INSTITUTO NACIONAL DE CIÊNCIA E TECNOLOGIA SOBRE COMPORTAMENTO, COGNIÇÃO E ENSINO

(NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY ON BEHAVIOR, COGNITION AND TEACHING)

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RESEARCH PROGRAM
Relational Learning and Symbolic Functioning: Basic and Applied Research

ANNUAL ACTIVITY REPORT
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April, 2010
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AFFILILATED UNIVERSITIES
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THE INSTITUTE (INCT-ECCE): CONTEXT AND GOALS

The National Institute of Science and Technology on Behavior, Cognition, and Teaching is an expansion of the Nucleus of Studies of Behavior, Cognition, and Teaching that has organized, since 1996, the efforts of researchers at UFSCar, USP, UnB, UNESP, UFPA and the University of Massachusetts Medical School (UMMS). The group first secured financial support in the PRONEX competition in 1997, support that was renewed in a new edition of PRONEX in 2003. This recent Institute incorporated additional researches from two other universities (UFMG and UNCISAL) and plans to further develop, integrate, and expand its existing network of laboratories.

This multi-institutional, multi-regional network focuses on behavioral science and technology addressing symbolic functioning and functional deficits, particularly in children (e.g., dysfunctional communication skills, delayed language development due to congenital deafness, failure to achieve basic competencies in reading and mathematics, etc.). Functional deficits in symbolic functioning represent a substantial challenge for affected individuals, their families, and their larger communities. Such deficits may result from neurological disorders, impoverished environments, and/or their interactions. Whatever the etiology, however, the primary approach to prevention and remediation of deficits in symbolic functioning is provision of behavior intervention, enhanced educational support, and other interventions to reduce their impact.

Our network currently integrates basic and applied research in a multi-institutional program that focuses on a number of aspects of symbolic functioning in children. In continuity to our previous work, the primary research objectives of the Institute’s activities are the scientific analysis of symbolic functions and their determinants, including (but not limited to):

(1) Identification of the necessary and sufficient conditions for development of age-appropriate symbolic functioning;

(2) Development and/or refinement of specific procedures for managing challenges of inter-individual variability in response to educational and/or therapeutic procedures, including those designed to improve function and also those to manage symbolic function deficits prosthetically;

(3) Investigation and development of methodology for establishing symbolic functioning in educational and therapeutic settings.

Other objectives of the Institute include mentoring to accelerate the professional development of young scientists within the program and disseminating the fruits of the work to the general public in a form that will be readily understandable for individuals without formal training in and/or experience with science and technology.
ORGANIZATIONAL STRUCTURE

The following positions are incorporated within the governance structure of the Institute:

The Institute Program Coordinator and Vice-Coordinator, charged with scientific direction and oversight of the Institute, team-building activities, human resource development, budgetary management, and multi-site coordination of Institute activities.

Project Site Coordinators at each of the participating universities. The Project Site Coordinator has primary responsibility for interfacing with the administrative structures at their home universities and for coordinating activities of researchers to accomplish objectives at each site. Table 1 lists the Project Site Coordinators and their home universities. The following positions are incorporated within the governance structure of the Institute:

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<tr>
<th>University</th>
<th>Coordinator</th>
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<tbody>
<tr>
<td>Universidade Federal de São Carlos (UFSCar)</td>
<td>Júlio Cesar de Rose</td>
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<td>Universidade de Brasilia (UNB)</td>
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<td>Gerson Yukio Tomanari</td>
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<td>Universidade Estadual Paulista (UNESP)</td>
<td>Ana Claudia Almeida-Verdu</td>
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<tr>
<td>Universidade Estadual de Ciências da Saúde de Alagoas (UNCISAL)</td>
<td>Heloisa Helena Motta Bandini</td>
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<tr>
<td>University of Massachusetts Medical School (UMMS)</td>
<td>William Jay McIlvane</td>
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To implement its three main foci (i.e., Basic, Translational, and Applied Sciences), the Institute has three Scientific Program Coordinating Committees (see Table 2) that have trans-site responsibilities within specific areas of expertise. These three committees are expected to (1) Monitor activities of and facilitate communications among the investigators and sites that participate in each area of science; (2) Promote team-building efforts within each scientific program, thus reinforcing the Institute’s larger team-building mission; (3) Establish ongoing, well-defined mentor-mentee relationships between senior and mid-career faculty participating in the program, thus addressing the Institute’s larger mission to develop its Human Resources for the future. The last of these objectives has been accomplished via teaming two senior faculty members (one national and one international) with two mid-career faculty members on each of the three Scientific Program Coordinating Committees. Thus, the Institute has provisions not only to effectively manage and coordinate its activities in the short- and medium-term, but also to develop future leadership that will continue the Institute activities when the present leaders are no longer active in their roles.
Table 2: Membership of Institute Scientific Program Coordinating Committees

<table>
<thead>
<tr>
<th>Basic Science</th>
<th>Translational Science</th>
<th>Applied Science</th>
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<tr>
<td>Olavo F. Galvão (UFPA)</td>
<td>Julio C. de Rose (UFSCar)</td>
<td>Deisy G. de Souza (UFSCar)</td>
</tr>
<tr>
<td>William V. Dube (UMMS)</td>
<td>William J. McIlvane (UMMS)</td>
<td>Richard W. Serna (UMMS)</td>
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<tr>
<td>Gerson Y. Tomanari (USP)</td>
<td>Carlos B. Souza (UFPA)</td>
<td>Martha C. Hubner (USP)</td>
</tr>
<tr>
<td>Romariz S. Barros (UFPA)</td>
<td>Jorge M. Castro (UNB)</td>
<td>Elenice S. Hannah (UNB)</td>
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</tbody>
</table>

Institute Decision-making and Governance Processes.

The Institute constituted standing committees to effect program oversight, review, logistical management, and other components of Institute operations: An Institute Executive Committee comprised of members of the Institute faculty involved in project direction and coordination, a National Board of Advisors, comprised of distinguished senior scientists from top-level research universities in Brasil, and an International Board of Advisors, comprised of distinguished international scholars (Figure 2). Both the National and International Boards represent expertise in different aspects of behavioral science relevant to the Institute's scientific programs.

![Figure 2: INCT-ECCE Executive Committee and Advisory Groups](image-url)
THE RESEARCH PROGRAM

Relational Learning and Symbolic Functioning: Basic and Applied Research

The structure of the research and professional development program has followed long-standing practice in the biomedical, biobehavioral, and behavioral sciences. There are three major components to the program under development:

(1) A Basic Science component charged with the development of new knowledge and new methodologies relevant to the understanding and potential prevention or amelioration of symbolic function deficits. Targets of the Basic Science component include:
   
   (a) Investigations of the necessary and sufficient conditions for the development of symbolic functioning, its components, and its precursors;
   
   (b) Investigations of attentional processes (e.g., observing behavior) that are necessary for the development of symbolic functioning;
   
   (c) Further development and refinement of animal models that may inform analysis of the determinants of symbolic behavior and the development of remedial procedures for individuals with deficits in symbolic functioning;
   
(2) A Translational Science component charged with effecting validation of new principles and/or new procedures deriving from the basic studies in initial clinical/educational trials under quasi-controlled conditions.

(3) An Applied Science component charged with developing feasible, cost-effective solutions to challenges of widespread dissemination of evidence-based educational and therapeutic procedures to typical settings of service (e.g., schools, hospitals, clinics, etc).

OVERVIEW OF SCIENTIFIC TOPICS ADDRESSED BY INSTITUTE PROGRAMS

BASIC SCIENCE

Program Overview

The major short- and medium-term objectives of the Institute's Basic Science Program are to advance basic knowledge and methodological control of behavioral processes involved in symbolic function and symbolic communication. A longer-term objective is to take advantage of conceptual and methodological advances to define symbolic behavioral processes in relation to their determinants within the biological substrate. Work proposed in this research program concerns the operational definition and study of basic symbolic
processes and their behavioral prerequisites. Two dimensions are emphasized: (1) Processes involved in establishing contextually-defined equivalence relations between symbols and their referents; (2) processes that render symbolic relations conventional in the sense that two or more individuals exhibit (a) joint attention to the physical features that define symbols and their referents and (b) behavior consistent with joint understanding of the symbol-referent relation.

As such, the Basic Science Program of the Institute addresses a variety of interrelated topics relevant to its primary interests. These include but are not limited to (a) basic processes in perception and attention relevant to symbolic functions, (b) within- and across-modality stimulus-stimulus relational learning, (c) behavioral emergence based on equivalence and ordinal stimulus-stimulus relations of the type that constitute simple semantic and syntactic relations, and (d) phylogenic status in relation to items a, b, and c.

These interests have been and will be pursued in the following series of projects:

1. Complex Relational Learning Methodologies
   Description and Rationale: Studies proposed in this category explore a number of novel methodologies for the study of complex symbolic functioning in normally capable children and adults. Complex symbolic functioning is defined in terms of multi-element symbolic relations and networks, including those representing natural categorical and dimensional equivalence relations and those developed specifically in the laboratory for research purposes. As a group, the intent of these studies is to bring to light behavioral processes occurring during acquisition of complex symbolic relations via model systems that bring naturally occurring symbolic relations and networks into the laboratory.

   Specific topics within this research line include (but are not limited to) (a) transfer and/or transformation of stimulus functions within laboratory models of semantics and syntactic networks (e.g., topics such as assessment of psychological distance in stimulus-stimulus relations, evaluation of basic and polymorphous class/category structures, etc.), (b) model systems that isolate processes of acquisition of symbolic relations from past symbolic learning (e.g. acquisition of musical notation reading in individuals who have no prior experience with this task), and (c) competition between experimenter-targeted equivalence relations and task-irrelevant (from the experimenter’s perspective) relations in re-acquisition or repeated acquisition of symbolic stimulus-stimulus relations (e.g., symbolic relation learning set, transfer from “effortful” to “automatic” information processing via elimination of initially strategic but later unnecessary precurrent responses, etc.).

2. Selective Attending and Observing Behavior in Symbolic Tasks
   Description and Rationale: Projects in this category address the behavioral prerequisites for conventional symbolic functioning. A working hypothesis of several projects within the Institute program is that seeming failures of conventional symbolic functioning may
be due instead to deficient or procedurally dysregulated attention processes. Essential to pursuit of this research hypothesis are (a) studies that measure correlates of attending, such as the direction of gaze, and (b) development or refinement of behavioral procedures that direct attending effectively or efficiently by manipulations of physical or temporal structure of stimuli presented in and/or the response requirements of behavioral procedures.

3. Animal Models of Symbolic Behavior and its Prerequisites

**Description and Rationale:** Projects in this category address the development of animal models that may potentially inform other studies within the Institute program and that may prove useful ultimately in applications of program research findings in basic and comparative neuroscience. Work with *Cebus apella* was substantially advanced during the recent PRONEX grant period, developing state-of-the-art methodology for establishing reliable inter- and intra-individual procedural control of certain critical aspects of relational learning (e.g., relating visual stimuli as either *same* or *different* on a generalized basis). Also advanced was development of methodology for assessing and potentially establishing featural (i.e., iconic) and functional equivalence relations in this species. New studies will build upon these successes, pursuing especially those that address apparent homology in certain behavioral processes exhibited in both humans and nonhuman primates.

A medium-to-long term objective of this program is to extend current preliminary work on virtual reality environments with basic discrimination tasks to address larger issues of physical feature and functional equivalence in the generalization and emergence of complex behavior, initially in *Cebus apella* and ultimately in humans. Laboratory models within virtual reality environments may prove especially informative in relating models to real world activity and ultimately may support translational and applied studies targeted at prevention or amelioration of learning challenges in regular and special education environments.

A new project with canines will derive in part from work conducted with *Cebus apella*, addressing species capacities that may clarify, for example, phylogenetic status of behavioral processes underlying the rapid expansion of symbolic repertoires of typically developing toddler-aged children (i.e., are these processes uniquely human or are they represented in some form in other species).

Additional work with honeybees, some of which is derivative from and will be informed by other Institute projects, will address behavioral processes that may underlie the rudimentary symbolic capacity of this species, perhaps leading ultimately to useful models for neuroscience research to clarify the biochemical and molecular processes involved.

**TRANSLATIONAL SCIENCE PROGRAM**

**Program Overview**
The major short- and medium-term objectives of the Institute’s Translational Science Program are to continue and extend a research program that has successfully translated laboratory methodologies developed with humans and nonhumans to resolve certain well-known challenges in regular and special education classrooms, hospitals and clinics, and other environments that provide services to children and adult humans. As in translational research in the biomedical sciences, translational behavioral research represents initial efforts to validate laboratory findings and methodologies in environments that emulate certain aspects of laboratory control but introduce also features of environments in which educational or clinical services are provided. The goal is to establish that success of laboratory-derived methodologies does not depend on the highly-controlled environments that are typical of basic science projects.

While some focus on translational science has been a feature of past programs, the Institute will expand the nature and scope of topics addressed within its larger focus on symbolic functioning. Translational research on pre-academic and academic instruction will be extended from its initial focus on very basic reading prerequisites to the more complex performances involved in skilled reading and mathematics. Foundational work on basic symbolic functioning in children with post- and pre-lingual deafness addressed via cochlear implants will be extended to address a broader range of issues affecting this population. Also considered within the translational domain will be extension of work that has translated methodologies developed originally with nonhumans, school-aged children, and individuals with intellectual disabilities to study the transition from preverbal to verbal behavior in infants and toddlers – studies that may serve as foundations for further translational research to model early intervention potential and ultimately applications in early intervention for infants and toddlers at risk for neurodevelopmental disabilities. A new direction for the Institute will include translation of past work to address new populations and behavioral capabilities with a specific focus on investigating relationships between brain and behavior. Projects proposed within the Translational Science Program will include:

4. Perception, Discrimination, and Equivalence

**Description and Rationale:** Projects in this category derive for work initiated within previous research program, and that remain targets for translational research. Regarding the work with children whose deafness was addressed by cochlear implantation, certain basic issues have been resolved for the population in general (e.g., symbolic functioning tends to be consistent with language age which in turn appears highly correlated with the length of auditory experience). There remain, however, many questions to be answered about the short-, medium-, and long-term prospects for CI-implanted children, especially those whose functioning does not achieve expected levels of development. Regarding the latter children, is failure of cochlear implantation to render their level of functioning typical of their peers due to some aspect of the quality of their auditory input or to some other variable (e.g., undetected
Regarding studies with preverbal children, the new Institute will build upon initial successes in methodological studies aimed at adapting methods from other components of the program to address questions relating to the development of symbolic functions and their behavioral prerequisites in the period from 12-30 months of age. Among the primary research targets of this program will be developing reliable methodology for studying symbolic functioning/prerequisites in the highly-engaged behavior of the individual child, work that may prove informative and perhaps more educationally/clinically relevant than studies employing group methodology and statistical control of inter-individual variability.

5. Relational Learning in Basic Academics

Description and Rationale: Projects in this category address a longstanding interest of our research programs, application of laboratory-derived methods to establish very early instances of reading printed words and relating them with their visual referents (objects, pictures, etc.) and auditory counterparts in children at risk for or already exhibiting protracted failure in school. A computer-based model research curriculum has been devised to (1) establish the first or very early instances of printed word-dictated word and printed word-picture relations, (2) expand that relational repertoire via further structured teaching, and (3) to build gradually the word attack skills that permit children to read new words with little or no training via recombination of syllabic units and other processes that may be involved in the development of phonological awareness. The Institute program will further develop and refine the model research curriculum and investigate extensions of the methodology to the realm of basic mathematic skills. This translational research effort is intended to serve as an ongoing and expanding conduit of new and/or refined methodology for the Institute’s Applied Science Programs in which laboratory-derived and validated instructional technology is exported for use in regular and special education classrooms.

6. Extensions to Neurobehavioral Science (Neurology, Vision, etc.)

Description and Rationale: Projects in this category are new translational science additions to the Institute’s research program that derive in part from past basic and translational research by current Institute faculty. Included in this category will be extensions of existing methodology to characterize neurobehavioral functioning in individuals with communication skills that have been compromised due to congenital or acquired neurodevelopmental disabilities. The project will build upon results of projects that have addressed selected aspects of sensory and cognitive functions in nonhuman primates and children with limited language development, work that will be extended to study individuals with confirmed or suspected neurological disorders.
APPLIED SCIENCE PROGRAM

7. Behavioral Technology Delivery Systems

Program Overview and Rationale: Projects in this category have a common short- and intermediate-term target, dissemination of methods for delivering efficient, cost-effective, evidence-based behavioral technology to the classroom, clinic, and other settings that concern improvement of behavioral functioning, especially that relating to symbolic functioning. For example, past projects have investigated large-scale applications of instructional technology in school systems local to UFSCar. These projects will be continued and expanded. Ongoing and new Institute initiatives will investigate computer-assisted instructional technology to promote dissemination, such as that which is increasingly possible via the Internet. Related projects concern the development of individualized instructional technology that implements instructional procedures derived from the Institute’s Translational Science Program.

For the longer-term, the Institute plans to initiate dissemination of virtual reality instructional programs (VRIPs) as merited by progress in research conducted within its translational research initiative. Consistent with the themes of the Institute program, such VRIPs will target prevention or amelioration of deficits of symbolic functioning with school-aged children being the primary population of initial interest.

SPECIFIC INSTITUTE RESEARCH PROJECTS

The following list of projects summarizes the programmatic nature of research that the Institute seeks to accomplish.

BASIC SCIENCE PROJECTS

Laboratory Investigations of Basic Prerequisites for Symbolic Functioning

Basic Science Projects. 1: Complex Relational Learning Methodologies
Project 1A: Categorical-Dimensional Interactions In Symbolic Categories
Project 1B: Recombinative Generalization of Symbolic Repertoires
Project 1C: Development of Automaticity and Fluency of Symbolic Repertoires

Basic Science Projects. 2: Selective Attending and Observing in Symbolic Tasks
Project 2A: Procedural Control of Observing Behavior in Sample-Matching Tasks
Project 2B: Procedural Control of Observing Behavior in Go/No-Go Tasks
Basic Science Projects. 3: Animal Models of Symbolic Behavior and its Prerequisites

Project 3A: Relational Learning in Cebus apella

3A.2. Visual information processing in Cebus apella.
3A.3. Auditory learning in Cebus apella.
3A.4. Virtual reality environments for Cebus apella.

Project 3B: Relational Learning in Dogs
Project 3C: Relational Learning in Bees

TRANSLATIONAL SCIENCE

Populations with Developmental and/or Acquired Limitations in Symbolic Functioning

Translational Projects. 4: Perception, Discrimination, and Equivalence

Project 4A: Development of Symbolic Function in Infants
Project 4B: Fast Mapping Strategies in Toddler-Age Children
Project 4C: Relational Learning in Newly Hearing Children
Project 4D: Promoting Symbolic Function in Preverbal Populations

Translational Projects. 5: Relational Learning in Basic Academics

Project 5A: Basic and Remedial Instruction in Reading
Project 5B: Basic and Remedial Instruction in Mathematics and Related Skills

Translational Projects. 6: Extensions to Neurobehavioral Science

Project 6A: Laboratory-Derived Neuropsychological Methodology
Project 6B: Translational Studies of Neurobehavioral Effects of Mercury Exposure

APPLIED SCIENCE PROGRAM

Dissemination of Methods for Delivering Efficient, Cost-Effective, Evidence-Based Behavioral Technology

Applied Projects. 7: Behavioral Technology Delivery Systems

Project 7A: Reading, Writing, & Mathematics in the Classroom
Project 7B: Computer-assisted Instruction
Project 7C: Augmentative Communication (CI, AAC, etc.)
Project 7D: Motivational Analyses in Instructional Environments
Project 7E: Virtual Reality Applications
MAIN SCIENTIFIC RESULTS

During this first year the Institute attained the majority of its research goals (although this may not reflect clearly in the number of publications, due to the long time-course of research and the typically protracted editorial processing of the journals in the field). The accelerated rhythm in the development of the investigation is due, mostly, to the fact that the research network was already operative before the onset of the Institute, and to the cumulative results of this work along a period of several years. The references of research articles are presented in Appendix 1. There were 32 published articles (22 in national journals and 10 in international journals), 27 other articles are currently in press (14 in national and 13 in international journals), and 16 (9 national and 6 international) manuscripts have been submitted and are currently under revision. Publications of the Institute members at the foreign institution (UMASS) were included only when in collaboration with the Brazilian members of the Institute, and the production of the members that are currently being affiliated to the Institute was also not included. Therefore, a total of 24 team members had their production included. The total of published articles was 66.7% above the annual average of publications by the same researchers between 1998 and 2008 (cf. p. 115 of the Institute project), and 28% above the average in the period 2006-7 (data from 2008 were not included because the compilation for the project was made in September, 2008). The number of 27 articles in press and the conservative estimation that 50% of the submitted articles will be accepted indicates that the production in the second year of the project will increase even more. The goals of the team include a qualitative gain together with a quantitative one, and the increase in international publications is an indication of this effort.

This section summarizes the main results of the scientific investigation, including methodological advances and major findings, listed according to the general research programs and the general topics of subprojects.

BASIC RESEARCH PROGRAM

Considering the ongoing status of the research program, some specific projects are already well developed, while others are underway and generated only preliminary results; finally, some projects will be implemented later, as described in the original proposal, due to since they will require the preparation of the necessary conditions. We will comment on the status of each project, following the sequential structure with transitions from basic (Projects 1-3) to translational (Projects 4-6) and to applied research (Projects # 7).

1. Methodology for the investigation of complex relational learning

1. Categorical-Dimensional Interactions InSymbolic Categories
1.1 (1). Consistent and accumulating results validating stimulus equivalence as a model of symbolic functioning have been obtained. Relations of meaning demonstrated
through stimulus equivalence tests have been systematically confirmed through independent methods, such as semantic differential, Implicit Relational Assessment Protocol (IRAP), or semantic priming, confirming that stimulus equivalence is indeed a model of semantic meaning. Ongoing research (with about 200 participants) will provide psychometrical validation to the semantic differential used to evaluate transfer of meaning through equivalence relations, contributing to the investigation of parameters of equivalence class formation and to the general applicability of the stimulus equivalence paradigm (and transfer of function) to the investigation of development and disorders of symbolic functioning.

1.1. Preliminary results show the acquisition of musical reading in musically illiterate individuals, modeling a system to isolate the acquisition of symbolic relations from past symbolic experiences. The results replicate findings with alphabetic reading and extend them to musical reading. The procedures that have been developed constitute methodological contributions to the evaluation and teaching of conditional relations with auditory stimuli as choice alternatives.

1.2. Identification and description, through an artificial linguistic mini-system, of critical variables for the expansion of symbolic repertoires by recombinative generalization. The development of abstract control by all elements involved in recombination is favored by exposure to (1) variable compound stimuli, (2) whose elements are displayed in variable positions within the learned stimuli, and (3) with superimposition, i.e., the same element as a component of different stimuli. The direct teaching of relations involving the elements to be recombined may accelerate the recombinative repertoire.

2. Selective attention and observing behavior in symbolic tasks

2.1. Studies offered an original contribution in demonstrating controlling relations on looking behavior derived from reinforcement contingencies, i.e., looking dimensions (measured by ISCAN technology and for a new procedure developed within the Institute’s scope) co-vary with controlling relations in simple and conditional discrimination tasks, implying the possibility of development of technologies for control of attentional processes that result in more efficiency in the development of symbolic repertoires. The next steps will be the increase in the database and the development of more precise and automated experimental control for individual participants.

2.2. Studies in this subproject demonstrated emergent symbolic behavior (conditional discriminations and equivalence) through simple discrimination of compound stimuli displayed successively (go-no go procedure), and also through simple simultaneous discrimination. These results contribute to extend the empirical basis on conditions to establish stimulus equivalence (beyond the standard use of matching to sample) and, additionally, to standardize new procedures and protocols that increase the possibilities of investigation in the field.
3. Animal Models of Symbolic Behavior and its Prerequisites

There were advances in the demonstration in infra-humans of basic behavioral processes that are requisite for symbolic behavior. These advances sprung from improvements in experimental procedures and teaching approaches.

Relational Learning in Cebus apella

There were advances in the demonstration in infra-humans of basic behavioral processes that are requisite for symbolic behavior. These advances sprung from improvements in experimental procedures and teaching approaches.

3A1. With Cebus apella the Institute has well established procedures to generate, consistently and predictably, simple visual discriminations, discrimination reversal, and conditional discriminations by identity, with emergent generalized identity. Indications of symmetry were recently obtained, representing a significant advance in the sense that this finding reproduced in capuchin monkeys some of the basic characteristics of symbolic relations in humans. Such an advance is especially significant if compared to failures reported in the literature and in previous studies of the Institute. Both successes and failures recently obtained suggest that procedural variables are very important in this kind of research, contrary the hypotheses favored in most of the literature, attributing failures to subject variables. In this respect, recent studies suggesting the use of successive rather than simultaneous procedures are now being replicated with capuchin monkeys. Our replications are showing that the successive procedure is highly sensitive to parametric variations, because of this sensitivity, considerable attention on procedural refinement was required, but the initial successes are beginning to be obtained also in this new line of investigation with successive pairings. Another important line of work now explored is the development of effective procedures to teach arbitrary conditional relations with little or no digression from the original planning. Overcoming this difficulty is fundamental for the success of this subgroup of studies and will be intensively discussed in the next general meeting of the Institute in June. So far, learning by exclusion and blocked discriminative training have been the more successful procedures. It is also necessary to add that the discriminative control that has been studied is being now extended to virtual reality environment, to natural stimuli, and to complex stimuli, such as objects, photos and videos.

3A2. In relation to visual information processing in Cebus paella, the Cambridge Systems were adapted for a well succeeded study of color discrimination in primates and infants (Goulart et al., 2008a, b). Preliminary data with one female and three male Cebus apella were consistent with available results obtained through electrophysiological and genetic methods. The female generated discrimination elipses compatible with trichromat vision and the male presented discrimination elipses compatible with dichromat vision.

3A3. Preliminary results showed difficulties in auditory discrimination by this species in laboratory conditions. Ongoing investigations are controlling/isolating procedural variables. The first successful studies to train auditory discrimination were based on the reduction of task complexity to adjust parametric variables of the successive discrimination procedure (as
the group has been doing with visual stimuli). With these procedural refinements, an ongoing study investigates the formation of functional classes by repeated reversals of auditory discriminations between six stimulus pairs. The next step will be to take advantage of the methodological advances to go back to the goal of investigating auditory-visual discrimination, that may permit to simulate features of human symbolic behavior.

Relational Learning in Dogs and Bees

3B.1. Estudos com cães demonstraram aprendizagem discriminativa simples e condicional, responder por exclusão e formação de classes funcionais, porém o volume de dados ainda é insuficiente para conclusões mais abrangentes. Novos projetos buscarão estender a generalidade dos dados, enquanto outros visam verificar a possibilidade de formação de classes de equivalência.

3C.1. Com abelhas foram demonstradas discriminações simples e condicionais por identidade, mas vêm sendo encontradas dificuldades ainda não resolvidas (de equipamento e de procedimento) no estabelecimento de discriminações condicionais arbitrárias e, consequentemente, na investigação da capacidade simbólica (ainda que rudimentar) desta espécie. O potencial de desenvolvimento de um modelo para a pesquisa de processos bioquímicos e moleculares relacionados a processos simbólicos ainda continua uma promessa, mas a pesquisa tem avançado (em colaboração com o professor Marcelo Valle, da UNB) com dados de discriminação simples.

TRANSLATIONAL SCIENCE

Populations with Developmental and/or Acquired Limitations in Symbolic Functioning

4: Perception, Discrimination, and Equivalence

4.1. The cumulative results aiming at understanding the development of processes of stimulus classification in human babies has produced the identification of optimal (or at least much improved) conditions and parameters of reinforcement, session duration, number of trials, and mastery criteria. Implementation of these conditions diminished experimental variability and yielded systematic and replicable data in the study of simple discrimination, discrimination reversal, identity conditional discrimination, generalized identity, and arbitrary conditional discrimination, in children in the age range of 15 to 24 months. The maintenance of the babies engaged in experimental sessions has been a fundamental conquest for the development of this line of investigation.

4.2. Studies on learning by exclusion advanced in several respects, including the demonstration of exclusion with children younger than those of previous studies.
4.2 (1) Babies with ages from 15 to 18 months showed exclusion responding, or fast mapping (rapid acquisition and retention of vocabulary, evidenced by emergent selections of an unfamiliar item in response to an unfamiliar item, concomitant with reliable selections of familiar items in response to familiar names), demonstrating, in new experimental preparations, the precociousness of this basic behavioral process in the human species. Animal studies of exclusion with Cebus and dogs also produced positive results, revealing an instigating prospect for data integration.

4.2 (2) Children with ages from 24 to 30 months learned by exclusion in the presence of new nonsense words simulating adjectives (properties), verbs (actions) and names, extending the generality of previously obtained data, which been described almost exclusively for names. This confirms the hypothesis that behavioral processes underlying exclusion with grammatical categories other than names are basically similar to those underlying names. This is an important contribution for the scientific analysis of processes of language acquisition in children with typical development, and may also be useful for planning preventive interventions with children at risk for delays in language acquisition.

4.3 Results on relational learning involving auditory stimuli, with children that recently received cochlear implant were extended and amplified. The institute demonstrated learning of auditory-visual conditional discriminations in this population, with various systematic replications. Results showed the incorporation of auditory stimuli into previously formed equivalence classes of visual stimuli, and the formation of new auditory-visual equivalence classes. A learning set effect (faster and more precise learning for successive problems) was also demonstrated. Children showed improvement in auditory tasks along a “curriculum” for teaching auditory-visual conditional discriminations with successive sets of words, and they also showed learning of auditory-visual conditional discrimination and recombinative generalization in matching-to-sample tasks with dictated sentences as samples.

Another advancement has been the improvement of a non-verbal operant procedure to obtain auditory tresholds with children with very recent implantation (who are not yet verbal). This procedure is been used not only in scientific research but also in clinical routines of implant adjustment.

5: Relational Learning in Basic Academics

5.1 The efficacy of a computerized individualized program to teach rudimentary reading skills, previously demonstrated with single subject designs, proved to be also robust in a group design. New studies explored variations in the basic procedure, such as specific differential consequences, adaptation of the program to a game setting, and access to games as a motivating condition to keep the student engaged in a longer teaching session.

5.2 (1) The Institute developed and evaluated a battery of tasks for assessment of pre-arithmetic behaviors, which will be important as a diagnostic tool.
5.2 (2) Studies demonstrated the efficacy of equivalence based instruction for the emergence of mathematical relations such as in teaching fractions.

6: Extensions to Neurobehavioral Science

6.1. Laboratory-Derived Neuropsychological Methodology. Researchers at the University of Massachusetts Medical School (UMMS, McIlvane, Dube) are in the late stage of a project designed to develop a mini-battery of neuropsychological tests for children with developmental limitations (e.g. preschool children, children with intellectual disabilities, etc.) that does not rely on syntactically-complex verbal instructions. The battery is designed also for adaptation to nonhuman primates, an extension that will be useful also in collaborations between the University Federal do Pará and the UMMS. The battery has tests for 1) sustained attention, 2) shifts in attention (executive functioning), 3) immediate and delayed memory, and 4) matching- and nonmatching to sample. There are two phases to the validation testing: 1) usability tests for psychologists and educators to assure that the test methods can be used appropriately by persons administering the tests and 2) tests of efficacy with children. The usability tests with professionals are underway, and the data to date indicate that the tests are both useful and desired by the target audience. The tests with children are also underway. Data thus far show that these tests can be used effectively with typically developing children in the 3-5 year age range. Data from the children with intellectual disabilities are also promising, but further work is indicated to adapt the methods for use with totally nonverbal children. We hope to complete the main phases of the project by December 2010, including efficacy evaluations on all of the neuropsychological tests with the children. Subsequent work will be targeted at reaching nonverbal children reliably via implementing a variety of stimulus control shaping methods that have been developed for this population in laboratory research conducted at UMMS and collaborating universities within the INCT-ECCE network.

6.2 Translational Studies of Neurobehavioral Effects of Mercury Exposure. This project is a collaboration between UMMS and UFPA researchers who will study the effects of mercury exposure on children in gold-mining areas of Brasil and in a nonhuman primate model. The work will be funded by the US National Institute of Environmental Health Sciences. Although this project was approved by the relevant Ethics Committees at UMMS and UFPA more than 16 months ago, securing the necessary approvals from the Brasilian and US governments required much more time than was anticipated. Approvals in Brasil were finalized in February 2010 and those in the US were finalized only in mid-April 2010. The US NIEHS is now in the process of issuing a "notice of grant award" (NOGA) to UMMS, which will allow the release of the financial support for the project. The NOGA is expected on or about May 1, 2010, which will permit the project to go forward. The initial planning meetings for the project will occur in late May 2010 when US and Brasilian researchers will meet at the meeting of the Association for Behavior Analysis in San Antonio (the end of May 2010) and in
a follow-up at the ANPEPP meeting in Fortaleza in June 2010. We hope to have the funding subcontract issued to UFPA by July 1, 2010 to support the Brazilian collaborators working on the project.

APPLIED SCIENCE PROGRAM

Dissemination of Methods for Delivering Efficient, Cost-Effective, Evidence-Based Behavioral Technology


This Institute program aims at the development of solutions with adequate cost-benefit ratio for demands for ample dissemination of evidence based procedures to teach symbolic repertoires. Procedures for computerized individualized teaching that showed validity and feasibility in small scale tests in natural environments are now being transposed for large scale tests. One of the main developments at the Institute in 2009 was the software Platform Gerenciador de Ensino Individualizado por Computador (GEIC, Manager of Computerized Individualized Teaching). Research on the evaluation of the viability of application of the teaching programs on reading and writing in this new mode and in large scale is being conducted using this platform. It involves 10 schools and more than 400 students which will generate data on more than 4000 teaching sessions; the global data collected in 2010 will yield a reliable analysis of the system’s viability. If the evaluation is successful, access to the program modules will be extended for use in the classrooms. Along the same line, curriculum modules will be designed and evaluated for the teaching of Mathematics as well as for distance audio rehabilitation (under the supervision of speech therapists and parents) for cochlear implant users.

Publications: References of Journal Articles, Books and Book Chapters

Details of research methods and results obtained during the period covered by this report are described in published and in press reports (papers, books, and book chapters), listed below (and also in master's theses and doctoral dissertations listed in the Academic Program section). The papers’ full texts are available at http://www.ufscar.br/ecce. Extended abstracts of selected papers are presented in the Appendix.

Figure 3 shows the frequency distribution of publications: 59 journal articles (36 in Brazilian journals; 23 in International journals), five books, and 14 book chapters. The average number of articles for researcher (n=24) was 2.45 and average of all items was 3.25.
Figure 3. Distribution of published and in press articles, books and book chapters during the project’s first year (2009-2010).

These numbers do not include publications of participants from the UMMAS, unless they were co-authored by Brazilian participants, nor papers published in 2009, but dated as earlier than 2009 (in cases of a journal’s schedule being late). Compared to previous publications rates of this group (data available in the original proposal, p.115) the percentage of published papers was 61.5% higher than the average during the period between 1998 and 2008 (19.2 per year) and 24% higher than the average (25) in 2006 – 2007. Based on the number of in press (26) and submitted articles (15), and on the commitment of the Institute members in submitting papers in preparation along this year, we estimate a larger increase in the publications rates for the next year. The Institute is also committed to looking for an increase in publications in international journals.

The following list of references of articles and books presents published items and in press items separately.

JOURNAL ARTICLES

International Journals

Published


3. Debert, P., Huziwara, E., Faggiani, R., Mathis, M.E., & McIlvane, W.J. (2009). Emergent conditional relations in a go/no-go procedure: Figure-ground and


**In Press**


23


**National Journals**

**Published**


**In Press**


and specific reinforcers on auditory-visual discriminatinon in capuchin monkeys].
Temas em Psicologia.

**BOOKS**

**Published**


**In Press**


**BOOK CHAPTERS**

**Published**


In Press


**SOFTWARES**


THE ACADEMIC PROGRAM: SHAPING SCIENTIFIC COMPETENCIES

Teaching and supervision in research training

The objectives of the Institute related to the professional development of young scientists within the program have been explored through teaching at the undergraduate and graduate levels, supervising research projects of undergraduate and graduate students, and by establishing ongoing, well-defined mentor-mentee relationships between senior and mid-career faculty participating in the program.

At the undergraduate level, disciplines on topics such as learning, behavior analysis, cognition, human development, motivation, research methods, tactics of scientific research, provide the conceptual and methodological foundations for the investigation of basic behavioral processes that are requisites for the students’ involvement with research projects (and have worked as an important source of students’ recruitment). These disciplines usually combine a strong emphasis on both teaching and research (basic and applied); it has been a systematic practice of this group to teach by providing all students enrolled in their disciplines (and not only a few students) with opportunities for participating in research activities.

At the graduate level, all the graduate programs of the affiliated institutions maintain disciplines directly relevant to the focus of the Institute (except for UNCISAL and UNESP-Marilia, which do not have graduate programs in this area). Also, the research in these programs is organized in research nuclei (or lines), most of them with the participation or leadership of faculty members affiliated to the INCT. For example, at UFSCar, the Graduate Program in Special Education and the Graduate Program in Psychology established, respectively, a nucleus on Learning and Cognition, and on Behavioral Analysis of Cognition. The Graduate Program in Experimental Psychology at USP has a nucleus on the analysis of operant behavior. The Graduate Program in Behavioral Sciences at UNB has two nuclei: Basic Behavioral Processes and Experimental Analysis of Behavior. Learning and Teaching is the focus at UNESP-Bauru. The Graduate Program in Behavior Theory and Research from UFPA presents Experimental Analysis of Behavior: Basic psychological processes, and the analysis of behavior: development of behavioral technology, as two research lines. And faculty members of the INCT in UFPA are currently planning the implementation of a bachelor’s degree in Behavioral Sciences.

Table 3 presents the number of students in different levels, supervised in research projects during 2009-2010. Sixty-four (68) completed their work during this period, and 122 are participating in ongoing projects. During the period covered by this report, the faculty supervised the projects of 54 undergraduate students (19 completed and 35 underway), 58 master’s theses (25 approved and 33 underway), 52 doctoral dissertations (11 approved and 42 ongoing projects), 11 post-doctoral works (four concluded and seven underway); 11
students had scholarships for technical training. The current amount of master’s and doctoral students (75) is close to the proposed goals (80 students per year).

**Table 4** shows the distribution of scholarships from national and state Brazilian funding agencies supporting the students’ scientific development. The average of students with financial support was 88.2% (range: 50-100%) among those who completed their projects and 78.7% (range: 66.7-100.0%) among those with projects in progress. Many graduate students were recruited for the first academic semester of 2010; the percentage of students with financial support may increase, depending on the approval of their projects by the funding agencies.

The students have been achieving progress in the scientific training track. Several undergraduate students were accepted in graduate programs; master students were accepted in doctoral programs; two post-doctoral researches were hired as faculty teachers.

The Institute’s effort in the development of new human resources for the research area is clear. The amount of students under direct supervision of the faculty members has the approximate dimensions of a regular graduate Program in Human Sciences in Brazil. An important aspect of this work is the practice of creating opportunities for students in different levels work together, during the laboratories routines, in meetings for discussion of ongoing work (reflections on its directions and significance), during scientific meetings. These practices produce a circulation of shared knowledge (on the broad range of research questions being investigated, procedures, techniques, problem solving strategies, among others) that seems fundamental for the preparation of researchers with an open and critic perspective about their research area, and about what this kind of work requires.

It is expected that at least a proportion of these students will maintain the symbolic functioning as the focus of their studies and/or professional carriers, thus attaining the Institute’s goals in developing future leadership.
Table 3.

Distribution of students participating in the INCT-ECCE research projects during 2009-2010.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>UNIVERSITIES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UFSCar</td>
<td>USP</td>
</tr>
<tr>
<td>COMPLETED PROJECTS</td>
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<tr>
<td>Undergraduate</td>
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<td>2</td>
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<tr>
<td>Master</td>
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<td>5</td>
</tr>
<tr>
<td>Doctoral</td>
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<td>5</td>
</tr>
<tr>
<td>Post-Doctoral</td>
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<td>2</td>
</tr>
<tr>
<td>Technical Training</td>
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<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
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<td>15</td>
</tr>
<tr>
<td>ONGOING PROJECTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
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<td>2</td>
</tr>
<tr>
<td>Master</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Doctoral</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Post-Doctoral</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Technical Training</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>40</td>
<td>27</td>
</tr>
</tbody>
</table>
Table 4

Distribution of students receiving scholarships for participation in the INCT-ECCE research projects during 2009-2010

<table>
<thead>
<tr>
<th>LEVEL (N)</th>
<th>FUNDING AGENCIES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CNPq</td>
<td>CAPES (SP)</td>
</tr>
<tr>
<td>Undergraduate (19)</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Master (25)</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Doctoral (11)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Post-Doctoral (4)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technical (9)</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total (68)</strong></td>
<td><strong>18</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

*Four masters and four doctoral scholarships underway are granted by CAPES to the INCTs’ Program, as well as the scholarships for technical training from CNPq (and there is a PD scholarship available to the INCT, that will be implemented next June).*
Complete references of Doctoral Dissertations and Master Theses supervised by the Institute faculty during this last year are listed below; their abstracts are available at http://www.ufscar.br/ecce and clicking on the titles gives access to full texts (except for recent dissertations yet not available*).

DOCTORAL DISSERTATIONS


Leila Felippe Bagaiolo Raphaelli (MMCHübner). *Padrões de aquisição de discriminação condicional durante a emergência do controle por unidades verbais mínimas na leitura em crianças com autismo e desenvolvimento típico* [Conditional discrimination acquisition patterns during the emergence of control by minimal verbal units in reading in autistic and typically developing children]. Programa de Pós-Graduação em Psicologia Experimental. USP. CNPq. Abr/2009.


Natalia Freitas Rossi (CMGiacheti). Caracterização do fenótipo comportamental e de linguagem na Síndrome de Williams-Beuren [Characterization of the behavioral and


**MASTER THeses**


Ariene Coelho Souza (MMCHübner). Efeitos do ensino de palavras monossilábicas via treino de relações condicionais arbitrárias sobre o controle por unidades mínimas em leitura recombinativa [Effects of teaching one syllable words via arbitrary conditional relations training on the control by minimal units in reading]. Dissertação. Programa de Pós-Graduação em Psicologia Experimental. USP. CAPES. Jun/2009.


Erick Rôso Huber (ESHanna). *Avaliação do ensino cumulativo de relações entre estímulos musicais sobre a formação de classes, o desempenho recombinativo e o tocar teclado* [Evaluation of cumulative teaching of musical stimuli relation on class formation, recombinative performance and playing the keyboard]. Dissertação. Programa de Pós-Graduação em Ciências do Comportamento. UNB. CAPES. Fev/2010


Juliana Ribeiro Diniz Souza (ESHanna). *Avaliação do tipo de resposta requerida e do procedimento de ensino no estabelecimento de controle de estímulos compostos* [Assessing the effects of the type of required responding and teaching procedure on


SOME IMPACTS OF THE INSTITUTE’S RESEARCH

In our research area the time that elapses between data collection and the actual publication of a manuscript is typically very long, especially in comparison to other areas. It is common to see many years pass between the beginning of a project and publication of the results. It is estimated that, for that very reason, the impact of work that has been recently conducted at the INCT will only be felt after a few years. What we can describe in this report is the impact of earlier research, mostly originated at the Nucleus of Studies on Behavior, Cognition and Teaching (Núcleo de Estudos sobre Comportamento, Cognição e Ensino-ECCE) which preceded and provided the seed for the current INCT. Therefore, we describe below how the earlier research produced different effects on the scientific community and the larger society, which may be considered, in a broad sense, as impacts of this research.

Complex relational learning

Research to validate stimulus equivalence as a model for symbolic behavior (e.g. Bortoloti & de Rose, 2009), attracted attention from researchers in the field even before results were published in journals, with convention presentations of the underlying assumption that the model can be strengthened if it resists tests with instruments that are independent of the model itself, such as the semantic differential. The project already yielded four published papers and two in press. Two of these are in journals of international visibility, *The Psychological Record* (Bortoloti & de Rose, 2009) and *Psicologia: Reflexão e Crítica* (Bortoloti & de Rose, in press), both international journals indexed by ISI.

Research on basic processes of repertoire recombination has the potential of having a major impact given the development of an artificial linguistic mini-system that allows rigorous experimental control to disentangle the effects of different variables concerning the learning history from the effects of experimental variables. Two papers were published in national journals. Another one is currently in press and one was submitted to the *Journal of the Experimental Analysis of Behavior* (JEAB), the most prestigious and selective journal in this research area. Interestingly, this type of research was originated from translational research on reading and writing acquisition – the difficulty in experimental control due to the fact that the studies had to be conducted while students were at school (and that could not be otherwise), was a challenge that led to the MSL proposal and the subsequent studies.

Similarly, an interesting derivation of research on reading is a line of investigation recently created by ECCE researchers which has been continued at INCT on musical reading: the acquisition of musical reading in musically illiterate individuals models a system that disentangles acquisition processes of symbolic relations from the past symbolic learning. Two master's theses on the subject have been produced at UNB and one paper is in press at *The Analysis of Verbal Behavior* (Perez & de Rose, in press), which will be published in the 2010 volume.
Selective attention and observation in symbolic tasks

Studies on selective attention and observation behavior, critical for the reliable investigation of controlling relations in simple and conditional discrimination tasks, are one of the fruits of the partnership between USP and UMMS; at USP, three master’s theses and one doctoral dissertation (Hamasaki, 2009) on observing response have been concluded, one doctoral dissertation will be concluded soon, four papers were published (for example, Pessoa et al., 2009, Journal of Eye Movement Research) and one is in press at the Journal of the Experimental Analysis of Behavior.

The empirical basis of conditions for establishing symbolic behavior (beyond the standard matching-to-sample procedure) and, additionally, for standardizing new procedures and experimental protocols, which broaden the research possibilities in the area, have been extended to studies with simultaneous and successive simple discrimination procedures (go/no go). At USP, two papers were published at the Journal of the Experimental Analysis of Behavior (Debert, Matos, & McIlvane, 2007; Debert et al., 2009) and one at Acta Comportamentalia (Perez, Campos, & Debert, 2009). Two master’s theses on the topic have been concluded at USP (Campos, 2009; Hora, 2009), one at UFSCar (Canovas, 2010), three at UPA (Liane Souza, 2009; R. Borges, 2010; S. Maués, 2010) and one doctoral dissertation at UNB (Moreira, 2010).

Experimental School for Primates and animal models of symbolic behavior

At the Experimental School for Primates (EEP), there are currently four INCT researchers, one post-doctoral fellow, four doctoral students, nine master students and 11 undergraduate students who are now working either on Scientific Initiation projects or their Honor’s theses. EEP has had many master and doctoral graduates and has offered research opportunities for a great number of undergraduate students.

EEP developed methodology for teaching and evaluation of pre-symbolic repertoires in Capuchin monkeys, which has recently been used in the investigation of visual and auditory perception in this species. The main finding was probably the demonstration of a generalized identity concept in this species. Equally important were the identification of specific relations of stimulus control on the performances of those individuals in the baseline and in tests of emergent relations. The international recognition of these studies is reflected by the publication of five papers in journals indexed by ISI in recent years, an expressive number especially considering the long time of investment in preparation and data collection in each one of these studies. Another important achievement of EEP has been the international interest it has been attracting given that this line of work has generated behavioral technology for the instruction of non verbal individuals. This type of technology can be applied to socially relevant problem solving, for example, the development by EEP researchers, in collaboration with the University of Massachusetts, of a battery of non verbal executive functioning tests which should be used to evaluate cognitive deficits caused by mercury contamination in Amazonia. The use of a non verbal battery could solve reliability
problems that have been found in standard testing that requires verbal instruction. Recent funding from NIEHS is an important impact of work being developed at EEP. A sign of the increasing international repercussion of behavioral technology being developed at EEP is the interest displayed by different international researchers in learning about this methodology, as was the recent case of Dr. Valentina Truppa from the *Instituto di Scienze e Tecnologie della Cognizione* in Rome, Italy.

The studies with infrahuman’s at The Experimental School for Primates which were previously conducted at INCT are expanded at the current Institute with more species being studied in projects involving animal models, like dogs and bees. The first studies with these species have just recently been published in national journals.

**Symbolic functioning in non verbal populations or with developmental delays**

**Identity matching and arbitrary matching in infants**

At INCT, one line of investigation, which had been started at ECCE, has been continued by three groups of researchers affiliated to labs from three different federal institutions. They have been working to create and test efficient methodologies for the study of precursors to symbolic behavior in babies and children up to 36 months. This line of research is relevant mainly for its potential to offer empirical basis to explanatory models of human symbolic functioning and to develop stimulation procedures for babies with developmental risks. Given the challenging nature of the task, one of the most important contributions of this group was the development of a methodology to investigate relational behavior in babies. Based on one doctoral dissertation and six master’s theses, the group has been able to publish different papers in national journals (Oliveira & Gil, 2008; Silva & Souza, 2009) and one has been accepted at *The Psychological Record* (Gil & Oliveira, in press).

**Exclusion Responding : a behavioral process and a procedure**

Research on responding by exclusion or fast mapping possibly involved in the rapid acquisition and retention of vocabulary has been conducted in collaboration between INCT researchers for many years in two different lines: the description of basic processes and application with the incorporation of opportunity to respond by exclusion as a procedural characteristic to promote learning. At UFSCar, two master’s theses and one doctoral dissertation in the first line have been defended and papers have been published at *The Psychological Record, Psicologia: Reflexão e Crítica, Revista Brasileira de Análise do Comportamento, Temas em Psicologia* and one paper is in press at *Acta Comportamentalia,* With regards to teaching, the procedure was administered in reading and writing programs (translational research) but more recently, it has been administered in preparations with babies and monkeys, resulting in robust learning when other procedures have failed. This interaction between the predictable behavior process and its management as a tool for the investigation of other processes has proved to be very productive (that is, has had an impact
on the progression of research at the Institute). Several papers are in preparation and should be submitted soon.

**Deafness and cochlear implant**

The collaboration between researchers that worked in the previous PRONEX project with the Center for Audiological Research at the Rehabilitation Hospital of Craniofacial Anomalies (CPA/HRAC) at USP in Bauru, which is considered one of the best implant surgery teams in Brazil (especially with babies), led us to invite to the INCT team Dr. Maria Cecilia Bevilacqua from CPA/HRAC, one our main collaborators now.

The collaboration with CPA/HRAC has goals that include scientific contribution and the development of useful technology for auditory rehabilitation in children who have received cochlear implants. Whereas the majority of studies on language development (production and comprehension) in implanted individuals have a descriptive and correlational nature (longitudinal follow-up and use of scales), the Institute has been documenting learning step by step, under rigorous experimental control; the methodologies being developed have the potential to contribute to the elucidation of failed cases or partial success cases of implant and the investigative procedures have the potential to generate rehabilitation technologies for this population.

Three doctoral dissertations and four master’s theses have been concluded and some of the most important findings have recently been published at the *Journal of the Experimental Analysis of Behavior* (Almeida-Verdu et al., 2008). This publication is an example of how long work in this area may take, since it groups the results from four experiments which have been conducted as work for one doctoral dissertation and one master’s thesis in the period of six years between the beginning of the project and publication of the final work. In addition to the scientific contribution of this work, which demonstrates the establishment of symbolic relations involving auditory stimuli in children with cochlear implant and identifies variables related to the development of these relations, it is hoped that this work results in effective practices of auditory rehabilitation for children with cochlear implants. A more direct contribution is probably the work of Silva, de Souza, Bevilacqua, Kimura and Lopes Jr. (in press), to be published at *Psicologia: Reflexão e Crítica*, which reports a non-verbal procedure to measure auditory thresholds and maximum comfort boundaries, which can be applied in the regulation of recent cochlear implants. This procedure has been refined in subsequent studies and is currently being used in clinical routines at CPA/HRAC.

**Procedures for the teaching of reading, writing and Mathematics based on stimuli equivalence and recombination of unities**

The group that founded INCT has published in this area since 1989 and in 1996 the work with the greatest repercussion so far was published (de Rose, de Souza & Hanna, 1996). The amount of repercussion this work has generated can be measured by the international impact- ISIS database—by reference books in the area and by the number of
citations in Brazilian journals. This work, published at the *Journal of Applied Behavior Analysis* has been cited 25 times in journals indexed by ISI. The number of citations is not small for the area, especially if we consider the work is on teaching reading in Portuguese. On the other hand, this work has also been cited in Brazilian published papers, in journals that are not included in the ISI database, therefore, the number of citations in this database is only a partial indicator of its impact. Additionally, this paper is also cited in one of the most renowned text books in the area of Applied Behavior Analysis (Cooper, Heron & Heward, 2007). In this book, de Rose, de Souza & Hanna’s paper (1996) is described and presented as a model for the application of stimuli equivalence processes in teaching. This application has been recently referred to as EBI (equivalence based instruction) and is a topic of many recent papers which expand EBI to new contexts, not only for the teaching of individuals with mental disabilities or learning disabilities. Recent publications have reported on the use of EBI on, for example, teaching of college level Mathematics, Neuroscience and Statistics, and de Rose et al.’s work is cited in some of these most recent publications as a demonstration of EBI applicability.

As a result of the repercussion of these studies, some INCT members have been invited to contribute a chapter (de Souza, de Rose, & Domeniconi, 2009) for the book organized by R. A. Rehfeldt and Y. Barnes-Holmes, *Derived Relational Responding. Applications for Learners with Autism and other Developmental Disabilities* (Rehfeldt & Barnes-Holmes, 2009). In this book’s preface, the renowned theorist and researcher Steven Hayes considers it a unique accomplishment in applied psychology and says: “I know of no other book that extends a single approach within basic experimental psychology into intervention programs across the full range of issues that need to be addressed in applied work in human language and cognition.” The participation of INCT members in such endeavor is certainly an important impact of work that has been developed by this group.

Another important impact of this scientific work on the teaching of reading and writing is the application of acquired knowledge and of developed institutional programs in the remediation of learning disabilities in reading and writing. Initially, this application was done in Computerized Classrooms for Beginning Readers (Unidades de Iniciação à Leitura). The UFSCar classroom, for instance, has been operative since 1998, in collaboration with public schools. These schools identify children with learning disabilities who are driven to the UFSCar classroom. Children participate in three different instructional programs using the computer and they start with the rudiments of reading and writing isolated words until they reach full reading (and comprehension) of texts. In addition to students from these schools, some parents also come to the center for help and are readily received by the research assistants. The classroom has received about 800 children since its foundation in extensive programs which generally involve 60 sessions with the children. Other classrooms have been recently created at UNB, UFPA and UNCISAL.
This classrooms and their instructional programs attracted interest of many towns in its vicinity which are willing to implement the program and thus reach all the students with learning disabilities in the area. The implementation of these reading classrooms started with two small towns (Boa Esperança do Sul, SP, and Muzambinho, MG) using the instructional programs developed by INCT researchers to help all the students with learning disabilities in reading and writing in the schools. Although the work has been interrupted in Muzambinho, it is still being used in Boa Esperança do Sul, where approximately 480 students have been instructed in the past five years. A similar service has been implemented three years ago in some schools in a larger town (Limeira, SP) and since 2008, it has been adopted by the Municipal Secretary of Education in Ibaté (SP) to be used in nine municipal schools. The expansion of the application of instructional programs has resulted in more demand from the municipal towns which have been investing on resources to help implement the program in their schools, mainly, on hiring and training of teachers and trainees. The direct application of this teaching program on solving real educational problems has reinforced the promising results obtained in experimental situations, also showing that the program can contribute to decrease school failure in concrete situations (e.g., de Souza et al., 2009; Reis, de Souza, & de Rose, 2009). Therefore, the work by INCT members has already had an impact on public policy regarding municipal education, which may increase as this work becomes more familiar to educators and administrators. It is hoped that this impact may be expanded with the possibility of access to instructional programs via internet, to be performed by the GEIC platform. In order to increase the dissemination and the consequent impact of the results obtained so far, the group has also been publishing work in Brazilian journals in the area of Education, as is the case of Reis, de Souza e de Rose (2009).
APPENDIX

Extended Abstracts of Selected Papers


A conditional discrimination establishes a relation between a set of two or more samples (e.g., A1, A2, ..., An) and a set of two or more comparison stimuli (e.g., B1, B2, ..., Bn), so that in the presence of sample An, selections of comparison stimulus Bn are reinforced whereas selections of any other comparison stimulus are unreinforced. Such a conditional discrimination is conventionally designated as AB, whereas the sets of samples and comparisons are designated as A and B, respectively. Sidman and Tailby (1982) showed that conditional discriminations learned by humans are usually equivalence relations, possessing the mathematical properties of reflexivity, symmetry, and transitivity. According to Sidman and Tailby (1982; see also Sidman, 1994, 2000), equivalence relations are symbolic. Therefore, if conditional discriminations such as AB and BC are shown to be equivalence relations, the related stimuli (An, Bn, and Cn) comprise classes of equivalent stimuli and each member of the class may be considered as a symbol of the others.

A previous work (Bortoloti & de Rose, 2007) examined the induction of meaning through equivalence relations using a semantic differential (Osgood, Suci & Tannenbaum, 1957). The semantic differential is a technique to measure the meaning of “concepts” (words, locutions, pictures, figures, etc). A concept is presented and participants have to assign Likert-type values ranging from -3 to +3 along many scales that are anchored by opposite adjectives (e.g., good and bad). Indifference related to any pair of adjectives is evaluated as 0. The measurement of meaning is based on the scatter of the scale values. This assessment device allows registering, quantifying and comparing the meaning of one or many concepts, for one or many participants, in one or many situations.

The experimental design employed by Bortoloti and de Rose (2007) involved two groups of college students. First, participants of an experimental group established three equivalence classes comprising pictures of human faces expressing emotions (presumed meaningful stimuli) and abstract pictures (presumed meaningless stimuli). Then, they evaluated some of the abstract stimuli through a semantic differential (a set of 7-point scales anchored by opposite adjectives, see Figure 1) and these evaluations were compared to evaluations made by a control group. The semantic differential scores for the abstract stimuli in the control group were compared to the corresponding scores for the same stimuli in the experimental group. A difference in scores could be attributed to the inclusion of these stimuli in the equivalence classes. The semantic differential scores produced by the abstract stimuli in the equivalence classes were also compared with the scores produced by the faces for the control group.
A happy face produced highly positive scores; angry and disgusted faces produced highly negative scores. The abstract stimuli in the control group produced scores that approached 0. The same stimuli when included in the equivalence classes produced scores that were similar to those produced by the faces in the corresponding class. This outcome demonstrated that the abstract stimuli acquired the meaning of the highly valenced faces equivalent to them. The comparison between values attributed to the faces and to the pictures generated also a quantitative assessment of transfer of functions which can be used to estimate the relatedness of these stimuli. This strategy was employed in the two experiments reported in the present study.

**Experiment 1**

Mathematically, equivalent stimuli are, by definition, equally related to each other. However, data by Fields and colleagues have suggested that stimuli that are members of equivalence classes may differ in their degree of “relatedness,” as a function of several experimental parameters (e.g., Fields, Adams, Verhave, & Newman, 1993).

Fields et al (1993) suggested a procedure to investigate quantitative variations in the relatedness of equivalent stimuli. According to the authors, conditional discrimination tests for equivalence involve only forced choices among discrete alternatives; consistent performances reveal that the participant established a contextualized equivalence among the related stimuli, but these performances do not permit a verification of quantitative differences
in the relations. One possible strategy to assess the relatedness of equivalent stimuli would involve the measurement of the transfer of functions established between them. Variations in the sharing of functions would indicate variations in the relatedness of equivalent stimuli.

This study used the semantic differential to compare effects of simultaneous and delayed matching to sample training on the transfer of function (induction of meaning) across equivalent stimuli. Subjects in two experimental groups formed three equivalence classes that had a nodal structure $B \leftarrow A \rightarrow C \rightarrow D$. The A stimuli were four different pictures of happy faces in one class, four pictures of angry faces in another class, and four pictures of neutral faces in a third class. The B, C, and D stimuli were meaningless abstract visual stimuli, as shown in Figure 2.

![Figure 2. Stimuli employed in Experiment 1.](image)

After class formation, the D stimuli from the happy and angry classes were presented with a semantic differential evaluation form. The two experimental groups differed in terms of the temporal overlap of the sample and comparison stimuli used in training and testing. In one group, the trials were presented in a simultaneous MTS format (SMTS) where the sample remained present together with the comparison stimulus until the participant made a choice. In the delayed MTS format, the sample stimulus disappeared 2 seconds before the onset of the comparison stimuli (DMTS). In the control group, participants evaluated through the semantic differential the 12 faces and the three D stimuli used as members of the equivalence classes in the experimental group. These participants did not receive conditional discrimination training. Semantic differentials were obtained separately for the D stimuli in the Happy and the Angry classes in both experimental conditions.

The scores for the D stimuli in the control group were compared to the corresponding scores for the D stimuli in the experimental groups after the formation of the equivalence classes. The scores produced by the D stimuli in the equivalence classes were also
compared with the scores produced by the A faces from the control group. These comparisons were made for participants in each of the experimental conditions. Finally, the differences in the scores of faces and D stimuli were compared for the participants who formed classes using trials presented in the SMTS and the DMTS formats. In general, the happy faces produced scores that were highly positives, and angry faces produced highly negative scores. The D stimuli in the control group produced scores that approached 0. The same D stimuli when included in equivalence classes produced scores that were similar to those produced by the faces equivalent to them, but the DMTS group assigned average values closer to the values assigned to the faces than the SMTS group.

**Experiment 2**

This study employed the same methodology to evaluate effects of delayed matching to sample and nodal number on the relatedness of equivalent stimuli. Participants in two experimental groups received a conditional discrimination training to establish three 7-member equivalence classes that had the nodal structure $B \leftarrow A \rightarrow C \rightarrow D \rightarrow E \rightarrow F \rightarrow G$. The trials were presented in a SMTS format for one group and in a DMTS format for the other. The A stimuli were four pictures of happy faces in one class, four pictures of angry faces in another class, and four pictures of neutral faces in the third class. The B, C, D, E, F and G stimuli were meaningless abstract visual stimuli, as shown in Figure 3.

The blocks of probe trials BG and GB tested equivalence class formation. More participants in the DMTS condition established equivalence classes. After class formation, half of the participants in each group evaluated the D stimuli (one node from the faces) and the other half evaluated the F stimuli (three nodes from the faces). The members of a control group evaluated the faces. Semantic differential scores were obtained for the happy and the angry faces in the control group and separately for the D and F stimuli in the Happy and the Angry classes in the experimental conditions.
The scores produced by the D and the F stimuli in the equivalence classes were compared with the scores produced by the A faces from the control group. These comparisons were made for subjects in each of the experimental conditions. The differences in the face-D and in the face-F scores were also compared for the subjects who formed classes using trials presented in the SMTS and the DMTS formats. The happy faces produced highly positive scores, and the angry faces produced highly negatives scores. The evaluations of the stimuli one node from the faces (D) were similar to the evaluations of the faces whereas the evaluations of the stimuli three nodes from the faces (F) were not similar. Comparing the similar evaluations, the DMTS group assigned average values closer to the values assigned to the faces than the SMTS group.

General discussion

Stimulus equivalence was proposed as a model to infer symbolic relations from observable behaviors. Although the results of stimulus equivalence studies have been very robust and consistent, they have not assessed the symbolic character of equivalent stimuli through instruments external to the equivalence model itself. The use of semantic differential scales in the present study permitted to determine that abstract stimuli, originally without meaning, acquire meanings similar to those of the facial expressions, through equivalence relations. Happy faces and the stimuli equivalent to them were judged positively whereas angry faces and stimuli equivalent to them were judged negatively. These data may confer external validity to stimulus equivalence as a model of meaning.

Results of this work show that a DMTS training can enhance and the nodal number can reduce the transfer of functions between equivalent stimuli, supporting the idea that the relatedness of stimuli can vary as a function of the experimental parameters employed. Tests of emergent relations conducted with conditional discrimination procedures could not reveal such differences: matching tests can reveal the presence of an emergent relation but not any possible difference in the degree of relatedness.

Taken together, the results of these two studies suggest that the methodology presented here may be useful for the investigation of quantitative parameters of equivalence relations. This methodology permits to evaluate to what extent abstract stimuli (“symbols”) acquire properties of meaningful stimuli (“referents”). The methodology was sensitive to the delay and the nodal number parameters. It is likely that the same methodology can be used to evaluate other parameters of class formation.

REFERENCES


This paper describes results of a sustained and accelerating effort to develop an effective program for teaching foundations of reading and spelling to Brazilian children, many of them socially disadvantaged and/or intellectually disabled. This program had its roots in Skinner’s (1957) analysis of “minimal units” in verbal relations and in laboratory-derived methods for promoting emergent behavior. The program addressed two key components of reading repertoires identified by behavior analysts (e.g., Skinner 1957): textual/echoic behavior and reading comprehension.

Development of textual and echoic repertoires may be critical to the development of a skilled reading repertoire (Skinner, 1957). Indeed, in calling attention to these functional relationships, Skinner pointed to phonological awareness, the ability to recognize the sounds that constitute words as repeatable units (in behavioral terms, discrimination and abstraction of within-word sound units, cf. Mueller, Olmi & Saunders, 2000) that is now assumed to underlie skilled reading repertoires (Goswani, & Bryant, 1990; Torgensen et al., 1992).

Words within a phrase, sentence, or other word sequence, can function as minimal textual units (recombinative generalization, cf. Goldstein, 1983, 1993). Illustrating the flexible nature of verbal relations, one can extend the recombinative approach to minimal units within individual words. The Portuguese language is especially well-suited to illustrate such minimal unit recombination, because many of its words are composed of combinations of consonant-vowel units. Much research within the Brazilian program has shown, for example, that when direct teaching that establishes appropriate oral naming of words comprised of such separable units (e.g., BOLO (BO+LO), VACA (VA+CA), that learning may be accompanied by emergent naming of recombinations of the constituent units (i.e., BOCA, CABO, LOBO) (de Rose, de Souza, Rossito, & de Rose, 1992).

The failure of much conventional reading instruction is a global problem, especially in developing nations. Our working hypothesis is that this problem can be resolved via a well-defined behavioral technology inspired by key aspects of Skinner’s (1957) analysis of verbal behavior and other advances in behavior analytic science, such as methodology for developing equivalence relations (Sidman & Tailby, 1982). An overarching goal of this research program has been to develop methodology that imbeds within it procedures for establishing the range of functional relations that constitute the basis for a functional reading repertoire. The methodology has evolved over a number of years of research that has progressively refined the techniques (e.g., de Rose, de Souza, & Hanna, 1996; Melchiori, de Souza, & de Rose, 2000; Matos, Avanzi, & McIlvane, 2006).
Overview of Present Study

Our working hypothesis was that contingencies designed in line with the analysis of Skinner (1957) and the procedures of Mackay and Sidman (1984) could prove sufficient to establish generative reading i.e., performances that emerge without direct training). We sought to encourage such behavior by also teaching the children to match printed to dictate syllables and to construct words with syllables – thereby establishing/verifying the necessary discriminations and relations involving syllable sounds and corresponding printed syllable units.

STUDY 1

Method

Participants

Participants were 12 children aged 8-12 years. All were selected based on teacher reports of protracted failure to acquire reading skills in school and a preliminary assessment test. Children were asked to read orally words presented one by one and to spell those words to dictation. Two response modes were assessed in spelling: constructed response and cursive writing. Ten of these assessment words were included in the teaching program (Training words) and five were used only during tests (Generalization words). No feedback was given.

Setting and Materials. The study was conducted in a laboratory at Universidade Federal de São Carlos, a university-based learning center that maintained certain aspects of laboratory conditions. Experimental operations on the computer were controlled by custom software written for that purpose.

Stimuli. All children were exposed to a computer-based teaching program that was organized in a series of units. The teaching program used common words in Portuguese that could be easily represented by pictures (the same words used by de Rose et al., 1996). Some words were used for training (Training words), while other words were used only for assessing recombinative reading (Generalization words).

Scheduling. Sessions were scheduled five days a week, but the actual number varied. Total length of participation in the study was variable due to factors such as the schedule of academic semesters, but 3-6 months of exposure to the curriculum was typical.

Procedures

The teaching program was a superset of the procedures described by de Rose and colleagues (1996). The main teaching goal was to establish accurate matching of printed word comparison stimuli to dictated-word sample stimuli. To that end, a CRMTS task was implemented to require children to copy printed-word sample stimuli (i.e., CRMTS identity matching), a procedure that verified letter-by-letter discrimination of the printed words.
Additions to the program were (1) a requirement that children learn to match printed syllables to dictated syllable names (i.e., the minimal units) and (2) computer-based teaching rather than the tabletop procedure used in previous versions (cf. de Rose et al., 1996; Melchiori et al., 2000). Syllable matching procedures were implemented in each teaching unit only after the child had learned to match the corresponding printed words and dictated words.

**General program structure.** The program was comprised of 17 teaching units and 11 assessment units. This implementation differed somewhat from previous ones, with the combined objectives of increasing the efficiency of training and testing and rendering the program suitable for automating most tasks.

Pretests and Post-tests included behavioral relations BC, CB, and CD, and a new relation AE, spelling words in response to dictation. Post-tests, distributed across two sessions, included (1) all of the words from a given training set, (2) newly introduced common Portuguese words to assess generalization, and (3) pseudo-words having the structure of Portuguese but not defined in that language to assess development of textual responding.

**Learning by exclusion.** The primary methodology for teaching new relations between dictated words (and later syllables) and corresponding visual stimuli was *learning by exclusion* (McIlvane & Stoddard, 1981).

**RESULTS AND DISCUSSION**

No child read more than three words correctly during the preliminary assessment. During the training, all children acquired highly accurate performances that were targeted by direct training aspects of the curriculum: (1) matching pictures to corresponding dictated words, (2) matching printed words to dictated words, and (3) matching printed syllables to dictated syllables. All children exhibited accurate emergent matching of printed words with pictures and vice versa, either immediately on initial unit post-tests or after the prerequisite matching relations were reviewed. In doing so, they demonstrated true reading comprehension according to the stimulus equivalence criteria defined by Sidman and Tailby (1982).

The outcome tests of primary interest here were those that concerned oral reading and spelling of printed words in response to dictated words. None of these performances had been taught explicitly; they were merely tested following the direct whole-word and syllable matching to dictation training via the exclusion procedure. These oral reading scores approached perfection in most children (mean – 97% correct), a substantial contrast with the very low scores that were exhibited on pretests conducted at the beginning of the study. Perhaps even more impressive, however, were the results of the oral reading tests with generalization words that had appeared thus far only on pretests.

The data on emergent oral reading and spelling show two clear order relationships. First, across the three types of tasks, children as a group were more likely to exhibit accurate
oral reading of words than spelling of those words by either constructed response syllabic matching or cursive writing. The second relationship was that children as a group tended to do better with training words than with the generalization words across all three tasks. Nevertheless, (1) the performance differences between those with training words and those with generalization words were of a fairly small magnitude and (2) scores on both training words and generalization words were much higher than those obtained on pretests. Thus, although the program did not achieve total procedural control of the relevant learning processes, the children clearly showed substantial benefit from it. Recall that all of the participants had exhibited more-or-less protracted histories of failure to acquire performances such as these in their school programs.

**STUDY 2**

One question concerning the positive training outcomes shown in Study 1 is the degree to which those outcomes were due to the curriculum *per se* and not some other variable correlated with passage of time spent in our instructional environment. For this reason, our group has been endeavoring to assess program efficacy via a group design comparing performances of groups of children who were exposed to our regular program to groups of comparable children who were exposed to a control program that did not teach reading. Our control groups can be considered as “placebo groups” (Wampold, Minami, Tierney, Baskin, & Bhati, 2005) or as non-specific treatment groups (Kazdin, 2003): participants are exposed to the same setting of instruction, but they are required merely to match pictures to dictated words (AB) and to name the pictures (BD). Reis, de Souza, & de Rose (2009), obtained results that were similar to those in the present Study 1 in an experimental group and little or no progress in a matched control group.

Another aspect of this line of research has been to assess whether the methodology that had been implemented in our university-based learning center could be implemented effectively within a public school environment. Study 2 systematically replicated the procedures of Reis and colleagues (2009) using student proctors to supervise the instruction instead of teachers or researchers.

**Methods**

Participants in this study were 17 children aged 8-11 years who had levels of school participation and achievement similar to those of children in Study 1. The primary qualification for participation in the study was failure to read orally or spell words on an initial pretest. In addition, school records were available to characterize these children. The children were assigned either to an Experimental Group (09) or to a Control Group (08) of comparably functioning children.

The setting was a quiet area within the children’s public school program, with the computer equipment necessary to implement the program in that environment. Procedures for the Experimental Group systematically replicated those described in Study 1, the primary difference being the change in the setting of instruction. The Control Group was exposed to a
similar program except that (1) the tasks included only matching pictures to dictated words (AB) and naming the pictures (BD); (2) each unit taught 9 word-picture relations; there were 30 word sets and these sets did not include the words used with the Experimental Group.

RESULTS AND DISCUSSION

Figure 1 presents the most important findings of this study, showing pre- and post-test results for individual participants (isolated points) in the Experimental and Control groups, and the median for the groups (solid lines). Learning outcomes comparable to those in Study 1 were obtained with the Experimental group whereas the Control group made little progress.

Although suggestive, the present findings cannot be taken as definitive proof of the sufficiency of the curriculum, by itself, to establish the performances of interest. One logical possibility is that our curriculum served to potentiate learning in the children’s school programs (many children do learn how to read in school). Nevertheless, longstanding experience and the findings of Study 2, together with the findings of Reis and colleagues (2009) do indicate that exposure to the curriculum was the key factor in allowing initially non-reading children to begin reading – performances that have served as the foundation for extensions of our larger program to teach reading of text passages, the results of which will be featured in a separate report.

Figure 1. Individual data: percent correct responses in reading and spelling to dictation before (B) and after (A) the administration of the programs. The medians of the groups’ performances in each task are represented by the solid lines.

General Discussion

The present work is very clearly in line with the essential concepts underlying Skinner’s (1968) objective of applying systematic principles of behavioral science to develop
a true technology of teaching. Two aspects of Skinner's analysis seem noteworthy in the present study. First, our addition of explicit teaching of relations between dictated and printed minimal syllabic units in the curriculum is consistent with the concept of fostering progressively evolving, empirically inspired improvements in instructional technology. Regarding oral reading of training words in Study 1, for example, the children averaged about 97% correct and the lowest scoring child exceeded 90%. Overall performance with generalization words in the present studies was far superior to earlier studies, however.

Perhaps even more important than the incremental improvement, however, was the demonstration that improvements in learning outcomes could be made outside the very controlled environment of the university-based learning center. Study 2 showed virtually the same levels of achievement when the curriculum was implemented within a public school environment. This finding shows that protracted failures to acquire reading fundamentals – as exhibited by many children in Brazilian primary grades is potentially correctable via the systematic application of an evidence-based technology of teaching.

REFERENCES


In the vast majority of stimulus equivalence research studies, matching-to-sample procedures are used for teaching stimulus-stimulus relations and testing for emergent relations (e.g., Sidman, 1994). Other procedures, however, have also been used in stimulus equivalence research, such as the go/no-go method recently reported by Debert, Matos, and McIlvane (2007).

In this study, two abstract black-and-white figures were displayed side-by-side on the screen of a computer that controlled all experimental operations. During go/no-go training, each two-component stimulus was presented successively for 4 s. Responses emitted in the presence of certain stimulus pairs (A1B1, A2B2, A3B3, B1C1, B2C2 and B3C3) were followed intermittently by reinforcers, whereas responses emitted in the presence of other compounds (A1B2, A2B1, A2B3, A3B1, A3B2, B1C2, B1C3, B2C1, B2C3, B3C1 and B3C2) were not. After accurate performances were established, probe tests in extinction displayed new compounds comprised of different arrangements of the component stimuli – BA, CB, AC, and CA. Five of six participants subsequently responded in a manner consistent with the ABC classes typical of such studies.

According to Sidman’s (1994) definition, matching-to-sample procedures are not essential to generate equivalence classes. Following Sidman’s logic, given the appropriate context, any procedure that entails ordered pairs of related events might potentially establish equivalence relations. The generality of equivalence class formation following other types of ordered-pair relations has not been studied systematically, and the possibilities suggested by Sidman’s analogy have been evaluated only rarely.

We assessed two procedural targets: (1) classical figure-ground relations similar to those that concerned Lashley (1938) and (2) stimulus-position relations.

Both experiments were conducted with normally capable adults. These two targets were selected in part to demonstrate another feature of go/no-go procedures – their applicability with stimulus relations that cannot be studied with straightforward matching-to-sample methods – one cannot separate the constituent elements of figure-ground or stimulus-position compound relation into sample and comparison stimuli. Moreover, these two procedure targets seem to map well onto contingencies encountered outside the laboratory that require individuals to respond if and only if certain conditions are fulfilled and otherwise do nothing (e.g., soldiers are required to salute only when an officer enters the room). Laboratory go/no-go procedures may be useful as a simple way to model such procedures for controlled study.

In Experiment 1, participants were two males and three females aged 18-29 years. An IBM computer with 14” color monitor was used. A program developed in Visual Basic
controlled stimulus presentations and data recording. Components of the two-component figure-ground stimuli could be any one of six abstract forms, designated as A1, A2, A3, C1, C2, and C3, and any one of three colors as backgrounds, designated at B1, B2, and B3. Each abstract form was centered within a colored background displayed in the center of the monitor’s screen.

In Phase I, one of the 18 two-component figure-ground stimulus was randomly presented in the center of the screen, and the counter (initially set at zero) was displayed in the left upper corner. Eighteen different figure-ground stimuli resulted from combinations of one of the six abstract forms and one of the three colored backgrounds. “Related” components were A1B1, A2B2, A3B3, B1C1, B2C2 and B3C3. “Not-related components” were A1B2, A1B3, A2B1, A2B3, A3B1, A3B2, B1C2, B1C3, B2C1, B2C3, B3C1 and B3C2. Each figure-ground stimulus with related and not-related components was presented for 4 s on each trial. During each trial, participants could click one or many times with the mouse. Each figure-ground stimulus with related components was presented twice in a block of trials, while each of the not-related figure-ground stimuli was presented once (see Figure 1).

Sessions consisted of 12 blocks of 24 trials each (288 trials per session) and lasted about 30 min.

![Figure 1](image)

Figure 1. Stimuli presented in each phase of Experiment 1. Stimuli with components To-Be-Related are underlined.

Valid responses to figure-ground stimuli with related components were followed by the sound of tokens falling and by the addition of 10 points on a counter positioned on the upper-left corner of the computer monitor. All trials were separated by an intertrial interval of 2 s. Button presses to related figure-ground stimuli were followed by points in a conjunctive
fixed-ratio 1 variable-time 2.5 s schedule. Phase I ended when participants completed a full session of responding to virtually all of related figure-ground stimulus and made virtually no responses to stimuli with not-related components (see Results).

Phase II tested for equivalence relations with the go/no-go procedure under extinction conditions involving new compounds with A and C components. Equivalence relations would be shown if participants (1) responded to pairs of forms that had appeared with the same colors on figure-ground training trials (i.e., A1C1, A2C2, A3C3, C1A1, C2A2 and C3A3) and (2) did not respond to form pairs that had appeared with different color on such trials. Phase II was conducted for one session only. Figure 1 shows all trial types presented in each phase. Form stimuli were presented in side-by-side pairs within a neutral background on the screen. All test trials started with 8 s presentations of a two-component stimulus. Six blocks of 24 trials were presented in a test session of about 30 min. The point counter was not displayed on any such trials.

Table 1 shows the percentage of correct performances during training and testing for each participant (i.e., the number of trials with one or more responses to figure-ground components defined as related added to the number of trials on which there were no responses to figure-ground components defined as not-related divided by the total number of trials). Participants required 3 to 4 session to achieve more 99.3% correct trials during training. All participants then immediately showed the emergence of equivalence relations within one testing session.

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<td>59.0</td>
<td>73.0</td>
<td>66.7</td>
<td>78.9</td>
</tr>
<tr>
<td>Session 2</td>
<td>96.5</td>
<td>93.8</td>
<td>94.5</td>
<td>97.2</td>
<td>99.6</td>
</tr>
<tr>
<td>Session 3</td>
<td>99.3</td>
<td>98.9</td>
<td>100</td>
<td>100</td>
<td>-----</td>
</tr>
<tr>
<td>Session 4</td>
<td>99.3</td>
<td>100</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>TEST</td>
<td>99.3</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.3</td>
</tr>
<tr>
<td>Session 1</td>
<td>(143/144)</td>
<td>(144/144)</td>
<td>(144/144)</td>
<td>(144/144)</td>
<td>(143/144)</td>
</tr>
</tbody>
</table>

* Values in parentheses represent the number of trials with correct responses and number of trials per session.

Like the participants in the study by Debert and colleagues (2007), the present participants exhibited emergent behavior and equivalence relations with novel combinations of stimulus components (i.e., the figures) presented contiguously with other components (i.e., the grounds) during training.

Experiment 2 addressed further extension of the go/no-go procedure to study potentially emergent behavior using form-position compound stimuli. The positions served the same role in this experiment as the colored grounds in Experiment 1, but there was no
added stimulus component – the nodal stimulus was merely the position of the form in the display.

Participants were two males and four females aged 20-26 years. The apparatus was the same as in Experiment 1. Compound stimuli were composed of four abstract forms (designated A1, C1, A2 and C2) presented on the left position (designated B1) or right position (designated B2) on the computer monitor. Each abstract form was presented in left or right location centered in an area at the bottom of the monitor’s screen (see Figure 3).

![Figure 3. Stimuli presented in each phase in Experiment 2. Stimuli with components To-Be-Related are underlined.](image)

Experiment 2 had the same two-phase structure as Experiment 1: Phase I – Training and Phase II - Equivalence Tests. In Phase I, eight different compound stimuli resulted from the combinations of one of the four abstract forms and one of the two locations. Compounds with related components were A1B1, A2B2, B1C1 and B2C2. Compounds with not-related components were A1B2, A2B1, B1C2 and B2C1. Sessions consisted of 12 blocks of 8 trials (96 trials per session). In Phase II, Equivalence Tests displayed two forms side-by-side (A1C1, A2C2, C1A1 and C2A2 – compounds with related components - and A1C2, A2C1, C1A2, and C2A1 - compounds with not-related components). Eight different compound stimuli resulted from the combinations of the four abstract forms (see Figure 3). Eight Equivalence tests were intermixed in unsystematic order within each of 12 test blocks (i.e., 96 total test trials). These tests were conducted under extinction conditions. Each compound was presented for 8 s and each session lasted for about 13 min.

Table 2 shows the percentage of correct performances during training and testing for each participant in Experiment 2. Correct performance was defined in the same manner as in Experiment 1. Participants took from two to six sessions to reach 100% of correct performances during training. All participants showed the emergence of equivalence relations.
within one or two testing sessions. Together with the immediate emergence of stimulus equivalence relations shown in Experiment 1, the data from Experiment 2, support the suggestion that unbalanced procedures are not the source of emergent equivalence relations in go/no-go procedures.

Table 2

Percentage of correct performances in each session for all participants in Experiment 2*

<table>
<thead>
<tr>
<th>PARTICIPANT</th>
<th>A (65.6% (R3/96))</th>
<th>B</th>
<th>C (55.2% (53/96))</th>
<th>D (50.0% (48/96))</th>
<th>E (74.0% (71/96))</th>
<th>G (75.0% (72/96))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>50.0 (48/96)</td>
<td>55.2</td>
<td>50.0 (48/96)</td>
<td>74.0 (71/96)</td>
<td>75.0 (72/96)</td>
<td></td>
</tr>
<tr>
<td>Session 2</td>
<td>94.8 (91/96)</td>
<td>70.0</td>
<td>70.0 (67/96)</td>
<td>94.8 (91/96)</td>
<td>100 (96/96)</td>
<td></td>
</tr>
<tr>
<td>Session 3</td>
<td>94.8 (91/96)</td>
<td>83.0</td>
<td>99.0 (95/96)</td>
<td>94.8 (91/96)</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Session 4</td>
<td>100 (96/96)</td>
<td>100</td>
<td>100 (96/96)</td>
<td>94.8 (91/96)</td>
<td>99.0 (95/96)</td>
<td></td>
</tr>
<tr>
<td>Session 5</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>95.9 (92/96)</td>
<td>96.9 (93/96)</td>
<td></td>
</tr>
<tr>
<td>Session 6</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>100 (96/96)</td>
<td>100 (96/96)</td>
<td></td>
</tr>
</tbody>
</table>

TRAIN

| Session 1   | 25.0 (24/96)       | 94.8 (91/96) | 100 (96/96) | 100 (96/96) | 25.0 (24/96) | 25.0 (24/96) |
| Session 2   | ------             | ------      | ----        | ------      | 100 (96/96) | 100 (96/96) |

TEST

* Values in parentheses represent the number of trials with correct responses and number of trials per session.

Clearly, the go/no-go procedure succeeds as an alternative to matching-to-sample for study of emergent stimulus-stimulus relations when training involves stimuli of the type employed in the present experiments. An issue for future research is whether procedures of the type reported here will produce similar results when used with nonhumans or humans with developmental limitations that tend not to show emergent relations with matching-to-sample procedure. On their face, such procedures seem to have the advantage of simplicity in the stimulus displays – one reason that they were deemed attractive in early research in comparative cognition (Mallot, Mallot, Svinicki, Kladder, & Ponicki, 1971; Zentall & Hogan, 1975). That these procedures will prove ultimately satisfactory is a cause for some concern in their future applications with nonhuman and very young and/or nonverbal humans given some possible complicating factors (e.g., the requirement to avoid responding largely or entirely on no-go trials). That acknowledged, go/no-go procedures have not received the same very extensive study and methodological development as matching-to-sample procedures. Perhaps a program of research focusing on these procedures specifically might overcome these possible complicating factors, permitting their other possible advantages to come to the forefront.

REFERENCES


Capuchin monkeys may show successful performances in simple and conditional discrimination studies with arbitrary visual stimuli (Barros, Galvão & McIlvane, 2002; Barros, Galvão, Brino, Goulart & McIlvane, 2005; Goulart, Mendonça, Barros, Galvão, & McIlvane, 2005), and photographs were used successfully with capuchins in simple discrimination studies (Beran, Klein, Evans, Chan, Flemming, Harris, Washburn, & Rumbaugh, 2008, among others). Demonstration of recognition of photos of faces in an identity matching to sample format could be taken as evidence that they possibly can respond to pictures as icons that are related to the conspecific photographed.

Similarly to the recognition studies, this paper intends to demonstrate the possibility of using pictures as stimuli with monkeys. The use of pictures of conspecifics’ faces, in simple discrimination, repeated shifts of simple discrimination, and conditional discrimination (IDMTS) with capuchins which have histories of generalized matching to sample with arbitrary black-gray-white drawings as stimuli is a preparation for the demonstration of equivalence between photographs and the items pictured, in a object-picture matching procedure.

This study also addressed the possibility that the monkeys may match by identity small parts of the nominal stimulus - the whole picture (overselectivity). Trying to verify this, after the IDMTS baseline was trained, the stimuli were partially covered to verify eventual restricted control by part of the stimuli, which would be documented with performance deterioration when the controlling part of the stimulus is covered.

Three male adult capuchin monkeys (Cebus apella): M07, ET; M12, Cotoh; M15, Louis Dubois, living in the same animal facility, but in separate cages. All participants had previous histories of simple discrimination and matching to sample with black-gray-white drawings.

Sessions were run in an experimental chamber equipped with a touch sensitive monitor and software (EAM v. 4.0), 190 mg pellet dispenser (MED Associates Inc ENV-203-190) provided one pellet per correct response. All the stimuli were pictures of conspecific faces of monkeys that lived in the same animal facility). Four stimulus sets (A, B, C and D) with four stimuli each were used, as shown in Figure 1). The stimuli, 5 x 5 cm, were presented on white background, in any of 9 locations in a 3x3 (three columns by three lines) matrix in the touch sensitive monitor screen.

Touching the correct stimulus (S+) twice was followed by delivery of a pellet of the preferred flavor for each subject, and an ITI of six seconds followed. One response (FR1) directed to any one of the incorrect choices (S-) produced only the ITI, and the same trial was repeated (correction procedure). In the simple discrimination procedure two or four stimuli were presented simultaneously in each trial; sessions ended when the maximum number of trials was reached or when six consecutive correct trials occurred. When criterion level was reached the correct stimulus was changed. In reversals of simple discrimination the S+ was
changed in shifts. In the IDMTS procedure, a stimulus was presented in any of the 9 positions in the monitor. Two touches in the sample were followed by the disappearance of the sample and the immediate presentation of the comparison stimuli. The number of choices in a given trial varied from 2 to 4. After learning criterion was reached, the partial mask procedure was introduced one-fourth of both comparison stimuli was covered by a blank square.

The mask covered eventually each of the four stimulus quadrants, A, B, C and D (Figure 2). In a given trial all comparison stimuli had the same quadrant covered.

Figure 2. Stimulus set A with Partial Mask (General Procedure).

<table>
<thead>
<tr>
<th></th>
<th>MKA</th>
<th>MKB</th>
<th>MKC</th>
<th>MKD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>A2</td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
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<tr>
<td>A3</td>
<td><img src="image9" alt="Image" /></td>
<td><img src="image10" alt="Image" /></td>
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<tr>
<td>A4</td>
<td><img src="image13" alt="Image" /></td>
<td><img src="image14" alt="Image" /></td>
<td><img src="image15" alt="Image" /></td>
<td><img src="image16" alt="Image" /></td>
</tr>
</tbody>
</table>

Procedure was divided in six phases, participants M07 and M15 were exposed to all Phases, except Phases 3.3 and 4.1; participant M12 begun at Phase 3.3 (see Table 1).

Participant M12 reached the criterion of 6 consecutive correct trials every session, and reached criterion in Phase 6.

In IDMTS training with sets A, B, C, D, all participants met criterion of 90% correct. Performance, in the trials with partial mask, with Set A, was of 94% correct responses, Set B, 68%, Set C, 50%, and Set D, 43%.
Table 1. Sequence of phases and participants. RSSD = Repeated shifts of simple discrimination.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M07</td>
</tr>
<tr>
<td>1 Reversals of simple discrimination, Set A</td>
<td>X</td>
</tr>
<tr>
<td>2 Simple discrimination, blank comparison probes</td>
<td>X</td>
</tr>
<tr>
<td>3 Re-training of simple discrimination, Set A</td>
<td>X</td>
</tr>
<tr>
<td>3.1 RSSD, four choices</td>
<td>X</td>
</tr>
<tr>
<td>3.2 RSSD, four choices, partial mask</td>
<td>X</td>
</tr>
<tr>
<td>3.3 RSSD, three and four choices</td>
<td></td>
</tr>
<tr>
<td>4 IDMTS, Sets A, B, C, D</td>
<td>X</td>
</tr>
<tr>
<td>4.1 Partial mask probes in IDMTS training of each set</td>
<td>X</td>
</tr>
<tr>
<td>5 Sets A, B, C, D mixed in the same session</td>
<td>X</td>
</tr>
<tr>
<td>6 Partial mask probes</td>
<td>X</td>
</tr>
</tbody>
</table>

Figure 3. Number of responses in A1/MKC and A2/MKC in trials with each S+ for participant M15 in reversals of simple discrimination with partial mask (Phase 5).
In Phase 10 IDMTS with stimulus sets A, B, C, D, mixed in the same session, with partial mask, performance was above 90% correct in the four last sessions, for all participants. In probe trials the overall performance was approximately of 80% (See Figure 4).

![Figure 4. Percent correct responses in all trials in IDMTS with partial mask (Phase 10).](image)

All three participants reached performance criterion in repeated shifts of simple discrimination, and identity conditional discrimination (IDMTS) with sets of four pictures of capuchins’ faces.

The use of partial mask covering one fourth of the pictures was intended to assess restricted control (i.e., responses that were under control of part of the stimulus). Control by part of the picture was found when shown three fourths of the pictures were similar while the hidden part was more conspicuously different between pictures, a different phenomenon from overselectivity found in autistic persons (Dube & McIlvane, 1999; Dickson, Deutsch, Wang & Dube, 2006). The insertion probes of sets B, C and D, indicated that with the procedure used there was no immediate transfer of identity matching to the new pictures. Participant M15 showed a gradual improvement of performance, reaching the criterion for generalized identity with the insertion probe for stimulus set D.

On repeated shifts of simple discrimination with partial mask, performance of participants M15 and M07, decreased when the quadrant C of stimuli A1 and A2 were covered by the partial mask, indicating overselectivity.

Performance in conditional discrimination when partial mask was in use decreased, indicating, one more time, the development of control by part of the stimulus.

The procedure used in this experiment can be used in the experimental approach to the study of symbolic behavior to describe the conditions to produce this kind of repertoire,
and eventually to develop baselines for analysis of pre-symbolic behavior at biobehavioral and neural levels (Galvão, Soares Filho, Barros, & Souza, 2008).

REFERENCES


Sidman’s classic work on the problem of stimulus equivalence has inspired a generation of behavior analytic research to define symbolic behavior in operational terms and to establish the necessary and sufficient conditions under which symbolic behavior is demonstrable in various populations (see Sidman, 1994, 2000 for coverage of the most salient contributions). The wide scope of Sidman’s original vision is evident in subsequent extensions to address the symbolic capacity of nonhumans (e.g., Schusterman & Kastak, 1993), the very complex symbolic behavior of highly verbal humans (e.g., Hayes, D. Barnes-Holmes & Roche, 2001), and, since the inception of stimulus equivalence work, symbolic functioning in persons with neurodevelopmental disabilities (Sidman, 1971; Rehfeldt & Y. Barnes-Holmes, 2009).

One curious feature in the evolution of stimulus equivalence work by behavior analysts is relative neglect of populations of humans who are minimally verbal or nonverbal due to very young age or intellectual disability (cf. O’Donnell & Saunders, 2003). The topic has not been neglected entirely (e.g., Lipkens, Hayes, & Hayes, 1993; Horne & Lowe, 1996; Carr, Wilkinson, Blackman, & McIlvane, 2000; Lionello-DeNolf et al., 2008), but examples are scarce indeed in comparison to the voluminous work conducted with other populations. Given the manifest importance of the need to develop a comprehensive account of the development of symbolic behavior within a behavior analytic framework, the relative neglect of minimally verbal/nonverbal populations is somewhat difficult to explain.

Perhaps the most likely explanation for the paucity of work in this critical area is the time, expense, logistical support, and, perhaps, methodological insufficiency when verbal instructions are virtually entirely precluded. Relevant to our last suggestion, Lipkens and colleagues (1993) studied a developing child in the second year of life and showed that simple differential reinforcement and prompting methods were largely ineffective by themselves to establish simple and conditional discriminations. Such methods also tend to produce highly variable response and frequent learning failures in frankly nonverbal persons with autism spectrum disorders (Lionello-DeNolf et al., 2008). Children who are more verbal (e.g., aged 24+ months) seem to pose somewhat less of a challenge to behavior analytic researchers using methods such as matching to sample (Boelens, Groek & Klarenbosh, 2000; Pilgrim, Jackson & Galizio, 2000; Jordan, Pilgrim & Galizio, 2001), but these individuals tend to have already acquired substantial verbal skills as speaker and listener.

Commenting on the problem of developing necessary performance baselines in preverbal children, O’Donnell and Saunders (2003) pointed out the seeming mismatch between the procedures and time course of model behavioral analytic methods used with nonhumans (precluding all verbal prompting, of course). Such methods require frequent sessions comprised of many discrimination trials with establishing operations such as food
restriction to increase reinforcer potency. By contrast, typically developing children in the
critical age range (i.e., approximately 14-21 months) are not usually available for and/or do
not tolerate lengthy individual sessions over a protracted training course. Permissible
establishing operations to enhance potency of consequences are very limited in scope
(happily and appropriately), and there has yet to be a comprehensive analysis of generalized
reinforcers – other than evanescent effects of stimulus novelty – that might be used
effectively within the targeted age range.

The methods of the study reported in this article were inspired by those of a long-term
program of methodological research conducted at the UMMS Shriver Center with humans
with severe intellectual disabilities (Dube & Serna, 1998). In pursuing the Shriver
methodological approach, it was necessary to adapt the methods to preverbal but otherwise
typically developing children. Whereas the Shriver group has typically been able to employ
generalized reinforcers such as tokens, identifying effective consequences for preverbal
children was a challenge. Necessary adaptations related principally to the difficulty of
maintaining the child in experimental situations (Kagan, 1981) and measuring stimulus
features to which the preverbal child attends (Wilkinson & McIlvane, 2001; O’Donnell &
Saunders, 2003). Creating opportunities for the child to manipulate or produce changes in the
environment seemed to be appropriate tactics, inspired in part by work relating to other
analyses of aspects of behavior of preverbal children (e.g., Weisberg & Rovee-Collier, 1998).

Our goal was to use environmental manipulation opportunities to assess whether a method
based on progressive expansion of simple-to-conditional discrimination could be an
appropriate route to identity matching to sample performances in preverbal children. If such
methodology could be established, it might lead ultimately to the capacity to assess
generalized identity matching and thus to test for the relational property of reflexivity, one of
the three defining properties of equivalence relations (Sidman & Tailby, 1982).

In pursuing our study, we thought it critical to employ an experimental setting with the
most natural characteristics possible (i.e., similar to those already experienced by the child).
Within this environment, we thought it critical further familiarize him/her so as to assure that
the child was calm, relaxed, and free to act without restrictions other than those always
employed with children (caretakers in immediate proximity, ability to touch and otherwise
interact with adults in the immediate vicinity [i.e., the experimenter]), freedom to crawl, stand
up, and/or walk around the room, etc.).
The study was conducted in a private room at a daycare center for children and toddlers. One girl and two boys aged 16, 17 and 21 months, respectively and the research sat together on the floor facing an apparatus with two windows.

The apparatus was designed to emulate one employed by McIlvane and Stoddard (1981). It consisted of a box measuring, with two side-by-side cut-outs in the front containing window openings. The child and researcher sat in front of the box, facing the windows. Stimuli to be discriminated were toys especially designed to attract the child’s attention and maintain continued interest. When a stacked pig was touched or otherwise manipulated, melodies and flashing lights were presented by embedded speakers and a five LEDs, respectively. Thus, manipulating a pig produced auditory, visual, and tactile stimulation.

On simple discrimination and discrimination reversal trials that were programmed in initial training, S+ and S- toys were displayed within the two windows. When the child touched the window containing the toy defined as S+ on a given trial, s/he was allowed to manipulate/play with that toy. Selections of the S- toy ended the trial without a play opportunity. On subsequent identity matching-to-sample trials, the child was first allowed to manipulate a sample toy. Then, S+ (matching) and S- (nonmatching) comparison toys were displayed within the windows, and the selection consequences were the same as on simple discrimination trials.

Data collection occurred over 14 weeks. Each session lasted approximately 10 minutes. Two sessions were typically conducted each week. Intervals between trials varied from approximately 15 to 20 seconds. The maximum number of trials per session was 12. Sessions were interrupted immediately if the child showed any signs of irritability or tiredness regardless of any other established criteria. Initial sessions were preceded by a familiarization period in which the researchers interacted with the children while participating in the daily routine of the daycare center.

<table>
<thead>
<tr>
<th>Training</th>
<th>Stimuli</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample</td>
<td>S+</td>
</tr>
<tr>
<td>Simple Discrimination 1</td>
<td>-</td>
<td>S1</td>
</tr>
<tr>
<td>Reversal 1</td>
<td>-</td>
<td>S2</td>
</tr>
<tr>
<td>Simple Discrimination 2</td>
<td>-</td>
<td>S3</td>
</tr>
<tr>
<td>Reversal 2</td>
<td>-</td>
<td>S4</td>
</tr>
<tr>
<td>Identity MTS</td>
<td>S4</td>
<td>S4</td>
</tr>
<tr>
<td>Same sample*</td>
<td>S5</td>
<td>S5</td>
</tr>
</tbody>
</table>
Identity MTS

Alternating samples**

<table>
<thead>
<tr>
<th></th>
<th>S2</th>
<th>S2</th>
<th>S6</th>
<th>Six consecutive corrects</th>
</tr>
</thead>
<tbody>
<tr>
<td>S6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. Pig sets: S1 = red / S2 = striped; S3 = yellow / S4 = polka dotted; S5 = blue; S6 = green.* for this training the change of sample stimulus depended on achieving the criterion. ** sample stimuli were alternated irregularly over trials

Criterion to master a given discrimination problem was at least four successive S+ selections. Thereafter, a discrimination reversal was initiated, and the mastery criterion was also at least four successive selections of the former S-. Each child completed training on two simple discrimination and two reversal problems with two different pairs of stimuli, then they beginning the identity-matching procedure, differed from the simple discrimination procedure in that trials commenced with presenting the child with a sample pig with sounds and lights deactivated. The child was allowed to play with the sample for a few seconds. Thereafter, comparison stimuli were presented in the two windows. In order to gain access to comparison set of pigs, the child was required to select the ones that were identical to the sample that s/he had just been given. If s/he did so, the child was given access to the comparison pigs, and s/he could then play with both the sample and the comparison pigs for a few seconds more. The identity-matching procedure was noncorrection: if the child chose the S-comparison, then the experimenter gently removed the sample pig from the child’s grasp (as necessary) and placed it out of view behind the curtain. The IDMTS procedure had two training phases: In a Phase 1 The “same sample” procedure was intended merely to introduce the child to the sequence of the IDMTS trials. True sample-matching was not required in the sense that selections on trials N+1, N+2, and N+3 could have reflected only simple discrimination. In Phase 2, however, the procedure was a conventional IDMTS procedure in which the identity of the sample and correct comparison stimulus alternated irregularly across trials in a 6-trial block, thus requiring true conditional discrimination in order to make consistently correct selections sufficient to meet the mastery criterion (6 consecutive correct IDMTS selections, e.g., with samples in an order such as S6, S2, S6, S2, S2, S6). In the service of promoting mastery of conditional discrimination, Phase 2 employed a procedure in which less than criterion performances were followed by presentation of another 6-trial block that presented different combinations of stimuli and different sequences of sample stimuli.

Figures 1, 2 and 3 present the individual participant data throughout the procedure. These figures are trial-by-trial cumulative records in which selection of either S+ or S- steps the corresponding record up. If neither the S+ nor the S- steps up on a given trial, then the child made no response on that selection opportunity. In overview, these records show that all children mastered simple discrimination, discrimination reversals, and ultimately identity matching to sample with alternating samples via the training. Because details of the training procedure differed slightly across the three participants, we will present each participant’s data separately.
In overview, these records show that all children mastered simple discrimination, discrimination reversals, and ultimately identity matching to sample with alternating samples via the training. Because details of the training procedure differed slightly across the three participants, we will present each participant’s data separately.

**Participant So.** Figure 1 shows that this participant completed the simple discrimination and discrimination reversal phases very quickly. Regarding the IDMTS performance, this child was the only one who received the “same sample” procedure on two different IDMTS problems prior to the alternating-sample procedure. This child’s rapid acquisition of conventional conditional discrimination suggested that training on two different same-sample IDMTS problems might not be important, and the procedure was not used with the other two children.

---

**Figure 1.** Cumulative selections of S+ and S- throughout the sequence of sessions for participant So. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 – S+ striped/S- red; REV1 - S+ red /S- striped ; SD2 – S+ yellow/S- polka dotted; REV2 - S+ polka dotted /S- yellow; Same sample (IDMTS1 – S+ green/S- striped; REV1 - S+ striped /S- green; IDMTS2 – S+ blue/S- polka dotted; REV2 - S+ polka dotted /S- blue); Alternating samples – stimuli green/striped.
Participant Ad. By contrast with child So, Figure 2 shows that this child showed slower acquisition of initial simple discrimination, discrimination reversal, and same-sample IDMTS. After these discriminations were mastered, however, alternating-sample IDMTS performance was acquired quickly. One possibility potentially accounting for initially less accurate discrimination performance was this child’s session behavior. He got up frequently and was clearly attentive to other aspects of the environment in the room (e.g., the light switch) as well as stimuli outside it (e.g., sounds coming from the next room).

Figure 2. Cumulative selections of S+ and S- throughout the sequence of sessions for participant Ad. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 = S+ striped/S-red; REV1 = S+ red /S-striped; SD2 = S+ yellow/S-polka dotted; REV2 = S+ polka dotted /S- yellow; Same sample (IDMTS1 = S+ green/S-striped; REV1 = S+ striped /S- green); Alternating samples – stimuli green/striped.

Participant Pe. Figure 3 shows that this child also displayed somewhat more protracted acquisition of simple discrimination and discrimination reversal, similar to that shown by
Participant Ad. Unlike Ad, however, training with both same-sample and alternating-sample IDMTS proceeded quickly.

**Figure 3.** Cumulative selections of S+ and S- throughout the sequence of sessions for participant Pe. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 – S+ yellow/S- polka dotted; REV1 - S+ polka dotted/S- yellow; SD2 – S+ red/S- striped; REV2 - S+ striped/S- red; Same sample (IDMTS1 – S+ blue/S- polka dotted; REV1 - S+ polka dotted/S- blue; Alternating samples – stimuli green/striped.

The results of this study show clearly that preverbal children can master conditional discrimination within the context of an identity matching-to-sample task that was similar procedurally to tasks used routinely in stimulus equivalence research. The results suggest that procedures modeled after those used with older children and adults may be within the capabilities of preverbal children, despite the unique problems that have long been acknowledged with this population (Weisberg & Rovee-Collier, 1998). Methodology of the type reported here may find applicability beyond merely the search for stimulus equivalence potential in preverbal children. Procedures for assessing and teaching conditional relations between/among stimuli have been used successfully in basic and applied research on learning, memory and perception in both regular education and special education (Saunders
The development of efficient, effective procedures for teaching discrimination skills in preverbal children can, concomitantly, lead to methodological advances for investigating aspects of child behavior and capabilities, assist in analysis of how complex discrimination repertoires such as symbolic behavior are acquired, and perhaps as a consequence, lead to improvements in methodology for teaching these repertoires to both typically and atypically developing individuals.

An important aspect of methodological development may be an effort to render the procedure a good match for naturally operating contingencies, as we did in adapting our methodology to resemble a play session in the children’s day care setting. As in such settings, we sought to attend carefully to individual differences, both in day-to-day variability and across children, in terms of variables such as the time individuals appeared willing to engage with the procedures, the number of trials that could be implemented without tiring the children, the degree of distractibility to outside events, and so on. The procedures that evolved in the course of designing and conducting in our study thus appeared to achieve a good match with the children’s needs in relationship to such variables.

The positive results of the procedures notwithstanding, certain methodological aspects still appear to need refinement to render the methodology broadly applicable and routinely replicable. Further analysis is likely to be necessary of variables such as the adequacy of criteria for assessing learning/learning set, the optimum lengths of sessions, intertrial periods, intersession intervals, and perhaps other variables.

To conclude, it appears that earlier empirical analyses of the behavioral requirements for conditional discrimination in older persons with disabilities (McIlvane, Dube, Kledaras, Iennaco & Stoddard, 1990; Dube, 1996; Dube & Serna, 1998) proved informative in informing our study with preverbal children. As in that work, our procedures systematically managed the transition from simple discrimination and simple discrimination reversal through to conditional discrimination. Interestingly, we saw that our seeming well-matched procedures led to a fairly rapid transition process in our children – protracted training was not needed as it frequently has been with older nonverbal children with intellectual disabilities. Might the speed of the transition seen in studies of the type reported here serve as an early predictor of the developmental trajectory when intellectual disability is suspected? Might development of such skills through early intervention play a pivotal role in altering the developmental trajectory? If so, it seems likely that we may be better positioned to ask and answer theoretical questions such as whether equivalence class formation is a basic behavioral process that is not reducible to other processes (Sidman, 1994, 2000) and that might be managed effectively via procedures that assist the learner to attend to the relevant environmental cues that lead to the development of conventional symbolic functioning.

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Musical reading may be considered an instance of *codic* verbal behavior (Michael, 1982), in which the response form is controlled by a verbal stimulus with which it has point-to-point correspondence, without similarity between stimulus and response product. In musical reading the stimulus is a series of symbols in a staff, a set of five parallel lines. The symbols are open or closed dots with or without stems. Each dot represents a note, with the pitch corresponding to the position of the dot on the staff and the duration represented by the form of the symbol (open or closed dot, with or without stem).

Like alphabetic reading, musical reading is recombinative. Recombinative systems are convenient because once a small number of symbols has been learned, the learner can respond appropriately to a virtually infinite number or recombinations of these symbols. Thus, after learning the sounds corresponding to the letters of the alphabet, one may read all words in a language; likewise, a musician that learned the symbols of musical reading may read a virtually infinite numbers of melodies, either by singing them or by playing them on a musical instrument.

Studies on alphabetic recombination have attempted to identify the variables that promote recombination. Some of these studies have suggested that recombination can be obtained by multiple-exemplar training with words that have common components (e.g., Hubner, Gomes & McIlvane, 2009). On the other hand, many studies indicate that recombination is easier to obtain when units are directly taught (e.g., Adams, 1994; de Souza et al., 2009).

A few studies of musical reading taught participants to respond to individual notes represented on the staff (e.g., Hayes, Thompson, & Hayes, 1989). A recent study by Batitucci (2007) taught sequences of notes rather than individual notes. Batitucci taught auditory-visual matching relations, in which a sequence of notes was played as a sample and the participant had to choose the corresponding notation from an array of staves, either in G or F clef. Participants showed equivalence between melodies and notations in different clefs. Once participants learned to respond to two different sequences of notes (C-E-G and E-G-C), the notes were recombined in three- and four-note sequences (e.g., G-C-E and C-E-G-E). Although performance of 2 participants in these tests was more accurate than in a pretest, recombinitive generalization was generally poor.

The present study investigated whether recombinative generalization could be enhanced if participant learned to respond to smaller units, comprised of two notes each.

**METHOD AND RESULTS**

The participant was a musically illiterate woman. A computer presented auditory and visual stimuli and recorded responses, through the MTS 11.6.7 software (Dube & Hiris, 1999). The participant learned to match six auditory two-note sequences to the corresponding...
notation on the staff. Each trial presented an auditory sequence together with four windows, each containing a staff (in the initial trials, only two staves were displayed). The six two-note sequences learned by the participant were C-E, C-G, E-G, G-E, G-C, and E-C. Training was gradual, with note sequences added progressively, until a criterion of 97% of correct responses was achieved with all note sequences presented in the same training session. Then, test trials presented three- and four-note sequences that recombined the learned units: C-E-G, C-G-E, E-G-C, E-C-G, G-E-C, G-C-E, C-E-G-E, C-G-E-G, E-G-C-E, E-C-G-E, G-E-C-E, and G-C-E-C. During test sessions, two test sequences were presented interspersed within a training block of trials.

The participant performed at chance level in a pre-test (two correct responses in six trials). In the post-test, she scored 11 correct responses in the 12 test trials.

DISCUSSION

This study contributes to the development of a method to study recombinative generalization in musical reading. Previous studies (e.g., Batitucci, 2007; Hayes et al., 1989) investigated recombinative generalization together with stimulus equivalence. The present investigation isolated recombinative generalization. Since stimulus equivalence is not necessary for recombination to occur (e.g., Hanna et al., submitted), recombinative generalization can be studied more directly after a single set of auditory-visual relations is learned.

The study needs to be replicated with more participants and with a larger set of units. The training of only three notes combined in two-note sequences restricted the scope of recombinations that could be generated and increased the probability of control by specific features or parts of the stimuli, such as the initial notes of a sequence. Control by all the notes in the sequence may also be achieved by “production” tests, require the participant, for instance, to press keys on a keyboard, such as in the studies of Batitucci (2007) and Hayes et al. (1989). The present results, nevertheless, are highly encouraging, and indicate that recombination research may contribute to the teaching of musical reading, as it has already contributed to the teaching of alphabetic reading. On the other hand, the study of recombination in a different reading system, such as musical reading, may contribute to clarify variables involved in recombination of units in general.

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Experimental investigations seeking to generate effective procedures to teach reading and spelling have been conducted by de Rose and colleagues and have originated an individualized instructional program to teach rudimentary reading skills (de Rose, de Souza, Rossito, & de Rose, 1989; de Rose, de Souza, & Hanna, 1996).

The program’s goal is to teach reading and spelling to people (mainly children learning to read) who exhibit difficulties in learning to read and spell through other methods. The reading and spelling skills emerge from relations between printed stimuli (words and syllables), dictated stimuli and pictures that are taught throughout the program by a matching-to-sample procedure.

The tasks taught throughout the program consist of selections of printed stimuli (words and syllables) in the presence of dictated samples, and also copying words in a constructed response task. In this task, a printed word is displayed as a sample and letters are available as choices, also called comparison stimuli. The participant must select the letters in order to construct a word that is identical to the sample. This sort of copy aims at developing discriminative control by the alphabetical units of the word, which is the basis for generalized reading (Mueller, Olmi, & Saunders, 2000). Generalized reading consists of reading new words constructed by recombination of syllables or letter-sound units of words directly taught (de Rose et al., 1996).

Studies that applied this teaching program (de Rose et al., 1989; de Rose et al., 1996; de Souza, de Rose, Hanna, Calcagno, & Galvão, 2004; Melchiori, de Souza, & de Rose 1992; 2000) have shown that participants learned the tasks taught and were then able to match printed words to pictures and vice-versa, name printed words and write dictated words.

The positive results obtained from the application of the teaching program in the controlled setting of the laboratory prompted researchers to inquire about its applicability in a wider scale, such as in a school setting, with the instructional program implemented by teachers rather than researchers. This article describes one such study, in which the
instructional program was applied in all schools of a small municipality in the State of São Paulo.

METHOD

Participants
Sixty four children who exhibited neither reading nor spelling skills participated. In an initial assessment all of the participants scored 0% accuracy in a reading task and rather low accuracy when spelling dictated words.

Thirty eight participants were assigned to the Experimental Group (immediately exposed to the teaching program being evaluated) and 26 to the Control Group (exposed to a different teaching program involving only matching between pictures and dictated words; these participants were later exposed to the program to teach reading).

Teaching sessions were conducted daily, in the schools where the children were enrolled, by teachers hired by the municipality specially to apply the program.

Reading and spelling instructional program
The instructional program teaches 51 words each with two or three syllables (usually CV syllables, with a consonant followed by a vowel). The program has 17 teaching steps (each teaching three words) and 15 assessment steps. Each teaching step comprises matching printed words to dictated words, matching printed syllables to dictated syllables; copy and dictation, both involving the constructed response task. The program was divided into 4 units, each comprising four steps, except the first unit, that had five steps. A pre-test and a post-test verified reading and spelling of the teaching words of each unit (cf. de Rose et al., 1989; de Rose et al., 1996). A second set of words was obtained through recombination of syllables and phonemes of the trained words, to assess generalized reading.

Vocabulary expansion program
This computerized and individualized program used matching-to-sample tasks to teach relations between pictures and dictated words and assessed naming of the pictures. The words were selected from the list compiled by Pinheiro (1996) and involve common
nouns (such as dog, book, tree, etc.), verbs (read, sing, sleep etc.), categories (food, fruits, animals, among others) and quantities or mathematical concepts (two, three, half, triangle, circle, etc.).

Exposure to the procedure

Following the initial assessment, participants from the Experimental Group were exposed to the reading and writing teaching program and participants from the Control Group were exposed to the vocabulary expansion program. At the end of the programs, the final repertoire of all the participants was assessed. The tasks of this assessment were the same as those of the initial one. Children of the control group were then exposed to the reading program, but these data are not reported here.

RESULTS AND DISCUSSION

Figure 1 shows the average accuracy of each group in the reading and spelling tasks at the initial assessment (pre-test) and final assessment (post-test). In the initial assessment, both groups scored 0% accuracy in reading, both with Word Set 1 (taught throughout the program) as with Set 2 (composed by the recombination of syllables from words taught). In both spelling tasks (constructed response and cursive), accuracy with the two sets of words was less than 5% both for the Experimental Group and the Control Group. In the final assessment, the Experimental Group read 96.8% of the words from Set 1 and 94.2% of the words from Set 2. Control Group read 35% of the words from Set 1 and 33.1% of the words from Set 2. In both spelling tasks, accuracy of the Experimental Group was considerably higher than that of the Control Group. Statistical analysis showed significant differences between the two groups in the post-test for reading and in both spelling post-tests. Results showed that both groups gained, both in reading and in spelling with the two types of words. Despite the fact that the Control Group showed an improvement from the initial to the final assessment, it is possible to conclude that the improvement of the Experimental Group in the final assessment resulted from the teaching program. This assertion is supported by the following facts: the groups did not differ significantly regarding their reading and spelling repertoire before they were exposed to the program; the only difference between the
experimental conditions to which both groups were exposed is that the instructional program taught reading and spelling to the experimental group, and vocabulary to the control group; and, moreover, none of the participants failed to attend school during the time the research was conducted. Since the only difference between the groups was the program to which they were exposed, we may conclude that this variable was relevant for the superior performance by the experimental group.

The results from this study replicate the findings from previous research conducted in laboratory setting (de Rose et al., 1989; de Rose et al., 1996; Melchiori et al., 1992; 2000, de Souza et al., 2004;) and indicate that the implementation of this program in larger scale can contribute to reduce the high indices of failure at elementary school.
Figure 1. Average accuracy in the tasks involving reading, spelling with constructed response, and cursive spelling for both groups. The bars to the left of the broken line show the performance of the Experimental Group: the white bars show performance in the pre-test and the black bars show performance on the post-test. The bars to the right of the broken line refer to the Control Group: the gray bars show pre-test data and the hatched bars show post-test data. For both groups, the first pair of bars refers to the performance with the words from Set 1 and the second one to the performance with words from Set 2.

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Most Brazilians and American eighth grade students fail in solving problems involving fractions, decimals and percentages (Carraher e Schliemann, 1992; Lynch & Cuvo, 1995; Brazil SAEB Report, 2001). Math skills will improve only with the development of effective instructional materials and teaching approaches that promote mathematical understanding (Lynch & Cuvo, 1995; McKinney, 1993).

Behavioral approaches to teach relatively complex math skills, such as equivalence of relative measures, have been examined by very few studies, despite new developments on behavioral technology seem promising. Stimulus equivalence phenomenon (Sidman & Taiby, 1982) is an economic functional system to teach several complex behavior, such as reading (e.g., de Rose, de Souza & Hanna, 1996; Sidman, 1971), spelling (Hanna, de Souza, de Rose & Fonseca, 2004; Stromer, Mackay, & Stoddard, 1992), premath (Green, 1993, in Lynch & Cuvo 1995), and fraction-decimal equivalence (Lynch & Cuvo, 1995; Leader & Barnes-Holmes, 2001). Match-to-sample tasks are usually employed to train conditional relations as prerequisites to the emergence of novel, untrained conditional relations. In a typical match-to-sample procedure, a conditional relation is established in a conditional choice reinforcement contingency. Participants learn to choose the stimulus alternative correspondent to a stimulus sample. In Lynch and Cuvo’s study, for example, participants were trained to select pictorial representations of fraction when a printed fraction ratio was the sample (AB relations), and to select the printed decimal correspondent to the pictorial representation of fraction (BC relations). After learning the basic relations, equivalence classes are said to have emerged if stimulus relations are symmetrical (participants show BA and CB relations), transitive (AC and CA emerge) and reflexive (AA, BB and CC) (Sidman & Taiby, 1982).

The present study verified whether equivalence of fractions could be established through the equivalence stimulus instruction. The procedure used in this study was thought to assess initially the formation of three classes of fractions (1/3, 1/4 e 1/5) with three members in each class (two numerical and one pictorial fractions). Once these classes emerged, additional numerical equivalent fraction was related to the original pictorial fraction and tests evaluated the expansion of the original stimulus classes to include the new numerical fraction. When the student scored poorly in the tests of the new relations, these relations were taught directly. The training-testing-training cycle was repeated three times with three different numerical fractions. For example, taking that the equivalence class emerged for pictorial 1/3 (A1), numerical 1/3 (B1) and numerical 2/6 (C1), student then learnt to relate numerical 3/9 (D1) to pictorial 1/3 (A1); class expansion tests (D1-A1B1C1) were followed by the training of these relations when test results were lower than 100% correct; the same procedure was repeated for numerical 4/12 and finally for numerical 5/15. It was questioned whether the use
of multiple exemplars related to the same pictorial fraction would be the sufficient condition to teach the concept of equivalence for 1/3.

Two additional interests of the present study were to evaluate if the students would show conceptual behavior for new sets of fractions (1/7, for example), and if they would improve problem solving with fraction in a traditional paper and pencil multiple choice exam.

Properties used to define stimulus control equivalence on behavior were derived from mathematical properties of equivalence: reflexivity, symmetry and transitivity (Sidman & Tailby, 1982). The study, besides the contribution to develop behavior technology to teach a mathematical concept that shows high index of school failure, can be an important evidence to illustrate the difference between behavioral and mathematical concept of equivalence.

METHOD

Twenty fifth grade students from a public school, ages between 11 and 17, participated. All students showed insufficient performance to solve problems of equivalence between fractions (numerical or pictorial) in a multiple choice exam conducted with paper and pencil in the classroom (Initial Assessment). Ten students with the poorest scores were randomly allocated to experimental groups (E1 and E2) and ten, with the next with poorest scores, to the Control Group (CG).

Participants of the experimental groups learned to choose numerical fractions (1/3, 1/4 or 1/5) conditionally to a pictorial sample (AB relations) or to other equivalent numerical fraction (e.g., 2/6, 2/8, 2/10 - BC relations) in a desktop computer. The numerators of correct and incorrect comparison stimuli were the same for five participants (E1) and varied for other five subjects (E2).

After training AB and BC relations separately all relations were mixed and participant should score 100% correct to end the training and start symmetry (BA/CB) and transitivity tests (AC/CA). Followed equivalence tests, relations between new numerical fraction and the original pictorial fractions (AD) were taught and tests assessed the expansion of the stimulus classes. Other two equivalent numerical fractions were related to each original pictorial fraction (AE and AF) and class expansion was tested. Relations between equivalent numerical fractions not present in any training condition were evaluated (Generalization Tests) before each class expansion test.

Experiment ended with a final assessment similar to the initial assessment, except that it was conducted in the lab with individual students. Control group was exposed only to the initial and final assessment.

RESULTS AND DISCUSSION

Results showed that matching to sample procedure was efficient to establish conditional discriminations between numerical and pictorial fractions (AB relations) and between two equivalent numerical fractions (BC relations). All subjects learned relations between fractions directly trained and showed emergence of symmetric and
transitive/equivalence relations: three classes of fraction (1/3, 1/4 and 1/5) with three members each (two numerical and one pictorial) were formed (see the first two bars of each graph of Figure 1). These results confirm previous findings on the use of equivalence instruction to teach fraction-decimal equivalence (Lynch & Cuvo, 1995; Leader & Barnes-Holmes, 2001) and extend to equivalent fractions. The study replicated previous stimulus equivalence research showing that teaching a few relations directly provided for emergence of many relations without additional training (e.g., de Rose et al. 1996; Green, 1993, in Lynch & Cuvo, 1995).

Figura 1. Percent correct in all tests for each participant of E1 (graphs on the left) and E2 (graphs on the right). The first two bars of each graph show Equivalence Tests (BA/CB and
AC/CA); 3rd to 5th bars represent Class Expasion Tests (D-ABC, E-ABCD and F-ABCDE); and the last 4 bars show Generalization Tests of equivalent fractions not trained.

Scores in all tests of participants E1 were generally higher than E2, suggesting that, by making numerator constant and varying denominators of comparison stimuli, control by relevant aspects of stimuli was improved or restricted control (Dube & McIlvane, 1997) was reduced. Math problems are essentially multidimensional and complex therefore is important to understand the conditions that drive stimulus control to the relevant aspects towards problem solving. Equal numerators of comparison stimuli of a trial showed to be one of the important aspects.

The expansion of the formed classes did not occur for the majority of the subjects after additional training of relations between new numerical fractions and the original pictorial fractions (see Figure 1, 3rd to 5th bars of each graph). It is possible that the one-to-many training structure of these relations did not favor the enlargement of the equivalence classes (Saunders & Green, 1999).

Correct choices for new classes of fractions, monitored throughout the experimental conditions, occurred for all subjects (see Figure 1, last four bars of each graph), and suggest that the procedure established control by the proportionality between fractions. However, if that was the case, high scores in tests of stimulus class expansion were expected. Further investigation is necessary to understand this discrepancy in the results.

Initial and final assessments conducted as multiple choice exams and applied in classroom setting showed significant gains for experimental subjects but not for the control group (GC) (see Figure 2). Further, scores for E1 were higher than for E2, again showing that participants that learned with same numerator fractions did better to solve problems which require relating equivalent fractions. The methodology used in the present study contributes to the development of effective instructional materials and teaching approaches that promote mathematical understanding by showing better results for experimental groups than those found for control groups exposed only to the traditional school methods.

**Figura 2.** Percent correct in the Inicial and Final Assessment for participants without training in the study (C1 and C2 – Control Groups), for participants trained with equal numerators (E1) and different numerators (E2). Some itens of the multiple choice exam in paper-and-pencil required relating absolute fractions (picture-number) and some required relating equivalent fraction (picture-number and number-number). Vertical bars represent one standard deviation of the group mean.
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Barros, Galvão e McIlvane (2002), Galvão, Barros, Rocha, Mendonça e Goulart, (2002), e Galvão, Barros, Santos, Brino, Brandão, Lavratti, Dube e McIlvane, (2005), estudando o comportamento de escolha em discriminações simples e condicionais com macacos-prego, relataram um procedimento geral que envolve a exposição gradual dos sujeitos a diferentes níveis de exigência de aprendizagem, inclusive para verificar e garantir a coerência entre as relações de controle de estímulos planejadas e aquelas aprendidas pelos sujeitos (ver também Barros e cols., 2003; Barros, Galvão, & Rocha, 2005). Em todos esses estudos, os sujeitos são submetidos inicialmente a tarefas mais simples (e.g., discriminações simples), para depois realizarem tarefas mais complexas (e.g., discriminações condicionais por identidade e arbitrárias).

Esses autores mostraram que os macacos-prego apresentavam indícios de identidade generalizada (IG) com estímulos bidimensionais (figuras mostradas na tela de um computador), após treinos de reversões repetidas de discriminação simples (RRDS) e de discriminação condicional por identidade (DCI) também com figuras (Barros e cols., 2002, Galvão e cols. 2002, e Galvão, e cols. 2005). Observou-se nesses estudos que os sujeitos apresentaram melhor desempenho nos testes de IG com as figuras que haviam sido utilizadas previamente em treinos de RRDS (Barros e cols., 2002; Galvão e cols., 2005).

Lima, Barros, Dahás, Cruz, Bezerra e Galvão (2007) avaliaram a aplicação de um procedimento “curricular” para a aquisição dos repertórios de RRDS, DCI e IG com estímulos tridimensionais (objetos apresentados em bandeja). Dois macacos-prego (M09 e M13) foram submetidos inicialmente a treinos de RRDS com um conjunto de dois estímulos, seguidos por treino de DCI com outro conjunto de dois estímulos (para linha de base), e, por fim, a testes de IG. O primeiro teste foi feito com os estímulos usados no treino de RRDS e os outros com conjuntos novos. Ambos apresentaram indícios de aquisição de IG, mas apenas com estímulos utilizados previamente no treino de RRDS, replicando os resultados obtidos com estímulos bidimensionais (Barros e cols., 2002; Galvão e cols., 2005).

No presente trabalho procurou-se estender os resultados prévios sobre a possibilidade de aquisição de IG com objetos por macacos-prego, avaliar a hipótese de efeito facilitador do treino prévio de DSMS com tentativas isoladas com os estímulos de teste de IG; e verificar se este efeito é função da exposição às contingências de alteração das funções dos estímulos ou simplesmente do contato com os estímulos, o que ameniza apenas o efeito de novidade da sua apresentação no teste de IG.

**MÉTODO**

Sujeito: Adam (M18), um macaco-prego (*Cebus apella*) macho, com 6 anos de idade e história prévia de treinos de DSMS e de DCI.
As condições de alojamento, manejo, alimentação e cuidados veterinários, bem como os procedimentos experimentais adotados no laboratório, foram aprovados pelo Comitê de Ética em Pesquisa com Animais da Universidade Federal do Pará (CEPAE-UFPA: PS001/2005) e pelo IBAMA (licença #207419, Código Unidade 381201-4)

**Equipamento:** a câmara experimental media 0,60 x 0,60 x 0,60 m.

**Estímulos:** foram usados 3 conjuntos (A, B e C) de 4 estímulos (Figura 1). Objetos de formas e cores diferentes, de plástico ou de madeira e com até 5,0 cm em seu maior comprimento. O Conjunto A era composto pelos estímulos de linha de base do repertório de DCI, utilizados para a retomada do treino de DCI realizado por Souza e Fonseca (2006).

**Figura 1:** Conjuntos de estímulos usados no experimento. O estímulo B5 substituiu B4 na fase de preparação para o Teste 3 (ver resultados do Teste 3)

**Procedimento:** foram conduzidos quatro testes de IG. Esses testes consistiam de uma sessão de DCI de 48 tentativas. O experimentador colocava na mesa os estímulos indicados na tela, nas posições correspondentes. Uma tentativa tinha a seguinte sequência: um dos objetos (modelo) era colocado sobre a caixa móvel da mesa e então o sujeito podia pegá-lo pela abertura na porta da câmara e devolvê-lo por uma outra abertura adaptada. Os estímulos de comparação eram em seguida colocados sobre a mesa e, se o sujeito pegasse
o objeto idêntico ao modelo (S+), uma pelota era liberada pelo dispensador automático e tinha início um Intervalo Entre Tentativas (IET) de 5 s. Caso o sujeito pegasse outro objeto (S-), a tentativa era encerrada, e tinha início um IET de 5 s. Nesse caso, uma nova tentativa só era iniciada após o sujeito ter devolvido o objeto S-.

TESTE 1
Consistiu em um teste padrão de IG, com estímulos nunca vistos pelo sujeito. Todas as sessões de teste tiveram 48 tentativas, todas com quatro comparações, sendo 32 com estímulos de linha de base e 16 com estímulos de teste, sendo quatro tentativas com cada estímulo como modelo, apresentadas de forma randômica. A resposta de escolha do sujeito na primeira tentativa de cada estímulo de teste não foi reforçada, possibilitando que se pudesse avaliar a emergência de identidade generalizada considerando principalmente as duas primeiras tentativas de cada relação e, adicionalmente, a manutenção do desempenho nas demais tentativas.

TESTE 2
Foi realizado para averiguar se um treino prévio DSMS com os estímulos de teste facilitaria a ocorrência de IG. Assim, os estímulos usados nos testes foram previamente apresentados em DSMS.

TESTE 3
Esse teste foi feito para verificar se apenas o contato direto prévio do sujeito com os estímulos de teste, sem nenhuma contingência de reforçamento programada, poderia facilitar a tarefa do teste. Desse modo, antes do teste propriamente dito, foram realizadas sessões nas quais os sujeitos simplesmente podiam manipular os objetos que seriam usados no teste subseqüente.

TESTE 4
Procurou avaliar a IG com os estímulos usados no Teste 3 após realizar treino DSMS com esses estímulos.

RESULTADOS E DISCUSSÃO
O desempenho do sujeito alcançou critério de acerto nos Testes 2 e 4. Estes resultados reforçam aqueles que apontam que macacos-prego podem adquirir IG com objetos (Lima e cols., 2007).

No Teste 1, das 16 tentativas com estímulos novos, o sujeito acertou duas.
Teste 2

Foram registrados 13 acertos nas 16 tentativas de teste. Houve 100% de acertos nas duas primeiras tentativas de cada relação, como mostra a Tabela 4. Nas tentativas de linha de base ele errou apenas 5 das 32.

Contudo, ainda não estava claro, até este ponto, se este efeito era função da exposição às contingências de alteração das funções dos estímulos ou simplesmente do contato com os estímulos, o que amenizaria o efeito de novidade da apresentação dos mesmos no teste de IG. O Teste 3 avaliou essa questão.

Teste 3

O desempenho do sujeito não alcançou o critério, uma vez que foram registrados apenas 4 acertos nas 8 tentativas críticas (duas primeiras de cada relação). Houve 11 acertos nas 16 tentativas de teste. O desempenho na linha de base foi preciso em 13 das 16 tentativas do Conjunto A e 11 das 16 do Conjunto B (Tabela 5).

Esse resultado indica que a simples exposição prévia aos estímulos de teste não foi suficiente para a ocorrência de IG, ainda que tenha favorecido o seu desenvolvimento, se se considera os 11 acertos nas 16 tentativas de teste, com 100% de acerto para um dos estímulos. Esses dados sugerem que o efeito de novidade dos estímulos no teste não é o único empecilho à pronta demonstração do repertório de IG. Parece ser importante que os estímulos de teste tenham estado presentes em situações prévias de exposição a contingências de reforçamento (em situações de MSDS ou de discriminação simples – ver Teste 4 e Considerações Finais a seguir).

Para confirmar o efeito do treino prévio de DSMS sobre a aquisição de IG, foi realizado o Teste 4.

Teste 4

Na sessão de teste, foram registrados 14 acertos nas 16 tentativas com os estímulos de teste. Considerando o desempenho do sujeito nas duas primeiras tentativas de cada relação, houve sete acertos em oito tentativas (o desempenho só não foi preciso na segunda tentativa da relação C1C1). Nas tentativas com os estímulos de linha de base acertou 12 do Conjunto A e 14 do B (ver Tabela 6). O desempenho do sujeito no Teste 4 sugere emergência de identidade generalizada com sete acertos em oito nas tentativas críticas e com manutenção de desempenho nas demais tentativas (14 acertos em 16 tentativas). Esse resultado reforça a idéia de que uma exposição prévia às contingências de reforçamento em treinos de RRDS/DSMS favorece a aquisição de IG.

CONSIDERAÇÕES FINAIS

Os testes nos quais o sujeito teve melhor desempenho foram precedidos de treino de indução de controle condicional com os estímulos de teste. Embora seja esperado que a
apresentação do S+ em tentativa isolada imediatamente antes da tentativa de DSMS favoreça o desenvolvimento de controle relacional, é possível que cada nova mudança de função seja resolvida estritamente como uma tarefa de DSMS, sem qualquer participação do “modelo” da tentativa isolada. Nesse caso, o efeito aparentemente facilitador do contato prévio com os estímulos de teste em DSMS seria da mesma natureza do observado em estudos anteriores (Barros e cols., 2002; Galvão e cols., 2005; Lima e cols., 2007).

Permanece por ser avaliado se o efeito da exposição prévia às contingências de reforçamento depende da simples exposição a situações de discriminação simples (DS), com ou sem tentativas isoladas, ou das sucessivas mudanças das funções dos estímulos que ocorre no treino de DSMS. Pode-se considerar, a princípio, que as alterações das funções dos estímulos de treinos de DSMS podem preparar melhor os sujeitos para a situação de pareamento ao modelo que caracteriza os testes de IG, uma vez que esse efeito foi documentado por Barros e cols. (2002) e Galvão e cols. (2005), sem o uso de tentativa isolada.

Desta forma, novos estudos que procurem avaliar a aquisição de IG em macacos-prego poderiam investigar aspectos tais como: 1) qual o efeito de treinos prévios em DS com os estímulos a serem usados em testes de IG; 2) se treinos sucessivos de DCI e DSMS com tentativa isolada com estímulos que não serão usados nos testes podem produzir a IG.

REFERÊNCIAS


According to some behavioral analysts (Sidman, 1994; de Rose, 2005; Hübner, 1990 among others), reading and writing involve several integrated skills, forming a network of relationships in which not all of them need to be taught directly, i.e., some relationships may emerge from those already trained. This analysis model is denominated stimuli equivalence paradigm, and is understood as the possible product of at least two conditional discriminations, with a common element (Sidman, 1971; Sidman & Tailby, 1982). According to this model, the teaching of some relationships can lead to the emergence of others, without being explicitly taught. The economy and efficiency of the teaching, since new relationships emerge from the training of others, have contributed to the increasing number of research using this analytical model to investigate issues related to the teaching and learning process (Sidman, 1971; de Rose, Souza, Rossito & de Rose, 1989; Melchiori, de Souza, & de Rose, 2000; Medeiros, Monteiro, & Zaccaron, 1997; Goyos & Freire, 2000; Haydu & Tini, 2003, among others). In spite of the fact that research in the area, with different populations, have pointed out to the effectiveness of this model, a person can learn and write the words LATA and BOCA and still not be able to read and write the words BOLA, TALA, CABO, and BOTA, formed by the recombination of the syllables in these words. In this sense, studies inspired in the work of Sidman (1971) on stimuli equivalence and in Skinner’s (1957) analysis of verbal behavior minimal units have being carried out (Hübner, Gomes, & MacIlvane, 2009). Many of these studies make use of the constructed response matching to sample procedure (CRMTS) (Mackay & Sidman, 1984; Stromer, Mackay & Stoddard, 1992; Matos, Hübner-D’Oliveira, 1992; de Rose, de Souza & Hanna, 1996; Souza, Goyos, Silvares, & Saunders, 2007, among others).

Studies that use the equivalence paradigm and the CRMTS procedure point out to the possibility of using games and plays to teach the relationship between printed words, spoken words, pictures and a group of letters or syllables (Sudo et al 2008). Due to the motivational character of games, and their popularity among children, as well as to the fact that the relationships involved in reading and writing can be taught through them (de Rose, 2005), studies investigating the effect of games on teaching reading and writing are necessary. Therefore, this work investigated whether the use of a board game, which makes the teaching of the relationships between printed words, group of syllables, pictures, written and spoken words possible, can lead to the reading and writing of teaching words and new words formed by the recombination of the syllables from these words (generalizing words).
METHOD

Participants: Nine children from a local public school.

Equipment and Material. The researchers used a camera, video tapes, paper and pencil to record the sessions, and a thematic board game – AbraKedabra: building words. The board game starts with each child receiving one or more printed words, which are read aloud without any help. Next, having the printed word as the sample stimulus and as comparison stimuli the squares that make up the board game, the child builds a word from the syllables he or she won during the game. The game ends when a printed word is built (relationship between the printed word and a group of syllables) and matched with the corresponding picture (relationship between printed word and picture).

Procedure. The work was carried out in 5 stages (Pre-test, Intervention, Probing, Post-test and Follow-up). During the Pre-test, the relationships between the printed word and the word spoken by the child, the spoken word and a group of syllables, the spoken word and the written word and the picture and the printed word were tested. Next, there were 15 sessions with the board game. Finally, the same relationships tested during the Pre-test stage were again evaluated (Probing and Post-test).

RESULTS AND DISCUSSION

None of the children wrote or read the words presented during the Pre-test. They also did not build words using the group of syllables presented as comparison stimuli nor selected the printed word corresponding to the sample picture.

After the intervention/game sessions, there was an increase in the number of training words read correctly, syllables correctly selected in constructing training words, teaching words and corresponding pictures matched correctly, and syllables written correctly (Fig.1). Despite these results with the teaching words, the reading and writing tests with the novel words did not show substantial changes, even though the number of syllables selected correctly increased.

As for dictation, results showed that while most children had written a great number of syllables from the teaching words correctly (seven out of nine participants), this increase occurred mainly after the use of an additional procedure. The relationship between spoken word and written word (dictation) was introduced during the game, only when the child landed on the Witch Who did not Know How to Write square. There were only two of these squares on the board game, i.e., the probability of a child to land on one during the game was of 0.04. Despite the fact that all children landed on this square, they did not have to write all words. This would explain their performance on the writing assessment test. On the other hand, the

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2 The board game was developed by Souza (2007).
additional teaching procedure, could have given the children the control of the letters that make up the words, thus improving their performance during the dictation sessions.

Figure 2. Children’s performance in the tested relations during the Pretest, Posttest, Final posttest and Follow-up: oral reading (Panels A1, A2 e A3), anagram construction (Panels B1, B2, B3), figure-writing word (Panels C1, C2, C3), dictated (trained words) (Panels D1, D2, D3).
Due to the motivational character of the games, no children gave up or refused to participate in the sessions. Informal observations showed that all children wanted to participate in the sessions and said they really loved the games. In conclusion, results from this study suggest the need for new investigations, especially those related to new technologies for teaching the relationships involved in reading and writing.

REFERENCES


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i RRDS é um procedimento no qual dois estímulos (S+ e S-) são apresentados ao sujeito e a escolha de somente um deles (S+) é reforçada. Quando o sujeito responde consistentemente ao S+, as funções de S+ e S- dos estímulos são revertidas. Novamente espera-se um bom desempenho para que outra reversão de funções ocorra. Quando são utilizados mais de dois estímulos o termo mais adequado para descrever a mudança da função dos estímulos é Mudanças Sucessivas de Discriminação Simples (MSDS).