedure was performed to assess score stability over time and followed commonly accepted recommendations for reliability studies (Koo & Li, 2016).

Instrument development

Item generation and refinement

The first version of the PPS was based on sensory-integration frameworks describing how somatosensory, vestibular, and visual inputs contribute to motor planning and action (Ayres, 1972; Bundy & Lane, 2020). Using evidence from the literature, clinical observations, and feedback from pediatric occupational therapists, an initial pool of 65 items was generated. These items were designed to represent four domains: Somatosensory Perception, Vestibular Perception, Visual Perception, and Motor Planning/Praxis.

Each item was written as an observable behavior that caregivers could identify during daily activities and play. Responses were rated using a five-point Likert scale (1 = Never, 5 = Always), with higher scores indicating greater perceptual–motor difficulty.

A group of seven experts, including occupational therapists, developmental psychologists, and psychometricians, reviewed the items for clarity, relevance, and content coverage. Item-level CVI values ranged from .80 to 1.00, while the scale-level CVI (S-CVI/Ave) was .93, exceeding recommended criteria (Polit & Beck, 2006). Items receiving lower ratings were revised, combined, or removed.

Following three rounds of expert review and a pilot study involving 50 caregivers, 18 items were removed because of redundancy, limited content relevance, or insufficient clarity. This process resulted in a preliminary 47-item version of the PPS. No additional items were removed during the EFA stage, as all retained items met the predefined retention criteria.

Procedure

After providing informed consent, caregivers completed the PPS in a quiet room within the preschool or clinical setting. Completion of the scale required approximately 15–20 minutes. For the test–retest analysis, the same caregivers completed the PPS again after a four-week interval under comparable conditions. All responses were anonymized, coded, and stored securely to protect participant confidentiality.

Data analysis

All analyses were conducted using SPSS version 29 and AMOS version 28. Prior to analysis, the dataset was screened for missing values, outliers, and distributional assumptions. Sample adequacy for factor analysis was evaluated using the Kaiser–Meyer–Olkin (KMO) statistic and Bartlett's test of sphericity (Tabachnick & Fidell, 2019).

The EFA was performed using Principal Axis Factoring with Promax rotation ($\kappa = 4$), given the expected correlations among latent factors. Factor retention decisions were based on eigenvalues greater than 1, scree plot inspection, and theoretical interpretability.

Items were retained if they demonstrated factor loadings of at least .40 and cross-loadings below .30. All 47 retained items satisfied these criteria and were therefore included in the final factor solution.

CFA was conducted on the second subsample using maximum-likelihood estimation to evaluate the proposed four-factor model. Model fit was assessed using χ^2/df, CFI, TLI, RMSEA (90% confidence interval), and SRMR according to established recommendations (Hu & Bentler, 1999).

Internal consistency was examined using Cronbach's α and McDonald's ω coefficients. Test–retest reliability was evaluated using ICC(2,1) with 95% confidence intervals (Koo & Li, 2016). The Standard Error of Measurement (SEM) and Minimal Detectable Change (MDC_{95}) were also calculated. Statistical significance was established at $p < .05$.

Ethical considerations

Ethics committee approval for this study was received from the Üsküdar University Non-Interventional Research Ethics Committee (Reference No: 61351342/020-811; approval letter dated January 31, 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Descriptive statistics

The analysis included data from 496 caregivers of typically developing children. The children had a mean age of 4.3 years (SD = 1.2), and the sample was almost evenly distributed by sex, with 51.4% boys and 48.6% girls. The PPS consisted of 47 items rated on a five-point Likert scale (1 = Never to 5 = Always), yielding a theoretical total score range from 47 to 235. In the present sample, observed total scores ranged from 58 to 229, with a mean of 146.7 (SD = 26.9). The skewness value of 0.21 and kurtosis value of −0.36 indicated an approximately normal distribution. Floor and ceiling effects were low, at 2.8% and 1.1%, respectively, both below the commonly accepted 15% threshold.

Table 1. Sample characteristics and descriptive statistics of the Perception and Praxis Scale

Variable	Statistic
Main sample	496 typically developing children
Age, years	4.3 ± 1.2
Sex	Boys: 51.4%; Girls: 48.6%
EFA subsample	n = 248
CFA subsample	n = 248
Test–retest subsample	n = 80
Test–retest subsample age, years	4.2 ± 1.1
Test–retest subsample sex	Boys: 52.5%; Girls: 47.5%
PPS total score, 47 items	146.7 ± 26.9
Theoretical / observed range	47–235 / 58–229
Skewness / kurtosis	0.21 / −0.36
Floor / ceiling effect	2.8% / 1.1%

Note. PPS = Perception and Praxis Scale; EFA = exploratory factor analysis; CFA = confirmatory factor analysis. Higher PPS scores indicate greater perceptual–motor difficulty. Floor and ceiling effects ≤ 15% were considered acceptable.

Exploratory factor analysis

The sample was suitable for factor analysis, as indicated by a Kaiser–Meyer–Olkin value of .93 and a significant Bartlett's test of sphericity, $\chi^2(1,081) = 7,984.62$, $p < .001$. Principal Axis Factoring with Promax rotation supported a four-factor structure consistent with the theoretical framework of the scale. The four factors were Somatosensory Perception, Vestibular Perception, Visual Perception, and Motor Planning/Praxis. Together, these factors explained 59.8% of the total variance.

Item-level factor loadings ranged from .46 to .83, and communalities ranged from .30 to .71. No item demonstrated a cross-loading above the predefined .30 criterion. Items with relatively lower primary loadings were retained because they exceeded the minimum retention criterion of .40, showed acceptable communalities and corrected item–total correlations, and represented theoretically important content within their respective domains. No additional items were removed during the EFA stage.

Table 2. Summary and representative item-level exploratory factor analysis results of the Perception and Praxis Scale (n=248)

Factor	No. of items	Representative item	Primary loading	Highest cross loading	h²	Corrected item–total r	Explained variance (%)
Somatosensory Perception	14	Difficulty discriminating tactile properties of objects	.79	.18	.67	.72	17.1
Somatosensory Perception	14	Difficulty applying appropriate force to objects	.72	.23	.55	.62	17.1
Somatosensory Perception	14	Difficulty identifying the location of bodily pain	.60	.27	.38	.49	17.1
Vestibular Perception	13	Difficulty using balance-related playground equipment	.80	.17	.69	.71	15.8
Vestibular Perception	13	Difficulty standing on one foot for five seconds	.76	.21	.60	.64	15.8
Vestibular Perception	13	Difficulty with coordination activities requiring bilateral use	.66	.28	.45	.52	15.8
Visual Perception	7	Difficulty finding toys on a visually complex surface	.83	.14	.71	.74	13.2
Visual Perception	7	Difficulty placing puzzle pieces correctly	.77	.18	.64	.68	13.2
Visual Perception	7	Difficulty identifying similarities and differences between visual stimuli	.65	.23	.46	.55	13.2
Motor Planning / Praxis	13	Difficulty initiating an activity	.78	.18	.65	.73	13.7
Motor Planning / Praxis	13	Difficulty imitating body, face, mouth, or hand movements	.74	.25	.55	.62	13.7
Motor Planning / Praxis	13	Difficulty performing self-care tasks requiring body planning	.70	.28	.48	.54	13.7
Total	47	—	.46–.83	< .30	.30–.71	.38–.74	59.8

Note. Extraction method = Principal Axis Factoring; rotation = Promax (κ = 4). h² = communality. Corrected item–total r values refer to item–total correlations within the relevant subscale. The table presents selected representative items from each factor to avoid an excessively long main-text table. All 47 items met the predefined retention criteria.

Instead of presenting all 47 items in the main text, Table 2 provides representative item-level examples from each subscale. To avoid an excessively long table, Table 2 presents representative item-level examples from each subscale while summarizing the full range of factor loadings, cross-loadings, communalities, and corrected item–total correlations for all retained items.

Confirmatory factor analysis

The four-factor structure identified in the EFA was tested in the second subsample (n = 248) using maximum-likelihood estimation. Because the final PPS version included 47 items, the CFA degrees of freedom were revised accordingly. The model demonstrated acceptable to good fit: $\chi^2(1{,}028) = 2{,}210.20$, $\chi^2/df = 2.15$, CFI = .94, TLI = .93, RMSEA = .047, 90% CI [.041, .054], and SRMR = .049. All standardized factor loadings were statistically significant ($p < .001$) and ranged from .47 to .81. Inter-factor correlations ranged from .42 to .63, supporting the interpretation that the four domains were related but distinct constructs.

Table 3. Fit Indices for the four-factor confirmatory model of the Perception and Praxis Scale (n = 248)

Fit index	Acceptable criterion	Observed value
χ²	—	2,210.20
df	—	1,028
χ²/df	< 5.00	2.15
CFI	≥ .90	.94
TLI	≥ .90	.93
RMSEA (90% CI)	≤ .08	.047 [.041, .054]
SRMR	≤ .08	.049

Note. CFA was conducted using maximum-likelihood estimation. CFI = Comparative Fit Index; TLI = Tucker–Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual.

Convergent and discriminant validity

Additional construct validity evidence was examined using composite reliability (CR), average variance extracted (AVE), maximum shared variance (MSV), the square root of AVE, and HTMT values. CR values ranged from .88 to .94, indicating adequate composite reliability across all factors. AVE values ranged from .50 to .53, supporting acceptable convergent validity. For each factor, the square root of AVE exceeded the highest inter-factor correlation, and MSV values were lower than AVE values. In addition, all HTMT values were below .85, supporting discriminant validity among the four PPS domains.

Table 4. Convergent and discriminant validity evidence for the four PPS factors

Factor	CR	AVE	MSV	√AVE	Highest inter-factor r	Highest HTMT
Somatosensory Perception	.93	.50	.40	.71	.63	.73
Vestibular Perception	.93	.52	.40	.72	.63	.73
Visual Perception	.88	.52	.29	.72	.54	.62
Motor Planning / Praxis	.94	.53	.36	.73	.60	.70

Note. CR = composite reliability; AVE = average variance extracted; MSV = maximum shared variance; HTMT = heterotrait–monotrait ratio. Discriminant validity was supported because AVE values exceeded MSV values, √AVE values exceeded the highest inter-factor correlations, and HTMT values were below .85.

Internal consistency and test–retest reliability

The PPS demonstrated high internal consistency across all subscales and the total scale. Cronbach's α values ranged from .86 to .95, and McDonald's ω values ranged from .87 to .95. Test–retest reliability over a four-week interval was strong across subscales, with ICC values ranging from .83 to .90. The total scale ICC was .89, 95% CI [.84, .93], indicating strong temporal stability. The SEM for the total scale was 5.2 points, and the MDC_{95} was 14.4 points.

Item discrimination

Independent-samples t-tests were conducted to compare the upper and lower 27% groups based on PPS total scores (n = 134 per group). All items significantly differentiated between the lower-scoring and upper-scoring groups after Bonferroni correction ($p < .001$). Item-level t values ranged from 6.2 to

Table 5. Internal consistency and test–retest reliability of the Perception and Praxis Scale

Subscale	No. of items	Cronbach's α	McDonald's ω	ICC (95% CI)	SEM	MDC_{95}
Somatosensory Perception	14	.91	.92	.88 [.82, .92]	2.9	8.0
Vestibular Perception	13	.88	.89	.87 [.81, .91]	3.1	8.6
Visual Perception	7	.86	.87	.83 [.76, .89]	2.7	7.5
Motor Planning / Praxis	13	.94	.95	.90 [.85, .93]	3.0	8.3
Total Scale	47	.95	.95	.89 [.84, .93]	5.2	14.4

Note. Internal consistency analyses were based on the full sample (N = 496). ICC values were calculated using the four-week test–retest subsample (n = 80). ICC = intraclass correlation coefficient; SEM = Standard Error of Measurement; MDC_{95} = Minimal Detectable Change at the 95% confidence level.

13.5, and Cohen's d values ranged from .76 to 1.65, indicating moderate to very large discrimination effects. The total PPS score also demonstrated a large discrimination effect, d = 1.34.

To avoid an excessively long main-text table, Table 6 presents representative item-level discrimination results from each subscale rather than all 47 items. The total-scale effect size is reported separately because it was calculated using PPS total scores rather than individual item scores.

Discussion

The present study aimed to develop and validate the PPS as a caregiver-report measure of sensory–motor integration in early childhood. The findings supported a four-factor structure consisting of somatosensory perception, vestibular perception, visual perception, and motor planning/praxis. These domains were related to one another but represented distinct components of perceptual–motor organization. Each domain reflects a different aspect of how children process sensory information and transform it into purposeful action. This multidimensional structure is consistent with sensory integration theory, which conceptualizes praxis as a distributed process involving sensory registration, sensory discrimination, body awareness, and movement sequencing (Ayres, 1972; Bundy & Lane, 2020). By operationalizing these constructs through observable daily behaviors, the PPS provides a caregiver-report framework that links theoretical models of sensory processing with functional performance in natural contexts.

The four-factor structure also supports the view that perception and motor planning develop through interacting but partially separable sensory–motor pathways during early childhood. Research in sensory integration indicates that tactile, proprioceptive, vestibular, and visual systems contribute differently to postural control, bilateral coordination, body awareness, and adaptive action (Miller et al., 2007; Schaaf & Mailloux, 2015). In this respect, the PPS factors appear conceptually coherent: somatosensory items reflect tactile discrimination, body awareness, and force modulation; vestibular items reflect balance, postural control, and movement-related stability; visual perception items reflect visual discrimination and visual organization; and motor planning/praxis items reflect activity initiation, imitation, sequencing, and body planning. This structure is compatible with developmental accounts suggesting that sensory–motor and visuomotor processes gradually become integrated with higher-level planning and body-schema functions across childhood (Diamond, 2020; Ferri et al., 2017; Moriguchi, 2022).

The factor loadings and item discrimination findings further support the internal structure of the PPS. Although a small number of items showed relatively lower but acceptable factor loadings, these items exceeded the predefined retention criterion and represented clinically meaningful aspects of perceptual–motor functioning. Retaining these items was therefore theoretically justified, particularly because early childhood behaviors may show natural variability across everyday contexts. The absence of problematic cross-loadings also suggests that the items were sufficiently aligned with their intended domains. Together, these findings indicate that the PPS does not merely group behaviors statistically but also reflects clinically interpretable dimensions of perception and praxis.

Additional construct validity evidence strengthened the interpretation of the four-factor model. The composite reliability, average variance extracted, and discriminant validity findings indicated that the PPS domains showed adequate internal coherence while remaining distinguishable from one another. This is important because perceptual–motor functioning is expected to involve related but non-identical processes.

Table 6. Representative item-level discrimination results of the PPS based on upper–lower 27% groups (n = 268)

Factor	Representative item	t	p	Cohen's d
Somatosensory Perception	Difficulty discriminating tactile properties of objects	6.2	< .001	.76
Somatosensory Perception	Difficulty applying appropriate force to objects	8.6	< .001	1.05
Somatosensory Perception	Difficulty identifying the location of bodily pain	11.0	< .001	1.34
Vestibular Perception	Difficulty using balance-related playground equipment	6.4	< .001	.78
Vestibular Perception	Difficulty standing on one foot for five seconds	8.9	< .001	1.09
Vestibular Perception	Difficulty with coordination activities requiring bilateral use	10.8	< .001	1.32
Visual Perception	Difficulty finding toys on a visually complex surface	7.0	< .001	.86
Visual Perception	Difficulty placing puzzle pieces correctly	8.1	< .001	.99
Visual Perception	Difficulty identifying similarities and differences between visual stimuli	9.9	< .001	1.21
Motor Planning / Praxis	Difficulty initiating an activity	6.3	< .001	.77
Motor Planning / Praxis	Difficulty imitating body, face, mouth, or hand movements	9.5	< .001	1.16
Motor Planning / Praxis	Difficulty performing self-care tasks requiring body planning	12.5	< .001	1.53
Total PPS score	Total scale score	11.0	< .001	1.34

Note. Upper and lower groups were formed using the upper and lower 27% of PPS total scores. Higher PPS scores indicate greater perceptual–motor difficulty. All p values remained significant after Bonferroni correction. Cohen's d values were calculated for independent groups. The total PPS score effect size is presented separately from item-level effect sizes.

If the domains were completely overlapping, the scale would provide limited multidimensional information. Conversely, if the domains were unrelated, the theoretical unity of perceptual–motor integration would be weakened. The present pattern therefore supports the PPS as a multidimensional measure in which the four domains contribute to a broader construct while preserving domain-specific meaning.

The test–retest results suggested that PPS scores remained stable over a four-week interval. This finding supports the temporal reliability of caregiver-reported perceptual–motor behaviors and indicates that the scale can provide consistent information over short follow-up periods. This result is consistent with developmental work suggesting that motor planning and adaptive action become increasingly organized during the preschool years (Libertus & Violi, 2016; Lobo & Galloway, 2013). However, the PPS should be interpreted as a measure of observable behavioral patterns rather than as a diagnostic instrument. Its value lies in supporting screening, clinical reasoning, intervention planning, and follow-up when used alongside other developmental and performance-based assessments.

The clear Motor Planning/Praxis factor highlights the cognitive component of movement. Praxis involves ideation, organization of action sequences, and execution of purposeful movement, processes that are associated with executive control and working memory (Diamond, 2020; Zelazo, 2015). The PPS captures this relationship by including caregiver-observable behaviors such as activity initiation, imitation, use of objects, multi-step task performance, and self-care actions requiring body planning. This supports embodied-cognition perspectives suggesting that cognitive control and adaptive behavior are closely linked to early sensorimotor experiences (Barsalou, 2020). Therefore, the motor planning/praxis domain may help clinicians identify children whose functional difficulties are not limited to motor output but also involve planning, sequencing, and adaptive use of sensory information.

From a clinical perspective, the PPS offers a practical caregiver-report option for evaluating perceptual and praxis-related behaviors in early childhood. Many performance-based tools require structured testing environments, trained examiners, and specific materials, which may limit their ability to capture how children function across daily routines (Case-Smith & O'Brien, 2015). Parent reports can provide complementary information from home, preschool, and community contexts, especially when items are concrete and behaviorally anchored (Dunn, 2001; Parham et al., 2011). In this context, the PPS should be considered a complementary assessment tool rather than a replacement for standardized motor or developmental tests. For children showing early signs of perceptual–motor difficulty, developmental coordination problems, or sensory processing differences, the PPS may help clinicians organize caregiver observations into theoretically meaningful domains (Blank et al., 2019).

Conceptually, the findings support the interpretation of sensory processing and praxis as components of a broader adaptive self-regulatory system. Sensory–motor organization is closely related to how children engage with their environment, participate in daily occupations, and regulate their actions in response to contextual demands (Beauchaine & Crowell, 2020; Perry et al., 2018). The present findings suggest that perceptual and praxis-related behaviors can be examined together within a coherent multidimensional structure. Future research may extend these findings by examining longitudinal stability, clinical cut-off values, sensitivity to intervention-related change, and cross-cultural measurement properties. Such work would further clarify how the PPS can be used to monitor perceptual–motor development and support clinical decision-making in early childhood.

Conclusion

This study suggests that the PPS is a practical caregiver-report measure for assessing perceptual–motor integration in early childhood. The four-factor structure provides evidence that somatosensory perception, vestibular perception, visual perception, and motor planning/praxis represent related but distinguishable components of early perceptual–motor functioning. The findings on construct validity, internal consistency, and test–retest reliability indicate that caregivers can provide meaningful information about children's sensory–motor behaviors in daily routines.

In clinical and educational settings, the PPS may be used as a complementary tool to organize caregiver observations and support the identification of perceptual–motor difficulties in young children. Its focus on observable behaviors may help translate theoretical constructs of sensory integration and praxis into clinically interpretable information. The scale should not be considered a replacement for standardized developmental or motor assessments; rather, it may provide additional context-based information about how children use sensory and motor abilities in everyday activities. Future studies should further examine the scale's clinical sensitivity, longitudinal stability, and applicability across different populations.

Ethics Committee Approval

Ethics committee approval was obtained from Non-Interventional Research Ethics Committee of Üsküdar University (Board Decision No: 2025-25/01) on January 28, 2025.

Informed Consent

Written informed consent was obtained from all caregivers prior to participation.

Peer-Review

Externally peer-reviewed.

Author Contributions

A.F.C.: Study Design, Data Collection, Data Analysis, Interpretation of Findings, Manuscript Drafting and Revision.

E.G.: Item Development Support, Expert Clinical Feedback, Critical Review, and Approval of the Final Manuscript.

Conflict of Interest

There is no conflict of interest.

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