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Evaluating the Interdependency of the PEAK Comprehensive Assessment as It Relates to Performance Estimation and Curricular Programming for Autistic Learners

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EVALUATING THE INTERDEPENDENCY OF THE PEAK COMPREHENSIVE ASSESSMENT AS IT RELATES TO PERFORMANCE ESTIMATION AND CURRICULAR PROGRAMMING FOR AUTISTIC LEARNERS

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Master of Science, Behavioral Analysis and Therapy

By

Julia Busam

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ABSTRACT

Assessments are widely used by behavior analysts throughout the field of Applied Behavior Analysis when determining curriculum and intervention for individuals with autism spectrum disorder (ASD). This thesis combines and discusses two collaborative manuscripts that revolve around the subject of one commonly used ABA assessment and curriculum. The PEAK Relational Training System (PEAK, Dixon 2014-2016) provides a wide-ranging assessment and training program that incorporates Skinnerian verbal operant learning and derived relational responding expressed in contemporary Relational Frame Theories (Hayes et al., 2001). The PEAK Comprehensive Assessment (PEAK-CA; Dixon, 2018) was developed to standardize and streamline assessments from all four PEAK modules (Direct Training, Generalization, Equivalence, Transformation) into a single direct assessment to provide an estimate of performance across each of these verbal and relational learning modalities. In the first chapter, 174 PEAK-CA scores were obtained from de-identified data from a prior approved study with participants receiving behavior analytic autism services and evaluated the interdependency of items using a principal component analysis (PCA). Results of the PCA revealed both a 2 and 3 factor model where items in the PEAK-CA were highly interdependent. These results support the interdependence of relational learning and verbal operant learning while generally supporting clustering of PEAK-CA items within and across modules that build in relational complexity allowing for shaping of language and cognitive skills within the curriculum. The second chapter aimed to determine underestimation in the PCA by identifying the total number of trial blocks until mastery in mastered PEAK programs from a de-identified data set from a previously approved study. 22 participants diagnosed with ASD were a part of this study along with 861 total mastered programs across all participants. Results showed an underestimation in the PCA in that majority of PEAK programs are mastered in the first trial block and decay in mastery over subsequent trial blocks.

KEYWORDS: principal component analysis, autism, PEAK, interdependence, mastery, PCA

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OVERVIEW

This thesis combines and discusses two collaborative manuscripts that revolve around the subject of one commonly used ABA assessment and curriculum, the PEAK Comprehensive Assessment (PEAK-CA) and the PEAK Relational Training System. The first manuscript submitted in this thesis by Belisle et.al (under review) in which I was an author evaluated the interdependency on each item of the PEAK-CA using a principal component analysis (PCA). The second manuscript submitted in this thesis by Busam et.al (under review) assessed the estimation of performance for autistic learners receiving ABA services based on scores achieved on the PEAK Comprehensive Assessment using a clinical record review. Together, both manuscripts aid in furthering research in the field of ABA to guide behavior analytic assessment and intervention programming for autistic learners.

Practitioners in the field of ABA use behavior analytic assessments frequently for a variety of reasons one importantly being creating intervention and curriculum for individuals. Commonly used assessments throughout the field include the Verbal Behavior Milestones Assessment and Placement and Program (VB-MAPP), Assessment of Basic Language Learning Skills (ABLLS), Vineland Adaptive Behavior Skills, and the Promoting Emergence of Advanced Knowledge Relational Training System (PEAK). PEAK is noticeably different than most assessments as it integrates both verbal behavior with language modules focused on relational frame theory rather than being exclusively based on Skinner's verbal behavior theory (Hayes et.al, 2001). The PEAK Comprehensive Assessment, developed by (Dixon, 2018), is a frequently used assessment as it assesses skills in verbal behavior and relational responding across five specific subtests. Due to the separate modules implemented throughout the assessment, interdependency can be analyzed to determine how an individual best learns the emergence of verbal operants and relational learning. Belisle et.al, (2018), details in a study the level of interdependence shown between the relational frame theories and the level of interdependence reported between relational learning and verbal operants may be occurring. With data supporting interdependency of verbal operants and relational learning in the PEAK Comprehensive Assessment (PEAK-CA) across modalities, practitioners in the field of behavior analysis have the ability to gain more knowledge on how to properly design intervention and curricular for individuals with autism spectrum disorder (ASD).

Another aspect aside from the interdependency of items on assessments used throughout the field of ABA, the estimation in performance on these assessment in autistic learners is not widely discussed. Two problems can occur when an individual's performance on an assessment is underestimated or overestimated. If performance is underestimated, delays in intervention can occur as the skills being targets may already be in the learner's repertoire. Overestimation in performance can lead to more extensive problems for a learner's curriculum as mastery may never be achieved if the prerequisite skills are not present. Individuals with autism spectrum disorder (ASD) may overestimate their abilities on academic tasks when compared to typically developing individuals in a study conducted by Furlano and Kelley (2020). On the other hand, Courchesne et.al (2015) found that autistic learners with minimal verbal language are underestimated due to their tasks on their assessment being narrow in scope and not assessing abilities that are strong in those who are minimally verbal.

Due to behavior analytic assessments being commonly used throughout the field of behavior analysis, these two manuscripts provide research and suggestions on ways to improve the way practitioners develop intervention and curriculum for autistic learners. By understanding how verbal behavior and relational learning is interdependent and occurring together as well as how to correctly estimate performance on assessments, behavior analysts will have knowledge on how to create the most effective interventions for individuals with autism spectrum disorder (ASD). Also important for the field of behavior analysis, is how practitioners can choose assessments and curriculums that best suit the needs and skill set of the learner based of the research provided throughout these two manuscripts. By including frameworks like interdependency and estimation of performance on behavior analytic assessments, the field of behavior analysis will be able to achieve more knowledge on the limitations of common assessments and curriculums for autistic learners.

MULTIDIMENIONAL EMERGENCE OF RELATIONAL LEARNING AND VERBAL BEHAVIOR IN AUTISTIC CHILDREN: PRINCIPAL COMPONENET ANALYSIS OF THE PEAK COMPREHENSIVE ASSESSMENT

According to the World Health Organization (WHO, 2022), 1 in 100 children are diagnosed with autism, and in the United States, 1 in 59 children 8 years old or younger are diagnosed with autism (Hodges et al., 2020). Autistic individuals[1] often need support in areas of social communication and interaction as well as restricted and repetitive behaviors. Applied Behavior Analysis (ABA) involves the application of behavior change principles to produce socially meaningful outcomes and approximately 80 percent of practicing behavior analysts in the United States work within autism services, either in special education or in medical care (Behavior Analysis Certification Board, 2024). Approaches within ABA services for autistic children vary considerably and broadly target adaptive behavior repertoires of daily living, communication, and self-management skills while addressing maladaptive behaviors that diminish quality of life like aggression or self-injurious behavior (Ivy & Schreck, 2016; Bahry et al., 2023). Given the influence of language and cognition on both adaptive and maladaptive behaviors, several assessments have emerged to evaluate language learning to develop curricular programming within ABA services such as the *Verbal Behavior Milestones Assessment and Placement Program* (VB-MAPP; Sundberg, 2008), *Assessment of Basic Language Learning Skills – Revised* (ABLLS-R; Partington, 2010), and the *Promoting the Emergence of Advanced Knowledge Relational Training System* (PEAK; Dixon 2014a, 2014b, 2015, 2016). Many assessments are based exclusively on verbal behavior theory (Skinner, 1957) while some

[1] We have chosen to use identity first language throughout the paper to respect the majority of autistic individuals' preference as described by Taboas et al. (2023).

assessments like PEAK integrate verbal behavior with more contemporary language learning modules rooted in relational frame theory (Hayes et al., 2001).

While these assessments are widely used by behavior analysts (Padilla, 2020), many have not empirically evaluated their validity, reliability, or efficacy when used to support autistic learners (Ackley et al., 2019; Padilla et al., 2023). Ackley et al. (2019) note that research on PEAK is comparatively extensive with several studies evaluating the validity and reliability of assessments contained within PEAK, the efficacy of PEAK programs based on verbal behavior theory and relational frame theory, and changes in intelligence test performance in autistic learners in early randomized control trial research (see Dixon et al., 2017, but also see Witts, 2018 and Beaujean & Farmer, 2021, along with responses by Belisle and Dixon, 2020 and Yi et al., 2021). PEAK as a comprehensive package contains four separate modules, including Direct Training (PEAK-DT; Dixon 2014a), Generalization (PEAK-G; Dixon, 2014b), Equivalence (PEAK-E, 2015), and Transformation (PEAK-T, 2016). Each module contains an assessment of 184 programs for a total of 736 programs in the comprehensive curriculum. A notable limitation is to directly test each item within 10-trial blocks would necessitate an assessment containing 7,360 trials, and as a result mixed methods of direct testing and indirect assessment of PEAK performances have been reported in the literature (e.g., Dixon et al., 2014). The PEAK Comprehensive Assessment (PEAK-CA; Dixon, 2018) was developed to provide a standardized and direct assessment of a representative sample of skills from PEAK to estimate performance for autistic learners to individualize curricular instruction across each of the four learning modalities. As a result, the PCA contains 64 PEAK-DT, 64 PEAK-G, 24 PEAK-E, and 192 PEAK-T items for a total of 344 total testing trials (representing 46.7 percent of total programs and 4.7 percent of trials needed to directly assess all programs in the curriculum).

The separate modules of the PEAK-CA may provide a unique opportunity to evaluate the interdependence and emergence of verbal operant and relational learning. PEAK-DT and PEAK-G were developed from verbal behavior theory focusing on the elementary and more advanced verbal operants (e.g., echoics, tacts, mands, metonymical tacts, audience control) and results on the full assessments are highly correlated with assessments like the VB-MAPP (Dixon et al., 2015) and ABLLS-R (Malkin et al., 2017) that extend from this same theoretical orientation. Within both assessments, earlier learning skills are described initially and increase in complexity as the assessment progresses allowing for shaping of verbal operant learning and generalization as a learner masters new and more complex programs. Both full assessments were evaluated using a principal component analysis (PCA) that revealed four factors representing increasing levels of complexity (Rowsey et al. 2015; Rowsey et al., 2017) and items in the PCA for these modules were sampled from these factors. PEAK-E and PEAK-T were developed from stimulus equivalence (Sidman, 1994) and relational frame theory (Hayes et al., 2001), respectively. Both modules also increase in complexity across four factors. In PEAK-E, the factors include reflexive, symmetrical, transitive, and equivalence responding and in PEAK-T the factors include non-arbitrary relational, culturally established arbitrary relational, simple arbitrary relational, and complex arbitrary relational responding. While PEAK-E includes only equivalence or coordinated relations, PEAK-T tests performance across each of six relational frame families, including coordination, distinction, opposition, comparison, hierarchy, and deictic relational responding.

By evaluating all four modules, the PEAK-CA takes a synthetic approach to verbal behavior theory and relational frame theory that is consistent with Barnes-Holmes et al.'s (2000) call for such an approach. Synthesizing relational framing and verbal operant learning is predicated on the assumption that both are interdependent learning processes. For example, Murphy et al. (2005) demonstrated the untrained emergence of derived manding across 3 autistic children. A growing literature on bidirectional naming and verbal development cusps are further revealing the interdependency of speaker and listener verbal behavior that includes programmed and incidental learning along a continuum (Sivaraman & Barnes-Holmes, 2023). Understanding the interplay between relational framing and verbal operant learning can be accomplished within a hyperdimensional and multilevel framework (HDML; Barnes-Holmes & Harte, 2022), where increasing complexity of relational responding may co-emerge with increasing complexity of verbal operant learning, resulting in coherent and flexible language and communication repertoires that are highly derived rather than directly trained. Using the same PCA strategy as Rowsey et al. (2015) and Rowsey et al. (2017), Belisle et al. (2022) evaluated the interdependency of items in the VB-MAPP across 85 participants and revealed not only a high level of interdependency across the verbal operants, but a factor structure that support clustering of items based on complexity and not their verbal operant category (i.e., interdependency within the verbal operants). Although interdependence between the relational frame families Is already assumed within the theory, data reported by Belisle et al. (2018) suggested interdependence between verbal operant and relational learning may be occurring. In their study, PEAK-DT score and PEAK-E scores were obtained for 64 participants along with measures of intelligence test performance. While correlations were evident for both modules an intelligence test performance, scores on the PEAK-E assessments mediated this relationship accounting entirely for the correlation between performance on PEAK-DT and on intelligence tests.

Applying a PCA to items in the PEAK-CA could provide a method of direct comparison of the interdependency of verbal operant and relational learning items across increasing levels of relational complexity. The PCA is a statistical analytic method that reduces variance within large datasets to produce factors of covarying items, where items that strongly load (i.e., factor loading) within the same factor are strongly related or may be indicative of the same construct. In construct measures like depression or anxiety inventories, divergence between separate factors can support the construct validity of a psychological inventory and is represented by low eigenvalues (e.g., eigenvalues less than 1.0) and separate components that account for a high percentage of the model variance. Conversely, when all items in an assessment are highly interdependent as may occur in an assessment like the PEAK-CA that synthesizes verbal operant and relational learning items, principal components may not be readily apparent in the data (e.g., eigenvalues greater than 1.0), while interdependent factors can be indicated using a scree plot and locating the point at which increases in explained variance are no longer apparent (i.e., an elbow is apparent in the plot). If results were to produce factors that ranged in complexity similar to outcomes reported in PCAs on PEAK-DT, PEAK-G, and the VB-MAPP, loading values could be plotted to provide a visual representation of the relationship between all items in the PEAK-CA, providing a preliminary visual depiction of the cross-sectional emergence of verbal operant and relational learning in a sample of autistic children.

Therefore, the purpose of the present study was to conduct an initial PCA on the PEAK-CA to evaluate the interdependency of each of the 344 items contained in the assessment using de-identified data from a previously approved study. Because interdependency of items is coherent with a synthetic approach to verbal behavior theory and relational frame theory, we did not anticipate the emergence of clear clusters or independent components, rather graphing the results of the PCA on a multidimensional scale equal to the number of factors could provide insight into the emergence of these repertoires in autistic learners receiving ABA services.

Importantly, given the sample size of the current study, results should be considered exploratory towards better understanding the multidimensional complexity of relational responding and the verbal operants to guide behavior analytic assessment and intervention programming.

Methods

Participants and Setting

PEAK-CA scores were obtained for 174 participants, including both males (n = 152) and females (n = 22) ranging in age from 1 to 16 years, with a mean age of 8.1 years and a standard deviation of 4.3 years. This study obtained de-identified data from a prior approved study and verification of approval for IRB-FY2019-576 is noted in Appendix A. In the sample, 50 participants also had a comorbid diagnosis (e.g., Down Syndrome, Generalized Anxiety Disorder, Attention Deficit Hyperactivity Disorder, Global Developmental Delay). All participants were receiving or seeking ABA services when PCA scores were collected due to medical necessity and scores used were the initial assessment prior-to undergoing PEAK curricular training. All PEAK-Cas were completed in ABA clinics or in participants' homes through an ABA service provider located in the Midwestern United States. All assessments were conducted in private rooms and attempts were made to minimize distractions by removing preferred objects that were not included in the assessment or utilized to reinforce completion of testing items. Rooms typically contained a table, two chairs, identified reinforcers, and the PEAK-CA testing kit. Assessments were conducted by Board-Certified Behavior Analysts or Registered Behavior Technicians who had completed the PEAK Level 1 Training and behavioral skills training implementing the assessment.

Along with completing the PCA, assessors also completed the *PEAK Autism Symptoms and Behavioral Observation Summary* (PAS-BOS) contained in the PCA. The PAS-BOS was completed by the assessor immediately after implementing the PEAK-CA and provides an estimate of the impact of maladaptive behaviors on social interactions, communication, and repetitive and restricted behavior observed during the session. Results for autism symptomology and severity are calculated by summing frequency and intensity totals for each section. The mean symptom severity frequency score was 16.3 (SD = 13.3) and the mean severity intensity score was 16.9 (SD = 12.7), indicating a moderate tier score for symptom severity. The mean challenging behavior frequency score was 4.6 (SD = 3.9) and the mean challenging behavior intensity score was 4.4 (SD = 3.9), also indicating a moderate tier score for symptom severity. Thus, scores on the PEAK-CA may have been moderately impacted by symptom severity and challenging behavior during assessment sessions.

Materials and Procedure

PEAK Comprehensive Assessment

Assessments were completed using the standardized PEAK-CA materials that included the client record booklet, the assessment book, and three books containing stimuli needed to administer the assessment items. The assessment consists of 344 items across four modules and each module contains 4 factors or levels of complexity. The PEAK-T module additionally contains a Receptive and Expressive subtest. The distribution of PEAK-CA items is shown in Table 1. In total, the PEAK-CA includes 5 subtests. Instructions for administering the assessment are described in the assessment book. For each item, the participant Is presented with an instruction and corresponding stimuli. When visual stimuli are needed, the stimuli are contained in the corresponding stimulus books. When auditory stimuli are needed, the stimulus book is removed from sight and the auditory stimulus is delivered vocally by the assessor. For the PEAK-DT and PEAK-G modules, all items are administered within a given level with no discontinuation criterion within the level. If a participant scores 0 on a level, then the subsequent level is not administered. For the PEAK-E module, all items contain one or multiple training trials to establish trained relations before testing for derived relations (e.g., train A is the same as B and test B is the same as A; Level 2 – Symmetry). In this test, a level is discontinued if 2 consecutive items are scored as 0. For the PEAK-T modules, training phases are implemented throughout the test (e.g., train A is bigger than B, then later train A is the same as C and B is the same as D, and test C is bigger than D and D is smaller than C; Level 2 and 3 – Comparison). In this test, a level is discontinued if 3 consecutive items are scored as 0. Scores are then summed to achieve a total score for each module or subtest and a PEAK-CA total score ranging from 0 to 344 as a raw score value. Scores can be adjusted by weight using the equations described in the administration manual.

Data Analysis

Data were analyzed using de-identified scores from all items on the PEAK-CA by conducting a PCA using Statistica Statistical software. Statistica is a software that both allows for advanced statistical analyses like the PCA and visual graphing along multiple dimensions (i.e., two- or three- dimensional representations of the data). To conduct the PCA, all scores across all participants were summarized as 0 (incorrect response on the PEAK-CA) or 1 (correct response on the PEAK-CA). Because the PEAK-CA contains 344 items and there were 174 participants in the study, the dataset for analysis contained 59,856 units of data. The analysis conducted was the Principal Components and Classification Analysis that produced factor loadings consistent with both a two-factor and three-factor model. The PCA was conducted through the correlation matrix rather than the covariance matrix. A scree plot was developed showing the variance accounted for by a N-factor model and eigenvalues for each model were summarized in the plot. The scree plot was then used to determine the number of factors (N) for a preliminary analysis of the interdependency of PEAK-CA items. To obtain a visual analysis of the cross-sectional emergence of the PEAK-CA items, factor loadings in the obtained N-factor model were used as dimensions (i.e., factor coordinates) in a multidimensional scale, where the proximity of each item to the other items represented the covariance of those items across N-factors in the graphical output. This visual display was then used to draw tentative conclusions about the cross-sectional emergence of these items relative to other items, across the obtained factor dimensions. Finally, to determine if the dimensions represented skill or item complexity, the factor coordinates were used as a predictor of item mastery within the sample and examined using a linear regression. Finally, the factor coordinates were used to create a multiplier to apply to PEAK programs across modules and levels to estimate the complexity of program targets that can be used by behavior analysts within ABA services.

Results

All results for this study obtained de-identified data from a prior approved study. The results of the PCA of the PEAK-CA are summarized in Figures 1 through 4 and in Table 2. Figure 1 shows the obtained scree plot. As can be seen in the figure, the percentage of variance accounted for by a one-factor model is 40.3 percent, by a two-factor model is 47.9 percent, and by a three-factor model is 50.8 percent. Visual analysis of the plot suggests that either a two-factor or three-factor model are most appropriate for analyzing the interdependency of these data. As can be seen in the plot, additional factors did not produce eigenvalues below 1.0 that is consistent with results when items in the assessment do not necessarily represent independent constructs (i.e., interdependency).

The factor loadings for both a two-factor and three-factor model are provided in the Supplementary File. In the outputs, the directionality of the factor loadings (either positive or negative) are relative to the computed construct that does not have a pre-specified direction, and therefore the directionality is arbitrary. When reviewing the items and their factor loadings in the two-factor model, the construct appeared to be opposite for both factors (i.e., more positive scores represented more complex or less simple items on the PEAK-CA for Factor 1 and represented more simple or less complex items on the PEAK-CA for Factor 2). To allow for an analysis where both factors represented item complexity rather than item simplicity, Factor 2 loadings were multiplied by negative 1 to invert this factor. When reviewing the items and their factor loadings in the three-factor model, Factor 2 appeared to progress in the opposite direction of Factors 1 and 3. Therefore, Factor 2 loadings were again multiplied by negative 1 to invert this factor. The factor loadings were then used to produce factor coordinates in a multidimensional figure, including a two-dimensional figures (two-factor model) and a three-dimensional figure (three-factor model) to observe the relationship between items in the PEAK-CA.

Figure 2 shows the resulting analysis of the de-identified clinical data on a two-dimensional model where each axis represents a dimension of skill or item complexity. Because Factor 2 items were transformed to represent complexity rather than simplicity, lower and negative numbers represent less complex items while higher and positive numbers represent more complex items. Therefore, when graphed in this way, items closer to the lower left corner of the figure are less complex and items in the upper right corner of the figure are more complex. To support visual analysis of the data, the different modules are represented by different colors corresponding to the PEAK materials (PEAK-DT, green; PEAK-G, red; PEAK-E, blue; PEAK-

T, yellow). The different levels that theoretically increase in complexity within each PEAK module are represented by different symbols (Level 1, circle; Level 2, square; Level 3, diamond; Level 4, triangle). When viewing the distribution of programs along Complexity Dimension 1 (left is less complex and right is more complex), items appear to increase in complexity approximately consistently with their corresponding levels, where Level 1 items are largely clustered to the left of the space and Level 4 items are largely clustered to the right of the space. The items appear to become more complex along a continuum rather than in discrete clusters. The distribution of items across the modules appears to be approximately evenly dispersed or intermixed along this dimension, supporting the interdependency of verbal operant and relational responding, where both may co-emerge within complex verbal repertoires. When viewing the distribution of programs along Complexity Dimension 2 (bottom is less complex and upper is more complex), items appear to increase in complexity along with the introduction of successive PEAK modules. PEAK-DT items are interspersed with PEAK-G items (primarily Level 1 and Level 2) at the bottom of the space. These items represent elementary verbal operants and generalization. PEAK-T and PEAK-E programs are interspersed with some more complex (Level 4) items from PEAK-G at the top of the space. These items represent arbitrary relational responses and the generalization of more advanced verbal operant abilities. When viewing both dimensions together, the least complex skills (bottom left) appear to be Level 1 PEAK-T programs that represent non-arbitrary relational responding, Level 1 PEAK-E programs that represent non-arbitrary reflexive responding, and Level 1 and 2 PEAK-DT programs that represent the elementary verbal operants. The most complex skills (upper right) appear to be exclusively on Level 4 PEAK-T programs that represent advanced arbitrarily applicable relational response repertoires.

Figure 3 shows the resulting analysis of the de-identified clinical data on 2 views of the three-dimensional model where each axis again represents a dimension of skill or item complexity. In both plots, items closer to the bottom left are less complex and items closer to the upper right are more complex. When viewing the three-dimensional space emphasizing Complexity Dimension 1, results again show the interspersion of items from each of the PEAK modules, where Level 1 items from multiple modules appear towards the left of the space and Level 4 items from the PEAK-T module appear towards the right of the space. Similarly, it appears to be the case that Level 1 PEAK-T items (non-arbitrary relational responding) may be the least complex items in a three-dimensional model that then incorporate Level 1 and 2 PEAK-DT items. PEAK-G and PEAK-E items appear interspersed throughout the space but also show a clear level sequence along Complexity Dimension 1. The introduction of Complexity Dimension 3 as a third dimension appears to create a distribution that resembles a funnel that could represent the expansion of verbal operant and relational behavior from singular dimensional complexity (i.e., items are equally complex along these dimensions) on the bottom left to multidimensional complexity (i.e., items are differentially complex along these dimensions) towards the upper right. Within multidimensional complexity, a skill or item can be both relatively complex along one or multiple dimensions and relatively simple along one or multiple dimensions. When viewing the three-dimensional space emphasizing Complexity Dimension 2, distribution based on the different PEAK modules is more evident, where PEAK-DT items appear towards the bottom left of the funnel, PEAK-T items appear towards the upper right of the funnel, and PEAK-G and PEAK-E items are distributed throughout the space. Again, the funnel suggests that verbal operant and relational responding may be a multidimensional phenomenon as the repertoire increases in complexity.

The dimensions were assumed to represent complexity because the loadings approximately mirrored the modules and level system of the PEAK-CA that is designed to pinpoint training targets that increase in complexity to shape verbal operant and relational learning. To determine if the estimated complexity was predictive of program mastery, we evaluated the relationship between the factor coordinates and the proportion of participants who demonstrated mastery of each item in the PEAK-CA (ranging from 0 to 1.0) in Figure 4. The dimensional complexity was determined by first averaging the factor coordinates across all of the dimensions (two-dimensions in the two-factor model and three-dimensions in the three-factor model), then centering the data to ensure dimensional complexity was positive for comparative purposes by adding 0.6 units to the two-factor dimensional complexity values (i.e., the lowest value was -0.58) and adding 0.4 units to the three-factor dimensional complexity values (i.e., the lowest value was -0.39). The figure shows only the two-factor model prediction as this produced a stronger fit in the linear regression with an R^2 value of 0.80 compared to a value of 0.46 for the three-factor model. The obtained R^2 value is representative of a strong and negative relationship between the estimated dimensional complexity of a PEAK-CA item and the proportion of participants who mastered the item. Based on the obtained linear regression question ([Proportion mastered = (-1.34 * dimensional complexity) + 0.71]), approximately 71 percent of participants from our sample would be expected to show mastery of a PEAK-CA item with dimensional complexity equal to 0 (i.e., the y-intercept). Increases in 0.1 unit of dimensional complexity is predictive of a 13 percent decrease in the proportion of participants who would be expected to show mastery of the item (Proportion mastered = 0.71 – 0.13).

Table 2 shows the mean dimensional complexity and mean proportion of item mastery across the modules and levels of the PEAK-CA. This analysis serves three primary functions.

First, an increase in dimensional complexity across levels within modules would support the item progression within the PEAK curriculum because the PEAK-CA items are a subset of items from the comprehensive curriculum. Correspondingly, these data would provide information about the relative complexity of each PEAK module compared to one another. Second, these values can provide information needed to estimate the time and resources necessary to program for targets from the PEAK curriculum (i.e., more complex programs will take more time for the same learner). Finally, the scores could be used as a multiplier to show therapeutic gains not only in the number of programs over time, but also the complexity of skills gained over time (i.e., multiply 1 mastered program by [1 + dimensional complexity unit]). As can be seen in the table, these values approximately correspond with the structure of PEAK and this is most pronounced in the PEAK levels, where the least average complexity is observed in the Level 1 programs and the greatest average complexity is observed in the Level 4 programs. The PEAK modules themselves also appear to increase in complexity, where the least average complexity is observed in the PEAK-DT module and the PEAK-E and PEAK-T modules are nearly equivalent with an average value of 0.35 and 0.34, respectively. These outcomes correspond with the visual analysis of the two-factor model where Complexity Dimension 1 appeared to covary along with levels of the PEAK-CA and Complexity Dimension 2 appeared to covary along with the modules of the PEAK-CA. Importantly, complexity is intermixed across the different modules, supporting the interdependency of these learning processes.

Discussion

The present study provided an initial evaluation of the PEAK-CA using the PCA as an analytic strategy to evaluate the interdependency of items contained in the assessment, that represent a subset of items from the PEAK comprehensive curriculum. Barnes-Holmes et al.

(2000) discussed the possible synthesis of Skinner's verbal behavior theory (1957) and more contemporary approaches rooted in relational frame theory (Hayes et al., 2001). PEAK represents such a synthesis by combining verbal operant training strategies in the PEAK-DT and PEAK-G modules with relational training strategies in the PEAK-E and PEAK-T modules. Although separated by module, a growing literature suggests that relational operants and verbal operants do not emerge independently, but rather emerge interdependently, each supporting the development of the other (e.g., Belisle et al., 2018; Rowsey et al., 2015; Rowsey et al., 2017). A high level of interdependency within PEAK-CA items was evident in the obtained results. Analysis of the de-identified data collected by the research team revealed the PCA was not able to clearly identify only a few factors that items could be cleanly sorted into, suggesting that there are not clear independent constructs measured within the PCA. This is unlike results reported by Rowsey et al. (2015) and Rowsey et al. (2017) evaluating items exclusively pulled from the full PEAK-DT and PEAK-G assessments respectively, where items clustered into four categories of increasing complexity that informed the level system in the PEAK-CA for these modules (Dixon, 2018). This is supported by visual analysis of the data represented in both the two-dimensional and three-dimensional spaces, where items appear to increase in complexity along a continuum, but not along only a single dimension. Metaphorically speaking, a uniform increase in complexity may appear more linear and less like an interconnected cloud that would produce clearer independent factors.

The HDML (Barnes-Holmes & Harte, 2022) provides a framework to discuss relational learning that is compatible with the synthetic approach used in PEAK and assessed in the PEAK-CA. The HDML describes different dimensions and levels of relational behavior but discusses the dynamic interaction between dimensions and levels. In the context of PEAK-CA items, the dimension of complexity may be most relevant, where complexity is defined as the number of different relations contained within a relational response. Increases in levels of relational complexity may be most obvious in the PEAK-E and PEAK-T modules, where levels scale from non-arbitrary relational and reflexive responses (Level 1 of the PEAK-CA), to symmetrical and mutually entailed culturally relevant relational responses (Level 2 of the PEAK-CA), to increasingly complex forms of combinatorial entailment and use of analogy and metaphor (Levels 3 and 4 of the PEAK-CA). One important finding is observed in the three-dimensional figure that creates a figure resembling a cone or funnel, where the tip of the cone is at the bottom left of the figure (lower complexity) and the expanded base of the cone is at the top right of the figure (greater complexity). What this implies is that for less complex items, the different complexity dimensions do not differentially influence the location of the item within the space. That is to say, these items are differentially complex along only a singular dimension. However, for more complex items, an item can be both relatively simple along one dimension and relatively complex along another dimension, suggesting a multidimensional complexity. With respect to the HDML, while "complexity" may be one dimension of relational behavior along with coherence, derivation, and flexibility, complexity itself may also be a multidimensional phenomenon.

The factors identified in the PCA are arbitrary and we defined the factors as dimensions of complexity when viewing the apparent correspondence between the distribution of items and the structure of PEAK. More accurately, these items are likely interrelated along multiple dimensions that include complexity, derivation, coherence, and flexibility; however, these differences cannot be ascertained from the current data, and the concept of relational complexity is likely the most useful for developing verbal operant and relational training programs that seek to increase the complexity of language and communication abilities for autistic learners. The strong correlation between the dimensional complexity values and the proportion of participants in the study who demonstrated mastery of each item supports this conceptualization of the factors, where greater complexity was predictive of fewer subjects mastering each item. While the obtained R^2 value was relatively high, visual analysis of the data show that PEAK-E and PEAK-T items show a more linear correspondence than PEAK-DT and PEAK-G items that are more scattered. This lack of clarity in these items can also be seen in the table showing mean dimensional complexity values across levels for each module, where PEAK-E and PEAK-T show a clear progression across levels, the same cannot be said for PEAK-DT and PEAK-G. This may be an artifact of the different theoretical orientations guiding each module. Relational frame theory is clear in its progression from simple forms of non-arbitrary relational responding, mutual entailment and combinatorial entailment, and more complex transformations of stimulus function. Each additional level requires and contains within it the level before it. Conversely, while the verbal operants have been roughly described as elementary and more advanced, what precisely makes some verbal operant behaviors more complex than others is not well known, resulting in the proliferation of explanations, such as bidirectional naming and verbal mediation that closely resemble relational frame theory accounts by emphasizing derived or emergent learning processes.

Nonetheless, these findings may be clinically useful when informing ABA services for autistic learners. First, items across the four PEAK-CA modules are highly interdependent. While practitioners may be tempted to introduce programming from only a single PEAK module, this could limit learning when skills targeted in all four modules support one another. It is not the case that each module is independent, nor should programming be independent. This is consistent with results reported by Dixon, Belisle, et al. (2021) showing that programming built exclusively from the PEAK-DT module, while effective in directly training target skills, will not lead to meaningful improvement in derived relational responding that only occurred with the introduction of the PEAK-E module. Dixon, Paliliunas, et al. (2021) also demonstrated in a randomized control trial that programming using only the PEAK-DT and PEAK-G modules did not lead to significant increases in intelligence test performance, whereas comprehensive programming including all four PEAK modules was effective in significantly increasing intelligence test performance. Second, differences in complexity can be estimated using the dimensional complexity values summarized in Table 1. These values can be used in a number of ways, including estimating resources for verbal operant and relational training, and using a multiplier to apply to mastered programs to show improvements in performance that go beyond simply the number of programs mastered. We elected to provide these numbers for each module and level as an average rather than for each individual item because programming should not be developed exclusively from the PEAK-CA. The PEAK-CA represents only a subset of items from PEAK that are grouped by module and level, and therefore the multiplier can be applied to all programs within these categories. It is important to note that PEAK-E and PEAK-T dimensional complexity estimates appear to be more strongly related to item mastery in the PEAK-CA than PEAK-DT and PEAK-G estimates; therefore, greater caution and clinical judgement may be needed when interpreting complexity for these verbal operant modules.

There are several limitations in the current study and results should be considered preliminary to inform future, more robust analyses. A first limitation concerns the sample size of the current study. While 174 participants are a relatively large sample in behavior analytic research, especially when recruiting results obtained with a specialized population (i.e., autistic children receiving behavior analytic services), a larger sample may be needed to identify stable and independent constructs using a PCA strategy. As noted by Witts (2018) in response to early research on the PEAK-DT full assessment, more participants are better in PCA research, and Osborne and Costello (2019, as cited in Witts, 2018) suggest a 10:1 participant to item ratio that would require 3,440 participants in a more robust analysis. Belisle and Dixon (2020) responded to this and other criticisms of PEAK and discussed the pragmatic utility of inductive research with smaller samples to inform larger analyses and provide early answers to important research questions. In this current study, given the high interdependency observed across items, a larger sample may alter the distribution but not the overall finding of interdependency and progression across dimensions of complexity, that are the primary findings discussed in the study. Furthermore, these results may actually challenge the construct validity of separating PEAK by modules (that are interdependent) and levels (that are continuous and not discrete). However, PEAK is a training program, and the PEAK-CA is an instrument to guide instructional programming, where the modules more so describe the underlying learning process and training strategy, and levels are used to sequence programs based on the available data and conceptual models underlying the development and refinement of PEAK. That is to say, the PEAK-CA overall (i.e., as a measure of a singular or multidimensional construct) may provide a valid and reliable assessment of verbal operant and relational abilities, while the separate modules and factor level are more relevant to client programming within ABA services.

A second limitation is that we did not obtain data on interrater agreement or interobserver reliability. PEAK-CA scores were obtained from clients seeking or receiving existing clinical services increasing the external validity of these findings, while obtaining and reporting agreement measures could increase the internal validity of the obtained results. A third limitation is that the sample included autistic learners and not neurotypical peers, so we cannot determine from these data alone if the same cross-sectional emergence of verbal operant and relational learning would be observed in a neurotypical sample. In this case, the results may be externally valid with respect to autistic children receiving ABA services but lack external validity when inferring verbal operant and relational learning processes in the general population. A final limitation is that the PEAK-CA only represents a sample of programs contained in the comprehensive PEAK curriculum and each of the skills are only tested on a single trial, reducing the certainty of any singular response. Therefore, how to best translate results from the PEAK-CA to the full PEAK assessment requires further empirical investigation beyond the initial conversion matrix provided in the PEAK-CA administration manual (Dixon, 2018).

Overall, more research is needed on the PEAK-CA as a stand-alone tool within a growing ecosystem of PEAK technologies. While the PEAK-CA was developed from the full PEAK-DT and PEAK-G assessments and their corresponding factor analyses and the PEAK-E and PEAK-T pre-assessments that were evaluated in prior research (e.g., Belisle et al., 2021), research on the PEAK-CA itself is less extensive. Sutton et al. (2022) found internal consistency across PEAK-CA subtests that are consistent with the interdependency observed in the present study. The authors also demonstrated convergent validity between the PEAK-CA and measures of intelligence test performance as well as a negative relationship with the Vineland Adaptive Behavior Scale – Second Edition. The study was conducted with 73 children with autism, where a larger sample could allow for a more robust analysis and more specific findings in terms of PEAK-CA items or subtests and performance on these socially valid outcome measures. Relatedly, a normative analysis of the PEAK-CA would allow for direct comparison of scores from children receiving ABA services to neurotypically developing peers of the same age. In this case, scores could be reported as performance deviation rather than as a total summed score that does not consider the age of the client or what is developmentally appropriate to target in intervention. The results from the present study could inform such an analysis using the dimensional complexity multiplier that would not only provide information about the number of items above or below normative performance, but also the complexity of those items, to provide a better estimate of resource allocation that has implications for clinical decision making and funding. Finally, with respect to the co-emergence of verbal operant and relational behavior, research could begin to include items from other related assessments to build a synthetic assessment framework to estimate performance across verbal and relational operants that assume interdependency and multidimensional complexity.

In summary, ABA services can be informed by a multitude of behavioral assessments that are driven by conceptually systematic behavior analytic theories. Relational frame theory can be synthesized with verbal behavior theory to create comprehensive assessments and inform intervention approaches for children with autism. The PEAK-CA is the first technology designed for this application that operates from both theories and has established early research supporting its validity and clinical utility. The results reported here show a vast interdependent field of verbal operant and relational responses that build from relative simplicity to multidimensional complexity, and this is especially true with the introduction of arbitrarily applicable relational learning contexts. With respect to the HDML as an organizing framework, complexity is a dimension that may itself be multidimensional, that speaks to the difficulty in developing and testing instruments like the PEAK-CA. In this regard, the data presented here have the potential to inform future research and the development of new technologies, while supporting current applications of PEAK and relational training with autistic children as part of comprehensive ABA services.

References

Ackley, M., Subramanian, J. W., Moore, J. W., Litten, S., Lundy, M. P., & Bishop, S. K. (2019). A review of language development protocols for individuals with autism. *Journal of Behavioral Education*, 28(1), 362-388. https://doi.org/10.1007/s10864-019-09327-8

Bahry, S., Gerhardt, P. F., Weiss, M. J., Leaf, J. B., Putnam, R. F., & Bondy, A. (2023). The ethics of actually helping people: Targeting skill acquisition goals that promote meaningful outcomes for individuals with autism spectrum disorder. *Behavior Analysis in Practice*, 16(3), 672-695. https://doi.org/10.1007/s40617-022-00757-x

Barnes-Holmes, D., Barnes-Holmes, Y., & Cullinan, V. (2000). Relational frame theory and Skinner's Verbal Behavior: A possible synthesis. *The Behavior Analyst*, 23(1), 69-84. https://doi.org/10.1007/BF03392000

Barnes-Holmes, D., & Harte, C. (2022). Relational frame theory 20 years on: The Odysseus voyage and beyond. *Journal of the Experimental Analysis of Behavior*, 117(2), 240-266. https://doi.org/10.1002/jeab.733

Beaujean, A. A., & Farmer, R. L. (2021). Conceptual and methodological concerns: A commentary on "randomized controlled trial evaluation of ABA content on IQ gains in children with autism". *Journal of Behavioral Education*, 30(1), 479-488. https://doi.org/10.1007/s10864-020-09408-z

Behavior Analysis Certification Board (2024). BACB certificant data. Retrieved from https://www.bacb.com/bacb-certificant-data/

Belisle, J., & Dixon, M. R. (2020). Rational skepticism: A scientific review of Witts'(2018) criticisms of the PEAK relational training system. *Journal of Applied Behavior Analysis*, 53(2), 620-634. https://doi.org/10.1002/jaba.654

Belisle, J., Dixon, M. R., Malkin, A., Hollie, J., & Stanley, C. R. (2022). Exploratory factor analysis of the VB-MAPP: Support for the interdependency of elementary verbal operants. *Journal of Behavioral Education*, 31(1), 503-523. https://doi.org/10.1007/s10864-020-09413-2

Belisle, J., Dixon, M. R., Munoz, B. E., & Fricke-Steuber, K. (2021). The convergent validity of the PEAK-E-PA and two common assessments of language development: The ABLLS-R and the TOLD 1: 4. *Journal of Behavioral Education*, 31(1), 699-717. https://doi.org/10.1007/s10864-020-09426-x

Belisle, J., Dixon, M. R., & Stanley, C. R. (2018). The mediating effects of derived relational responding on the relationship between verbal operant development and IQ. *Behavior Analysis in Practice*, 11(1), 411-416. https://doi.org/10.1007/s40617-018-0215-2

Dixon, M. R. (2014a). *PEAK Direct Training.* Emergent Press.

Dixon, M. R. (2014b). *PEAK Generalization.* Emergent Press.

Dixon, M. R. (2015). *PEAK Equivalence.* Emergent Press.

Dixon, M. R. (2016). *PEAK Transformation.* Emergent Press.

Dixon, M. R. (2018). *PEAK Comprehensive Assessment*. Emergent Press.

Dixon, M. R., Belisle, J., Hayes, S. C., Stanley, C. R., Blevins, A., Gutknecht, K. F., ... & Lucas, C. (2021). Evidence from children with autism that derived relational responding is a generalized operant. *Behavior Analysis in Practice*, 14(1), 295-323. https://doi.org/10.1007/s40617-020-00425-y

Dixon, M. R., Belisle, J., McKeel, A., Whiting, S., Speelman, R., Daar, J. H., & Rowsey, K. (2017). An internal and critical review of the PEAK relational training system for children with autism and related intellectual disabilities: 2014–2017. *The Behavior Analyst*, 40(1), 493-521. https://doi.org/10.1007/s40614-017-0119-4

Dixon, M. R., Belisle, J., Stanley, C., Rowsey, K., Daar, J. H., & Szekely, S. (2015). Toward a behavior analysis of complex language for children with autism: Evaluating the relationship between PEAK and the VB-MAPP. *Journal of Developmental and Physical Disabilities*, 27(1), 223-233. https://doi.org/10.1007/s10882-014-9410-4

Dixon, M. R., Belisle, J., Whiting, S. W., & Rowsey, K. E. (2014). Normative sample of the PEAK relational training system: Direct training module and subsequent comparisons to individuals with autism. *Research in Autism Spectrum Disorders*, 8(11), 1597-1606. https://doi.org/10.1016/j.rasd.2014.07.020

Dixon, M. R., Paliliunas, D., Barron, B. F., Schmick, A. M., & Stanley, C. R. (2021). Randomized controlled trial evaluation of ABA content on IQ gains in children with autism. *Journal of Behavioral Education*, 30(1), 455-477. https://doi.org/10.1007/s10864-019-09344-7

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. Kluwer, Academic/Plenum Publishers.

Hodges, H., Fealko, C., & Soares, N. (2020). Autism spectrum disorder: definition, epidemiology, causes, and clinical evaluation. *Translational pediatrics*, 9(Suppl 1), S55. Doi: 10.21037/tp.2019.09.09

Ivy, J. W., & Schreck, K. A. (2016). The efficacy of ABA for individuals with autism across the lifespan. *Current Developmental Disorders Reports*, 3(1), 57-66. https://doi.org/10.1007/s40474-016-0070-1

Malkin, A., Dixon, M. R., Speelman, R. C., & Luke, N. (2017). Evaluating the relationships between the PEAK relational training system–direct training module, assessment of basic language and learning skills–revised, and the Vineland adaptive behavior scales–II. *Journal of Developmental and Physical Disabilities*, 29(1), 341-351. https://doi.org/10.1007/s10882-016-9527-8

Murphy, C., Barnes-Holmes, D., & Barnes-Holmes, Y. (2005). Derived manding in children with autism: Synthesizing Skinner's verbal behavior with relational frame theory. *Journal of Applied Behavior Analysis*, 38(4), 445-462. https://doi.org/10.1901/jaba.2005.97-04

Osborne, J. W., & Costello, A. B. (2019). Sample size and subject to item ratio in principal components analysis. *Practical Assessment, Research, and Evaluation*, 9(1), 11.

Padilla, K. L. (2020). Global assessment use and practices in applied behavior analysis: Surveying the field. *Research in Autism Spectrum Disorders*, 79(1), 101676. https://doi.org/10.1016/j.rasd.2020.101676

Padilla, K. L., Weston, R., Morgan, G. B., Lively, P., & O'Guinn, N. (2023). Validity and reliability evidence for assessments based in applied behavior analysis: A systematic review. *Behavior Modification*, 47(1), 247-288. https://doi.org/10.1177/01454455221098151

Partington, J. W. (2010). *The Assessment of Basic Language and Learning Skills-Revised.* Pleasant Hill: Behavior Analysts, Inc.

Rowsey, K. E., Belisle, J., & Dixon, M. R. (2015). Principal component analysis of the PEAK relational training system. *Journal of Developmental and Physical Disabilities*, 27(1), 15-23. https://doi.org/10.1007/s10882-014-9398-9

Rowsey, K. E., Belisle, J., Stanley, C. R., Daar, J. H., & Dixon, M. R. (2017). Principal component analysis of the PEAK generalization module. *Journal of Developmental and Physical Disabilities*, 29(1), 489-501. https://doi.org/10.1007/s10882-017-9539-z

Skinner, B. E. (1957). *Verbal behavior*. Appleton-Century-Crofts.

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Authors Cooperative.

Sivaraman, M., & Barnes-Holmes, D. (2023). Naming: What do we know so far? A systematic review. *Perspectives on Behavior Science*, 46(3), 585-615. https://doi.org/10.1007/s40614-023-00374-1

Sundberg, M. L. (2008). VB-MAPP Verbal Behavior Milestones Assessment and Placement Program: A language and social skills assessment program for children with autism or other developmental disabilities. Mark Sundberg.

Sutton, A., Pikula, A., Yi, Z., & Dixon, M. R. (2022). Evaluating the convergent validity of the PEAK Comprehensive Assessment (PCA): Intelligence, behavior challenges, and autism symptom severity. *Journal of Developmental and Physical Disabilities*, 34(1), 549-570. https://doi.org/10.1007/s10882-021-09814-9

Taboas, A., Doepke, K., & Zimmerman, C. (2023). Preferences for identity-first versus person-first language in a US sample of autism stakeholders. *Autism*, 27(2), 565-570. https://doi.org/10.1177/1362361322113084

Witts, B. N. (2018). An external review of the conclusions regarding the peak direct training module. *Journal of Applied Behavior Analysis*, 51(3), 719-737. https://doi.org/10.1002/jaba.491

World Health Organization (WHO) (2022). Autism. Retrieved from https://www.who.int/news-room/questions-and-answers/item/autism-spectrum-disorders-(asd)

Yi, Z., Schreiber, J. B., Paliliunas, D., Barron, B. F., & Dixon, M. R. (2021). P<. 05 is in the eye of the beholder: A response to Beaujean and Farmer (2020). *Journal of Behavioral Education*, 30(3), 489-511. https://doi.org/10.1007/s10864-021-09435-4

Tables

Table 1. Distribution of PEAK-CA items across the four PEAK modules (including PEAK-T Receptive and Expressive subtests) and four factors for each module. Levels increase in complexity, ranging from Level 1 (least difficult) to Level 4 (most difficult).

Module	Level 1	Level 2	Level 3	Level 4	Total
PEAK-DT	16	16	16	16	64
PEAK-G	16	16	16	16	64
PEAK-E	6	6	6	6	24
PEAK-T Rec	24	24	24	24	96
PEAK-R Exp	24	24	24	24	96
Total	86	86	86	86	344

Table 2. Mean dimensional complexity for each PEAK-CA module and level using the factor coordinates obtained from the two-factor model.

Module	Level 1	Level 2	Level 3	Level 4	Average
PEAK-DT	0.15	0.11	0.16	0.23	0.16
PEAK-G	0.12	0.27	0.24	0.30	0.23
PEAK-E	0.12	0.31	0.40	0.39	0.35
PEAK-T	0.21	0.27	0.39	0.48	0.34
Average	0.15	0.24	0.30	0.35	0.26

Figures

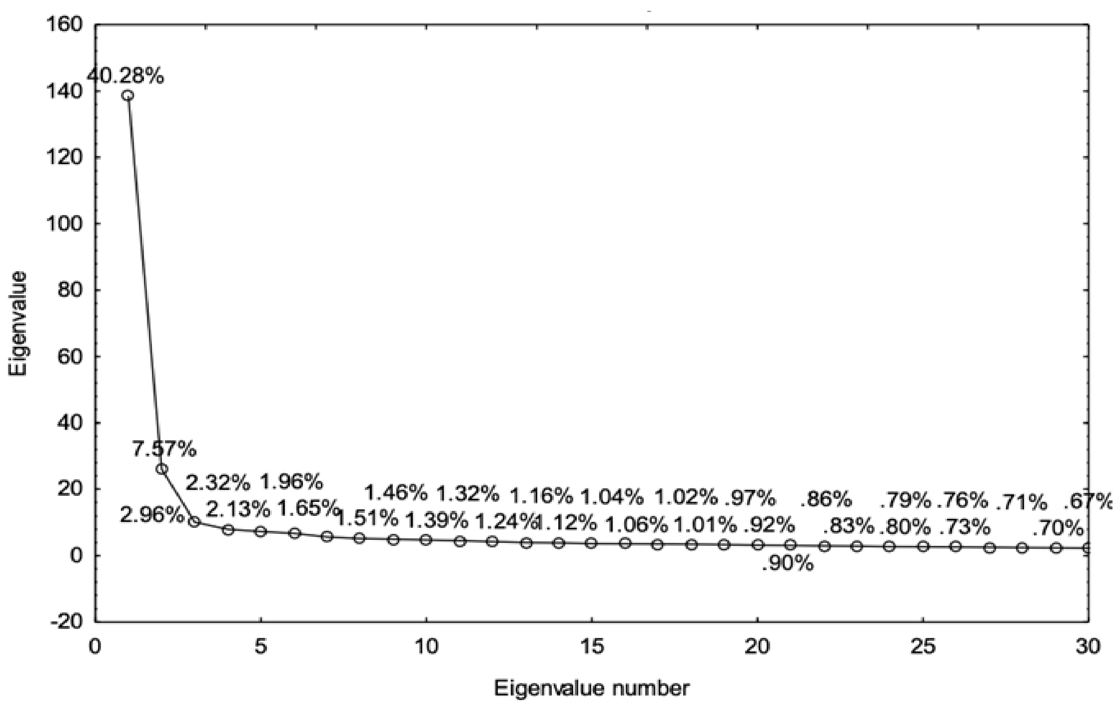

Figure 1. Scree plot based on a principal component analysis of the PEAK Comprehensive Assessment

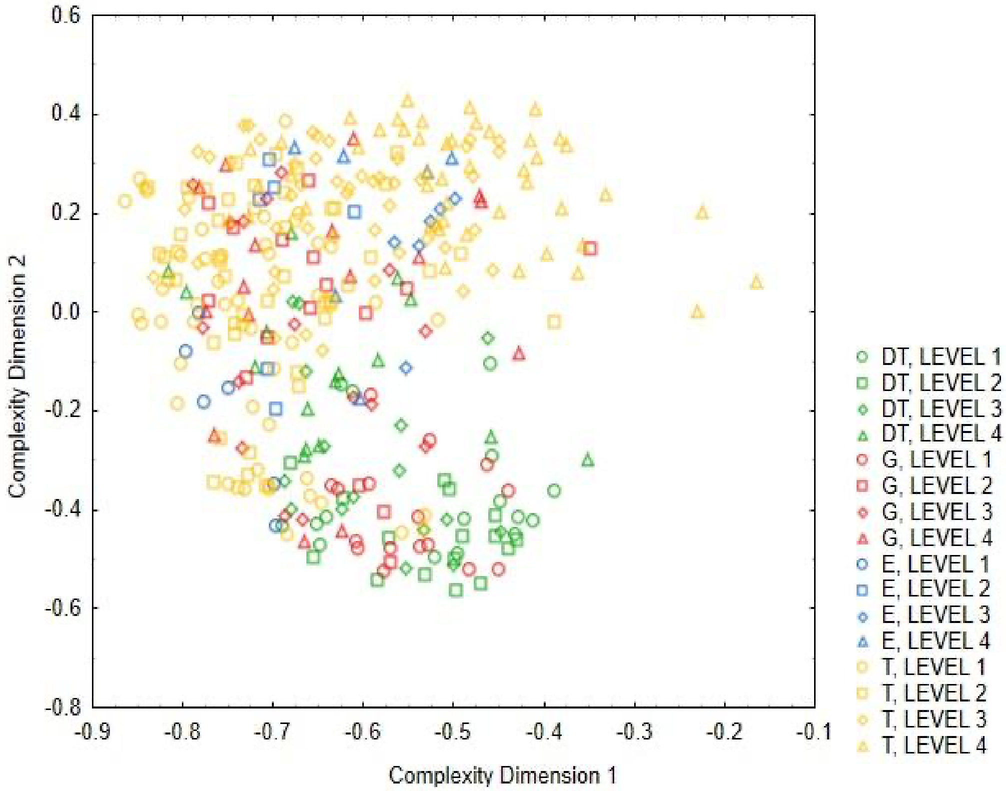

Figure 2. Two-dimensional plot of factor coordinates in the two-factor principal component analysis of the PEAK Comprehensive Assessment.

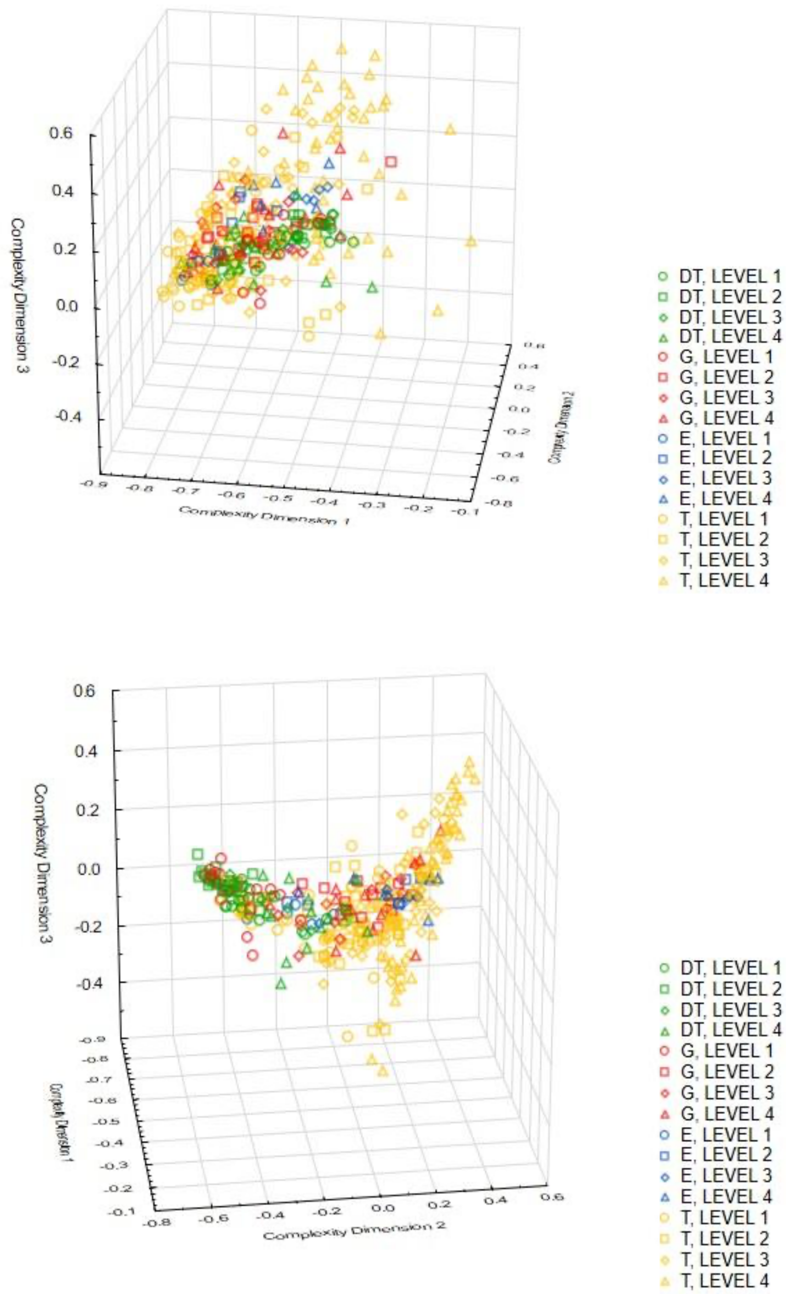

Figure 3. Three-dimensional plot of factor coordinates in the three-factor principal component analysis of the PEAK Comprehensive Assessment. The upper plot emphasizes Complexity Dimension 2 and the lower plot emphasizes Complexity Dimension 3. Both plots are the same factor coordinates viewed from different angles.

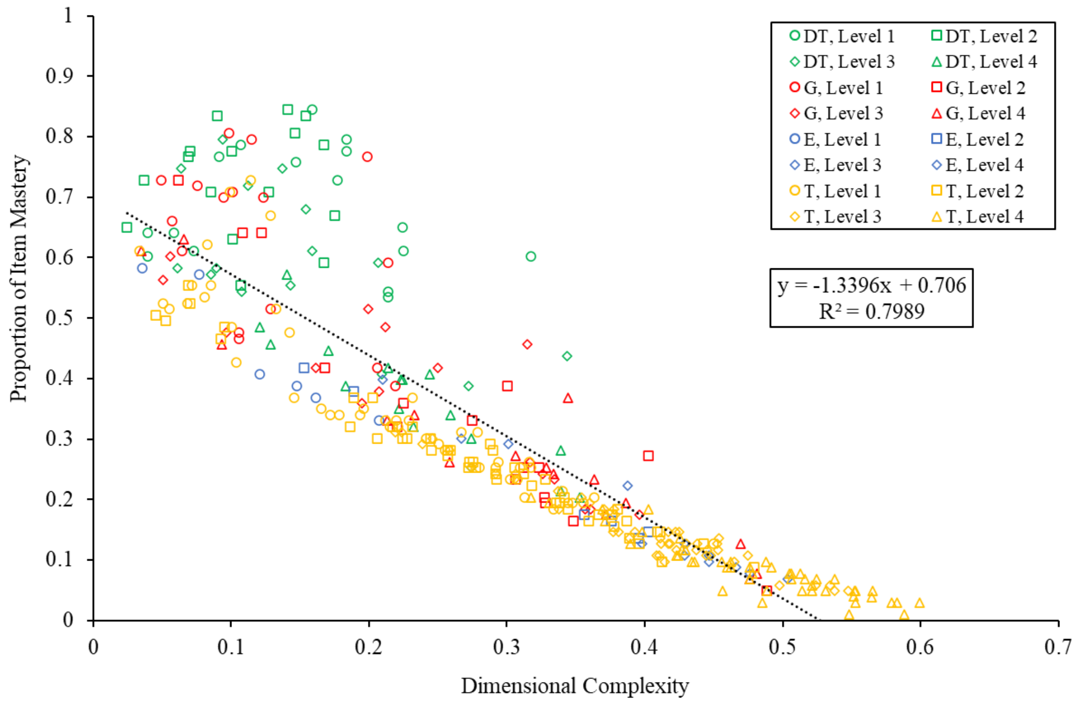

Figure 4. Scatterplot representing the relationship between average dimensional complexity for each PEAK-CA item and the proportion of participants who demonstrated mastery of the item. A Linear regression was fit to the data.

PERFORMANCE ESTIMATION AND CURRICULAR PROGRAMMING FOR AUTISTIC LEARNERS USING THE PEAK COMPREHENSIVE ASSESSMENT

Individuals with autism spectrum disorder (ASD), a neurodevelopmental disorder, often need support in areas of social communication as well as social interaction, involvement in daily activities, and restricted and repetitive behaviors, interests or activities (Maenner et.al, 2023). According to the World Health Organization (WHO) the international prevalence of autism spectrum disorder (ASD) is estimated at 0.76% with 1 in 59 children eight years or younger diagnosed with ASD (Hodges et.al, 2020). Autism spectrum disorder (ASD) is pervasive and can possibly affect a variety or all areas of a child's development in which behavior analytic services often seek to improve adaptive behavior repertoires that has resulted in the development of multiple assessments that are used to guide curricular programming (Padilla et.al, 2023). Commonly used assessments in the field of ABA include the Verbal Behavior Milestones Assessment and Placement and Program (VB-MAPP), Assessment of Basic Language Learning Skills (ABLLS), Vineland Adaptive Behavior Skills, and the Promoting Emergence of Advanced Knowledge Relational Training System (PEAK; Dixon 2014a, 2014b, 2015, 2016). The PEAK Comprehensive Assessment (PCA) has extensive research on the reliability and validity of the assessment and the psychometrics of the instrument (Padilla et.al, 2020). Ackley et al. (2019) also displays findings that PEAK has several studies that support the reliability and validity of the assessment with high inter-observer validity, high convergent validity, and effective programming shown throughout a randomized control trial. The PEAK Comprehensive Assessment (PCA) assess a variety of skills across five subtests and is directly linked to the PEAK curriculum in which targets can be developed for intervention in detailed step by step instructions based off specific skills missed on the assessment (Dixon, 2019). Sutton et.al (2022) points out that the PCA allows practitioners to reliably assess the language and cognition skill of the learner as well as sufficient convergent validity with many established instruments. The PEAK Comprehensive Assessment (PCA) has shown to be an effective tool when allowing practitioners to pinpoint specific targets and skills for individuals with ASD when determining how to proceed with intervention. Practitioners can interpret results from the PCA to understand the overall skill level of an individual as well as identifying the strengths and weaknesses of a learner in a less time-consuming manner (Sutton et.al, 2022). The PEAK curriculum derived from the PEAK assessment to aid in the production of intervention has shown to have effective results across a variety of skills and goals created for individuals with ASD. May and St. Cyr (2021) evaluated the PEAK curriculum on standardized measures of intelligence in which results displayed those participants in the PEAK intervention group showed increases in IQ scores versus participants in the control group who did not receive PEAK intervention. This shows that prior research conducted on the PEAK curriculum along with the PEAK assessment display a positive impact on the assessment and intervention of skills of learners.

When conducting assessments, one aspect that is not widely discussed is how these assessments can underestimate the performance of autistic learners. Underestimation in performance on assessments can be due to a variety of reasons, such as communication deficits, fatigue, lack of reinforcement, or the prevalence of challenging behaviors. Autistic learners may be disadvantaged during more complex language or cognitive tasks, or versions of tasks, because of language learning differences, especially when tests are developed based on responses of neurotypically developing peers, and often the learner may be deemed “untestable” based on the test being administered (Courchesne et.al, 2015). While the PCA was designed for use with autistic learners and has been tested directly with this population (Moore, 2020), there remains the potential for underestimating performance. Underestimation of performance can lead to delays in intervention when curricular programming is too simple, and teaching targets may already be in that learner's repertoire. Conversely, overestimation of performance may carry even greater risk when prerequisite skills are not present, and therefore mastery criterion are never achieved, where mastering of PEAK programs is a salient predictor of PEAK intervention outcomes (Belisle et al., under review).

Therefore, the purpose of the present study was to evaluate the estimation of performance for autistic learners receiving ABA services based on scores achieved on the PCA using a clinical record review of de-identified data from a previously approved study. Underestimation of performance may be indicated when most PEAK programming targets developed are mastered in an initial block, or baseline test (i.e., the curricular target was already in the learner's repertoire). Overestimation of performance may be indicated when a majority of PEAK programming requires extensive training to achieve program mastery, or if program mastery is never achieved. This preliminary analysis can be used to improve the efficiency of PEAK-based curricula developed from PCA outcomes by adjusting for potential estimation errors from PCA testing to PEAK curricular programming.

Methods

Participants and Setting

PEAK Comprehensive Assessment (PCA) scores and mastered PEAK programs were obtained for 22 participants, between the ages of 4 and 13 years of age (M=8) years; (Sd=2.7) years. The sample included both males (n=19) and females (n=3) and dates were obtained using a clinical case review method. This study obtained de-identified data from a prior approved study and verification of approval for IRB-FY2019-576 is noted in Appendix A. The average PEAK

Comprehensive Assessment (PCA) score across participants was 104.3 with a standard deviation of 76.1. In this study, all participants had a diagnoses of autism spectrum disorder (ASD) by a medical profession with experience in ASD and were receiving ABA services that included adaptive skill targets guided by performance on the PCA at an initial intake assessment. All PEAK Comprehensive Assessments (PCA) and PEAK programming were completed in ABA clinics located in the Midwestern United States. Assessments were conducted in private rooms free of distraction and frequently included a table, two chairs, identified reinforcers for breaks during the assessment, and the PCA testing materials. PEAK programming occurred in private session rooms that contained a table, two chairs, a computer for data collection, and individualized stimuli boxes that contained the relevant materials to run each individual PEAK program.

Materials

PEAK Comprehensive Assessment

All assessments were completed using the PEAK Comprehensive Assessment (PCA) materials which included the client record booklet, assessment book, and the assessment books containing the stimuli required to administer the assessment questions. The PCA is composed of 344 items that span across four modules, Direct Training, Generalization, Equivalence, and Transformation with additions of Expressive and Receptive subtests in the Transformation module for a total of five subtests administered throughout the assessment. For each subtest, clear instructions are provided in the assessment book at the start of each module.

PEAK Programming

Following the completion of the PEAK Comprehensive Assessment (PCA), programs from the PEAK Relational Training System are pulled for intervention. To successfully run a

PEAK program, an individual will need a variety of materials. These include a computer equipped with the Emergent Learning Digital software, access to client digital profiles, and individualized client boxes that include stimuli relevant to the individuals PEAK programming intervention.

Procedure and Analysis

All assessments were conducted by Board Certified Behavior Analysts or Registered Behavior Technicians who completed the necessary training to effectively implement the assessment. PEAK programming was pulled from participants assessment results by the participants individual Board-Certified Behavior Analyst and implemented and scored in private session rooms by Registered Behavior Technicians trained in the PEAK Relational Training System. PEAK Comprehensive Assessment (PCA) scores across all participants were summarized as 0 (incorrect response) or 1 (correct response). From there, PCA scores are analyzed for PEAK programming. Specific targets that are missed on the assessment directly correlate to PEAK programs in which practitioners can then develop a curriculum based off the distinct targets that an individual incorrectly answered. A total of 861 mastered PEAK programs were gathered for this analysis from pre-existing client data. The first presentation of a program is a test block meaning the individual either has the skill in the repertoire or not and reinforcement or feedback is not provided by the practitioner during this block. A score of 90% or above on the first block is considered mastered in baseline and if mastery is not reached during the first presentation, then the program continues to intervention. PEAK programs are considered mastered when an individual reaches 90% independence or above across three consecutive sessions.

Results and Discussion

All results from this study obtained de-identified data from a prior approved study The results of the number of programs mastered in each trial block and the number of programs mastered in the first trial block across the four modules are displayed in Figures 5 and 6. Figure 5 shows the resulting analysis of the de-identified clinical data of the number of programs mastered in each trial block across all 22 participants. A total of 861 programs were mastered ranging from mastery in the first trial block to mastery in the one hundredth trial block. As seen in the figure, 302 PEAK programs were mastered in baseline or during the first trial block meaning 35% of identified PEAK programs are already mastered. Due to the mastery criteria, programs are not able to be mastered in the second or third trial blocks, but the figure shows that the earliest level of mastery aside from in baseline is the fourth trial block in which 105 programs were mastered by the participants. Looking at the fourth trial block results, the probability that a program will be mastered quickly (i.e., an easy programming target) is 12% and 47% represents the probability that a given program is already in the repertoire based of the first and fourth trial block scores. When looking at the graph, the number of programs in the subsequent trial blocks following the first and fourth display a decrease in mastery suggesting an underestimation in performance from the assessment to intervention. With the total number of mastered programs and the number of participants, on average a participant is underestimated by 13.7 programs.

Figure 6 displays the resulting analysis of the de-identified clinical data of the percentage of PEAK programs mastered in each module during the first trial block across all the participants. The results across the PEAK modules in Figure 6 showed 33% of programs mastered in Direct Training, 19% mastered in Generalization, 27% mastered in Equivalence, and 21% mastered in Transformation during the first trial block.

Also looked at was the correlation between the participants PEAK Comprehensive Assessment (PCA) scores and their average first trial block score across their mastered PEAK programs. When looking at the participants average first trial block score in relation to their PCA score, the results varied across participants. Although there was some variability across participants, results showed that in most cases participants with a higher PCA score were more likely to master a program during the first trial versus someone with a lower PCA score. Looking more closely, the average first trial block score ranges from a low of 41 to a high of 95 and most participants with an assessment score of 113 and above showed an average first trial block score of 80 and above.

The present study provided an initial evaluation of the underestimation in performance on the PEAK Comprehensive Assessment (PCA) while evaluating the number of trial blocks until mastery in PEAK programs in a sample of individuals with autism spectrum disorder (ASD). Analysis of the de-identified data collected by the research team revealed that out of the 861 total mastered PEAK programs, 302 of those programs were mastered in baseline or during the first presentation of that program. More specifically, 35% of programs were mastered in the first trial block meaning the PEAK Comprehensive Assessment (PCA) does not appear to excessively underestimate performance nor does it overestimate performance. Although less than half of the programs were mastered in baseline, there are data described throughout this study supporting an error in underestimation on this assessment evidenced by most programs being mastered relatively quickly with only a few programs taking ten or more trial blocks to reach mastery. Underestimation in performance as previously mentioned could occur for a multitude of reasons. A study conducted by colleagues points out that a sample of individuals with autism spectrum disorder could be at risk for underestimation due to the difficulty to accurately assess their potential on aspects of the assessment that the individuals are not familiar with (Courchesne et.al, 2015). Like the PEAK Comprehensive Assessment (PCA), the contents of the assessment contain language that may be difficult to comprehend or provide an accurate answer on the assessment leading to underestimation in performance. Other reasons for underestimation could include the learner's language skills, duration of the assessment, lack of reinforcement provided throughout the assessment, and possible distress due to disruptions in routine.

As previously mentioned, 35% of programs were mastered during the first trial block by the participants in this study meaning that 35% of those assigned programs are already mastered. Having a significant number of programs mastered in the baseline phase has potential strengths and weaknesses. On one hand, having a sufficient amount of acquisition tasks already in the repertoire could help to build momentum on other tasks such as higher-level acquisition tasks. On the other hand, having a considerable amount of acquisition tasks that is already in an individual's repertoire could reduce programming efficiency and ultimately take time away from introducing new skills that an individual does not already have. With that being said, there are some considerations to be made by a behavior analyst when creating an intervention for an individual. For example, if you are wanting fewer mastered programs to start, a consideration could be to remove up to 35% of the initial programs from the curriculum or whatever percentage of programs were mastered in the baseline phase. Determining the range of initial programs to remove from the curriculum is up to the behavior analysts but it is crucial to not go past the percentage of programs mastered (i.e., 35%) or identified targets for that individual as failing to confirm that those skills are in the repertoire could lead to missed prerequisites. Looking back at the data, there were instances where a program took ten or more blocks to reach mastery. A program or skill taking an excessive amount of time to reach mastery is something that occurs frequently in the field of ABA and there are a few things that could be done to help that skill or program reach mastery. The skill could be broken down into smaller component skills, alternative training methods could be considered, or the program or skill could be placed "on hold" and return to it further down the road once other targets are mastered.

Overall, these results suggest that the PEAK Comprehensive Assessment (PCA) is appropriate for program selection and developing comprehensive curricula within ABA programming. Sutton et. al (2022) confirms these results as they discuss in their study that the PCA can be further interpreted to pinpoint specific programs in the PEAK curriculum for intervention and it adds to the clinical utility of the PCA as it displays many potential ways to proceed with intervention.

Although the results were successful in showing the effectiveness of the PCA when it comes to programming, there were a few limitations throughout this study. One limitation being the sample being primarily composed of individuals with autism spectrum disorder (ASD). Future research could examine an ASD sample versus a typically developing sample when looking at underestimation in performance when it comes to the PCA and PEAK programming. Another limitation is that data on interrater agreement or interobserver reliability was not obtained for this study. PEAK Comprehensive Assessment (PCA) scores were obtained from clients receiving existing clinical services so future research could include these reporting agreement measures which could increase the internal validity of the obtained results. A finial limitation could be exclusion of outside factors leading to underperformance on the PCA. Including those factors, for example fatigue, could develop future research to examine outside predictors as a potential factor for underestimation on acquisition skills and ways to finetune the assessment to accommodate those factors.

In conclusion, underestimation in performance on assessments is a common factor when developing intervention for individuals with autism spectrum disorder (ASD). The PEAK Comprehensive Assessment (PCA) is one assessment that guides program selection from assessment to the first presentation of the program. Data from this study goes to show some underestimation on the assessment but also shows the effectiveness of the assessment when it comes to programming. Potential future research from these results could further support the PEAK Comprehensive Assessment (PCA) and the PEAK curriculum by understanding the factors that lead to underestimation and how practitioners can further better develop interventions for individuals with autism spectrum disorder (ASD).

References

Ackley, M., Subramanian, J.W., Moore, J.W. *et al.* (2019). A Review of Language Development Protocols for Individuals with Autism. *Journal of Behavioral Education,* 28(1), 362–388. https://doi.org/10.1007/s10864-019-09327-8

Belisle, J., Dixon, M.R., Zuch, C., Blecha, S., Campbell, M., Busam, J., and Holtsman, L. (under review). *Multidimensional Emergence of Relational Learning and Verbal Behavior in Autistic Children: Principal Component Analysis of the PEAK Comprehensive Assessment*

Courchesne, V., Meilleur, A. A. S., Poulin-Lord, M. P., Dawson, M., & Soulières, I. (2015). Autistic children at risk of being underestimated: school-based pilot study of a strength-informed assessment. *Molecular autism*, 6(1), 1-10. https://doi.org/10.1186/s13229-015-0006-3

Dixon, M. R. (2014a). *PEAK Direct Training.* Emergent Press.

Dixon, M. R. (2014b). *PEAK Generalization.* Emergent Press.

Dixon, M. R. (2015). *PEAK Equivalence.* Emergent Press.

Dixon, M. R. (2016). *PEAK Transformation.* Emergent Press.

Dixon, M. R. (2018). *PEAK Comprehensive Assessment*. Emergent Press.

Dixon, M. R. (2019). *Peak comprehensive assessment: administration manual*. Carbondale, IL: Shawnee Scientific Press.

Hodges, H., Fealko, C., & Soares, N. (2020). Autism spectrum disorder: definition, epidemiology, causes, and clinical evaluation. *Translational pediatrics*, 9(Suppl 1), S55. Doi: 10.21037/tp.2019.09.09

Maenner, M. J. (2023). Prevalence and characteristics of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2020. *MMWR. Surveillance Summaries*, *72*. http://dx.doi.org/10.15585/mmwr.ss7202a1

May, B. K., & St. Cyr, J. (2021). The impact of the PEAK curriculum on standardized measures of intelligence: A systems level randomized control trial. *Advances in Neurodevelopmental Disorders*, 5(1), 245-255. https://doi.org/10.1007/s41252-021-00199-6

Moore, J. L., Yi, Z., Hinman, J. M., Barron, B. F., & Dixon, M. R. (2020). Examining the Convergent Validity Between the PEAK Relational Training System's Semi-Standardized and Standardized Skill Assessments. *Journal of Developmental and Physical Disabilities,* 33(1), 757-770. doi:10.1007/s10882-020-09771-9

Padilla, K. L. (2020). Global assessment use and practices in applied behavior analysis: Surveying the field. *Research in Autism Spectrum Disorders*, 79(1), 101676. https://doi.org/10.1016/j.rasd.2020.101676

Padilla, K. L., Weston, R., Morgan, G. B., Lively, P., & O'Guinn, N. (2023). Validity and Reliability Evidence for Assessments Based in Applied Behavior Analysis: A Systematic Review. *Behavior modification*, *47*(1), 247–288. https://doi.org/10.1177/01454455221098151

Sutton, A., Pikula, A., Yi, Z. *et al.* (2022). Evaluating the Convergent Validity of the PEAK Comprehensive Assessment (PCA): Intelligence, Behavior Challenges, and Autism Symptom Severity. *Journal of Developmental and Physical Disabilities,* 34(1), 549–570 (2022). https://doi.org/10.1007/s10882-021-09814-9

Figures

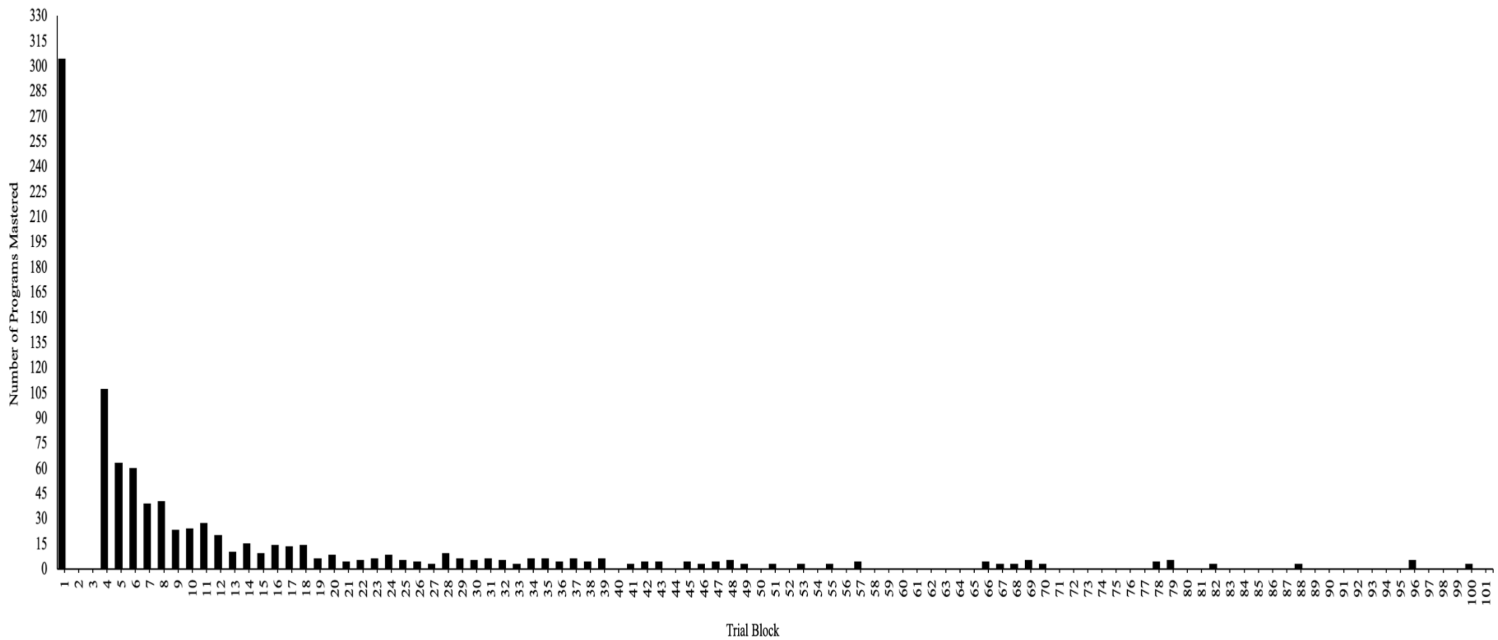

Figure 5: The number of mastered PEAK programs by trial block across all participants.

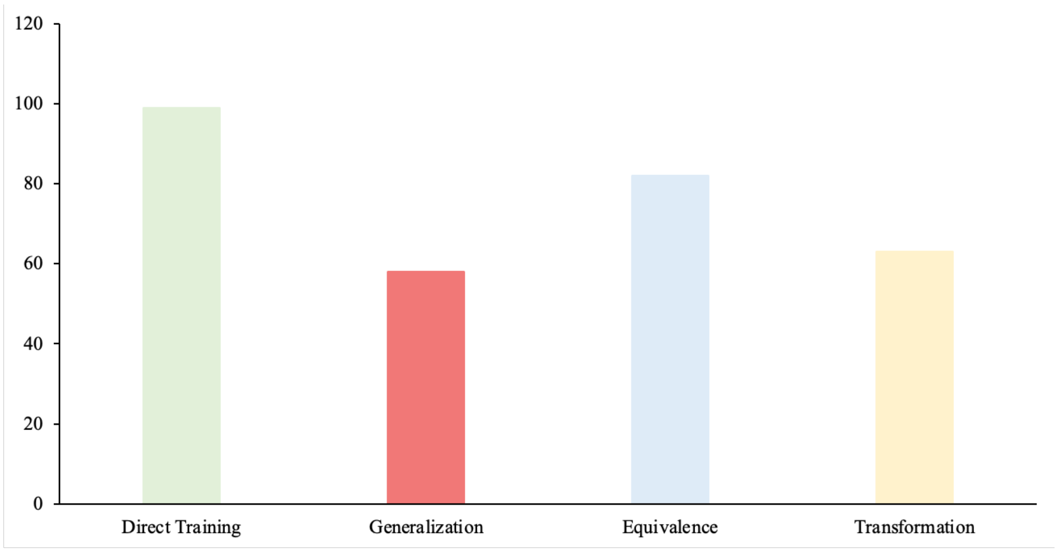

Figure 6: The percentage of PEAK programs mastered in each module during the first trial block across all the participants.

SUMMARY

The two manuscripts presented throughout this thesis help to aid the field of behavior analysis in a multitude of ways. The first manuscript discussed evaluated the interdependency of each item presented throughout the PEAK Comprehensive Assessment (PEAK-CA) using a principal component analysis (PCA). The results reported in Belisle et. al (under review) provide evidence of a high level of interdependency within items on the PEAK-CA. These results support a variety of articles suggesting that relational and verbal operants each support the develop of one another rather than emerging as independent skills (e.g., Belisle et al., 2018; Rowsey et al., 2015; Rowsey et al., 2017). The findings from this first manuscript are imperative for the field of behavior analysis especially in a sense of creating a curriculum for autistic learners. As mentioned, verbal operants and relational operants are interdependent and support the development of each other. This is crucial for practitioners in which interventions and curriculum should include a variety of skills and their complexities as confirming to one level of skill can lead to a lack of meaningful improvement in derived relational responding in more complex skills.

The second manuscript presented in this thesis evaluated performance estimation based on scores of the PEAK Comprehensive Assessment (PCA) in a sample of autistic learners. The results reported in Busam et.al (under review) provide evidence that the assessment does not excessively underestimate performance, but other supporting data suggest an error in underestimation. An error in underestimation is present in this study by most PEAK programs being mastered in the first trial block or relatively quickly in the subsequent trial blocks with only a few programs mastered in more than ten trial blocks. These results suggest a couple of findings. One being that the learners have enough acquisition tasks in their repertoire and another being that underestimation on the assessment could have occurred for a variety of outside factors with one reason being the disruption in routine as mentioned in a study conducted by Courchesne et.al (2015). Determining the estimation of performance on behaviors analytic assessments is a critical aspect of creating an effective intervention and is an uncommon issue that the field of behavior analysis should deem to address.

The topics presented in this paper related to behavior analytic assessments, verbal and relational leaning, and effective programming are connected in a variety of ways. Results presented in both studies can be generalized to each other and to other areas in the field of behavior analysis. Understanding the components of the PEAK Comprehensive Assessment (PCA) as its evaluated in both studies, could be beneficial when using other common assessments in the field. As we have learned, the skills in the PEAK-CA are interdependent and depend on one another for the development of all levels of skills. In more understanding, less complex skills cannot develop into more complex skills if the skills are taught independently. When looking at the results of mastery of skills in the second manuscript, teaching these skills independently would account for a massive loss of mastery of skills in different levels of complexity. With that and the skills being interdependent, not just one skill will be underestimated but multiple skills will face underestimation. Conversely, overestimation of a skill will lead to overestimation of a multitude of skills which can carry an even greater risk when attempting to create or run a curriculum. Both of these manuscripts provide results to allow for future research in the field of ABA as it relates to effective assessments and curricular programming for individuals with autism spectrum disorder (ASD). As the field of behavior analysis continues to emerge, future research needs to continue to foster aspects that are not commonly focused on (i.e., performance estimation on assessments for individuals with ASD).

ADDITIONAL REFERENCES

Belisle, J., Dixon, M. R., & Stanley, C. R. (2018). The mediating effects of derived relational responding on the relationship between verbal operant development and IQ. *Behavior Analysis in Practice*, 11(1), 411-416. https://doi.org/10.1007/s40617-018-0215-2

Belisle, J., Dixon, M.R., Zuch, C., Blecha, S., Campbell, M., Busam, J., and Holtsman, L. (under review). *Multidimensional Emergence of Relational Learning and Verbal Behavior in Autistic Children: Principal Component Analysis of the PEAK Comprehensive Assessment*

Busam, J., Belisle, J., Dixon, M.R., and Holtsman, L. (under review). *Performance Estimation and Curricular Programming for Autistic Learners Using the PEAK Comprehensive Assessment*

Courchesne, V., Meilleur, A. A. S., Poulin-Lord, M. P., Dawson, M., & Soulières, I. (2015). Autistic children at risk of being underestimated: school-based pilot study of a strength-informed assessment. *Molecular autism*, 6(1), 1-10. https://doi.org/10.1186/s13229-015-0006-3

Dixon, M. R. (2014a). *PEAK Direct Training*. Emergent Press.

Dixon, M. R. (2014b). *PEAK Generalization*. Emergent Press.

Dixon, M. R. (2015*). PEAK Equivalence*. Emergent Press.

Dixon, M. R. (2016). *PEAK Transformation*. Emergent Press.

Dixon, M. R. (2018). *PEAK Comprehensive Assessment*. Emergent Press.

Furlano, R., Kelley, E.A. (2020) Do Children with Autism Spectrum Disorder Understand Their Academic Competencies? *Journal of Autism and Developmental Disorders*, 50(1), 3101–3113 (2020). https://doi.org/10.1007/s10803-019-03988-0

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition.* Kluwer, Academic/Plenum Publishers.

Rowsey, K. E., Belisle, J., & Dixon, M. R. (2015). Principal component analysis of the PEAK relational training system. *Journal of Developmental and Physical Disabilities*, 27(1), 15-23. https://doi.org/10.1007/s10882-014-9398-9

Rowsey, K. E., Belisle, J., Stanley, C. R., Daar, J. H., & Dixon, M. R. (2017). Principal component analysis of the PEAK generalization module. *Journal of Developmental and Physical Disabilities*, 29(1), 489-501. https://doi.org/10.1007/s10882-017-9539-z

Appendix A: Human Subjects IRB Approval

For both manuscripts, final analyses were conducted from de-identified data collected through the Institute for Dynamic Behavior Science and Missouri State University made available by the primary investigator of those studies.
The studies were conducted consistent with the below IRB approval:

Missouri State
UNIVERSITY

To:
Jordan Belisle
Psychology

RE: Notice of IRB Approval
Submission Type: Initial
Study #: IRB-FY2019-576
Study Title: Evaluating the Efficacy of the PEAK Relational Training System in Active Clinical Settings - Existing Data
Decision: Approved

Approval Date: March 18, 2019
Expiration Date: --

This submission has been approved by the Missouri State University Institutional Review Board (IRB) for the period indicated.

Federal regulations require that all research be reviewed at least annually. It is the Principal Investigator's responsibility to submit for renewal and obtain approval before the expiration date. You may not continue any research activity beyond the expiration date without IRB approval. Failure to receive approval for continuation before the expiration date will result in automatic termination of the approval for this study on the expiration date.

You are required to obtain IRB approval for any changes to any aspect of this study before they can be implemented. Should any adverse event or unanticipated problem involving risks to subjects or others occur it must be reported immediately to the IRB.

This study was reviewed in accordance with federal regulations governing human subjects research, including those found at 45 CFR 46 (Common Rule), 45 CFR 164 (HIPAA), 21 CFR 50 & 56 (FDA), and 40 CFR 26 (EPA), where applicable.