1. Cover Page

Center for the Ecological Study of Perception and Action

Claudia Carello, Director

Budget: $600,000 per year (externally funded)

Participating Faculty:

Claudia Carello, Professor, Psychology
James Dixon, Associate Professor, Psychology
Carol Fowler, Professor, Psychology
Till Frank, Assistant Professor, Psychology
Bruce Kay, Associate Research Professor, Psychology
Kerry Marsh, Associate Professor, Psychology (Hartford Regional Campus)
Claire Michaels, Research Professor, Psychology
Jeffrey Kinsella-Shaw, Associate Professor, Kinesiology
Anjana Bhat, Assistant Professor, Kinesiology
Robert Shaw, Professor Emeritus, Psychology
Michael Turvey, Professor Emeritus, Psychology

2. Unit Description

Overview of the unit's role and mission

The Center for the Ecological Study of Perception and Action (CESPA) was established by the Board of Trustees in 1987. CESPA's primary goal is to understand the formal structure and empirical support for perceiving, acting, and knowing not as achievements of brain but as activities of ecosystems. We see Psychology as continuous with the natural sciences, amenable to the same kind of law-based strategy of explanation. The task of identifying general principles at the ecological scale poses new and exciting challenges to be met by the development of novel tactics within an interdisciplinary framework. Research at CESPA involves the application of modern tools for addressing complexity, self-organizing physics, nonlinear dynamics, and relevant mathematics to problems of biological coordination (e.g., locomotion, interceptive behavior, tool use). Collaborators include mathematicians, physicists, philosophers, physical therapists, movement scientists, and cognitive scientists. CESPA provides an organizational structure that allows unparalleled integration of research across specialties, with extensive collaboration among faculty and students. Specialists in optics, acoustics, haptics, coordinated movement, nonlinear dynamics, and language provide a breadth of training in ecological psychology that is unmatched anywhere.

Effectiveness in meeting mission and goals

During the preceding 5 years, CESPA has been particularly active in fulfilling our mission and meeting our goals. The documentation that follows illustrates a high degree of collaboration on grants, publications, conferences and workshops as well as distinguished visibility in terms of invited presentations and federal grant panels.

Our interdisciplinary mission has been extended in an applied domain via a formal collaboration with the Physical Therapy Program in the Department of Kinesiology. The Collaboratory for Rehabilitation Research (CoRR, funded by the provost's office) established a mechanism for translating basic research on perception and action into interventions and tools that optimize safety and ease of function in daily living for older adults and individuals with movement disorders. This has led to a variety of published manuscripts, conference presentations, post doctoral fellows, an external grant funded by NIMH, as well as a major equipment award from the University of Connecticut Research Foundation.

The long-standing theoretical focus of CESPA—treating perception and action as continuous with the natural sciences, amenable to the same kind of law-based explanation—has recently been recognized with an award from DARPA in the form of the project "Physical Intelligence." DARPA's Physical Intelligence Program supposes that the phenomena associated with *intelligence* and *evolution* can be understood as natural consequences of complex, open *thermodynamic* systems. As a subcontract with Hughes Research Laboratories, we are working with physicists, computer scientists, microbiologists, and chemists to bring 30 years of insights

from the ecological approach at the University of Connecticut that anchors perception (construed non-algorithmically) in thermodynamics.

Our success with respect to training graduate students is illustrated by our rich graduate curriculum, which has provided the model for similar programs nationwide, and the success of our graduates in securing positions upon graduation. We train students to be teacher/researchers in the disciplines of ecological science and the application of its modern tools for addressing perception-action-cognition (tools of complexity, self-organizing physics, nonlinear dynamics, and relevant mathematics to problems of biological coordination). We use an apprenticeship style: Students work closely with each other as well as faculty for technical training and intellectual debates. During the past 5 years we have produced 9 Ph.D.s.

We are especially renowned for our level of scholarly interaction, both within CESPA and in the number and variety of special events that we host. CESPA has an international reputation for its intellectual excitement and the hospitality in support of that. These interactions encourage an impressive degree of creativity on the part of our faculty and students, creativity that was the hallmark at our founding and that continues to this day.

3. Scholarly Productivity (past 5 years)

Publications:

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Carello, C., Kinsella-Shaw, J., Amazeen, E., & Turvey, M. T. (2006). Peripheral neuropathy and object length perception by effortful (dynamic) touch: A case study. *Neuroscience Letters*, 405, 159-163.
Kinsella-Shaw, J., Harrison, S., Colon-Semenza, C., & Turvey, M. T. (2006). Effects of the visual environment on quiet standing by young and old adults. *Journal of Motor Behavior*, 38, 251-264.
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Frank, T. D., van der Kamp, J., & Savelsbergh, G. J. P. (2010) On a multistable dynamic model of behavioral and perceptual infant development, *Developmental Psychobiology, 52:* 352-371

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Mongkolsakulvong, S., Frank, T. D. (2010) Canonical-dissipative limit cycle oscillators with short-range interaction in phase. *Condensed Matter Physics, 13:* 13001 (18 pages)

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Dixon, J. A., Stephen, D. G., Boncoddo, R. A. , & Anastas, J. (2010). The self-organization of cognitive structure. In B. Ross (Ed.), The *psychology of learning & motivation, vol. 52*, (pp. 343-384). San Diego, CA: Elsevier.

Mirman, D., Strauss, T. J., Dixon, J. A., & Magnuson, J. S. (2010). Effect of representational distance between meanings on recognition of ambiguous spoken words. *Cognitive Science*, *34*, 161-173.

Boncoddo, R., Dixon, J. A., & Kelley, E. (2010). The emergence of a novel representation from action: Evidence from preschoolers. *Developmental Science, 13,* 370-377.

Other creative contributions:

None

Contributions to the University's reputation:

Conferences hosted at the University of Connecticut
Society of Experimental Psychologists, Mach 8-10, 2007
A Natural-Physical Perspective on Perception-Action-Cognition, June 18-21, 2008 (funded by National Science Foundation)
New England Sequencing and Timing, March 6-7, 2009

Workshops Hosted
Philosophical Issues in Self-Organization, September 2007
Dynamics in Rehabilitation, November 2007
Ecologizing Al Liberman, January 2008
Perception-Action Development, February 2008
Ecological Human Factors, March 2008
Historical Issues in Ecological Psychology, April 2008
Organism-Environment System, May 2008
Levy Flight Dynamics, October 2008
UConn Workshop on Physical Intelligence (funded by DARPA), June 2010

We have established 4 annual workshops:
January: Arthur Iberall Distinguished Lecture on Life and the Sciences of Complexity (est, 2003)
August: The UConn Workshop on Cognition & Dynamics (est, 2006)
October: Geraldine Pellecchia Workshop on Cognition & Coordination (est, 2006)
May: Alvin & Isabelle Liberman Memorial Workshop on Current Research on Language (est, 2007)

Keynote addresses delivered
Carello, C. “Nonlinear Methods: Letting the System Speak,” keynote lecture, 1st APA Advanced Training Institute on Nonlinear Methods in Psychology, University of Cincinnati (2006)
Turvey, M. T. Keynote Address, X1X Symposium of the Spanish Society for the History of

Psychology—Madrid, Spain (2006)
Turvey, M. T. Keynote Address on Motor Development, North American Society of the Psychology of Sport and Physical Activity—Denver, CO (2006
Turvey, M. T. Keynote Address on Motor Development, North American Society of the Psychology of Sport and Physical Activity—Denver, CO (2006)
Turvey, M. T. Faculty, Motor Control Summer School—Ligonier, PA (2006)
Turvey, M. T. Lecturer, APA Advanced Technical Institute (Applications of Nonlinear Dynamics in Psychology)—Cincinnati, OH (2006)
Carello, C. "Nonlinear Methods: Letting the System Speak," keynote lecture, 2nd APA Advanced Training Institute on Nonlinear Methods in Psychology, University of Cincinnati (2007)
Turvey, M. T. Keynote Address, European Workshop on Movement Science 2007—Amsterdam, Netherlands (2007)
Turvey, M. T. Keynote Address, European Workshop on Movement Science 2007—Amsterdam, Netherlands (2007)
Carello, C. "Nonlinear Methods: Letting the System Speak," keynote lecture, 3rd APA Advanced Training Institute on Nonlinear Methods in Psychology, University of Cincinnati (2008)
Carello, C. "Self-organization of Action-Perception: Theory and Methods," International Congress of Complex Systems in Sport, Madeira, Portugal (2008)
Turvey, M. T. Keynote Address, European Society of Ecological Psychology—Madeira, Portugal (2008)
Turvey, M. T. Keynote Address, International Conference on Progress in Motor Control VI—Marseille, France (2009)
Turvey, M. T. Inauguration of the Center for Motor Control Lecture—Pennsylvania State University, PA (2009)
Turvey, M. T. Closing Address, 5th Biennial International Conference on the Philosophical, Epistemological, and Methodological Implications of the Theory of Complexity—Havana, Cuba (2010)

Invited Presentations
Carello, C. "The Physics and Psychology of the Muscle Sense," invited faculty at the 3rd Motor Control Summer School, Ligonier, PA (2006)
Dixon, J. A. (2006, February). The lexicon-grammar relationship: Revisiting the critical-mass hypothesis. Invited colloquium presented at Haskins Laboratories, New Haven, CT.
Frank, T. D. (2006, April 20-22). Perturbational theoretical treatment of nonlinear stochastic systems with time delays. Invited conference lecture, RGJ-PhD Congress VII, Thailand Research Fund Jomtien Palm Beach Resort, Chonburi, Thailand
Frank, T. D. (2006, May 18). Deterministic and stochastic components of human motor control systems: dynamical systems approach. Colloquium, University of Groningen, Groningen, The Netherlands
Frank, T. D. (2006, July 29 - August 4). Identifying deterministic and variable components of human motor control systems. Invited conference lecture, 5th World Congress of Biomechanics, Munich University of Applied Sciences, Munich, Germany
Frank, T. D. (2006, October 23). Random walks subjected to mean field forces and memory effects. Colloquium, EURANDOM, Technical University Eindhoven, Eindhoven, The

Netherlands

Michaels, C. F. (2006, June). Learning and Calibration. Symposium organized for the Annual Meeting of the International Society for Ecological Psychology, Cincinnati, Ohio.

Turvey, M. T. Faculty, Motor Control Summer School—Ligonier, PA (2006)

Turvey, M. T. Lecturer, APA Advanced Technical Institute (Applications of Nonlinear Dynamics in Psychology)—Cincinnati, OH (2006)

Turvey, M. T. Invited presentation, International Conference on Coordination Dynamics—Boca Raton, Turvey, M. T. FLA (2007)

Turvey, M. T. Invited presentations, 14th International Conference on Perception and Action—Yokohama, Japan (2007)

Turvey, M. T. Distinguished Ohio State University Alumnus Award, Centennial Celebration, Department of Psychology Lecture—Columbus, OH (2007)

Turvey, M. T. Centennial Celebration Lecture, College of Liberal Arts and Sciences, Purdue University—West Lafayette, IN (2007)

Mirman, D., Magnuson, J.S., Graf Estes, K., and Dixon, J.A. (June, 2007). Linking statistical learning to language processing. Invited paper presented at the Workshop on Current Issues in Language Acquisition: Artificial Languages and Statistical Learning, Calgary, Alberta, Canada.

Stephen, D. G., Sullivan, R., Dixon, J. A., & Eisenhower, R. W. (July, 2007). Dynamics in development: New structures through self-organization. Invited paper presented at the annual International Conference on Perception & Action, Yokohama, Japan.Frank, T. D. (2007, October 4-5). Principles of nonlinear stochastic modeling and applications. Invited conference lecture, Workshop and Conference on Mathematics, 35th Anniversary Celebration of Faculty of Science, Silpakorn University, Nakhon Pathom, Thailand

Carello, C. “Perceiving attachments to hand and foot.” Invited symposium speaker, 14th International Conference on Perception and Action, Yokohama, Japan (2007)

Turvey, M. T. Invited presentation, International Conference on Coordination Dynamics—Boca Raton, FLA (2007)

Bhat, A. “Early markers for developmental delays”, Haskins Laboratories Weekly Colloquium, New Haven, CT, July 2008.

Dixon, J. A. (January, 2008). Self-organization and the emergence of cognitive structure. Invited presentation, the Dynamical and Nonlinear Analysis of Communication and Problem Solving Workshop, Nijmegen, The Netherlands.

Dixon, J. A. (January, 2008). An introduction to Recurrence Quantification Analysis. Invited presentation, the Dynamical and Nonlinear Analysis of Communication and Problem Solving Workshop, Nijmegen, The Netherlands.

Turvey, M. T. Invited workshop on Sports Science and the Sciences of Complexity—Madeira, Portugal (2008)

Turvey, M. T. Invited lecture in the Lecture Series: George Berkeley's New Theory of Vision: 300 Years Later, Brown University—Providence, RI (2009)

Turvey, M. T. Invited presentation, 15th International Conference on Perception and Action—Minneapolis, MN (2009)

Bhat, A. “Motor incoordination in autism”, Combined Sections Meeting of the American Physical Therapy Association, Las Vegas NV, February 2009.

Carello, C. "Staying in the academic pipeline: Growing professionally in an economic drought—the four phases that matter." Women in Cognitive Science Panel, Psychonomic Society, Boston. (2009)

Michaels, C. F. (2009, May). Introduction to Ecological Psychology, Invited 3-day Seminar, Department of Psychology, New York University

Michaels, C. F., (2009, July). Ecological Psychology and the Brain Sciences. RIKEN Brain Institute, Tokyo, Japan.

Carello, C. "Complexity of event perception." Paper presented (R. W. Isenhower & J. J. C. Blau) at Complejidad 2010, the Fifth Biennial International Meeting on the Philosophical, Epistemological, and Methodological Implications of Complexity Theory. Havana, Cuba (2010).

Frank, T. D. (2010, April 23). Modeling transitions in grasping behavior: impacts of environmental and developmental factors. Invited presentation, Department of Psychology, University of Cincinnati.

Frank, T. D. (2010, June 25). From Newtonian mechanics to coupled nonlinear potential dynamics. Invited presentation, Advanced Training Institute on nonlinear methods for psychological science, University of Cincinnati.

Service on State and Federal Panels

CARELLO

National Science Foundation Integrative Graduate Education and Research Training
National Science Foundation Science and Learning Centers Committee of Visitors
National Science Foundation Science and Learning Center Site Visitor (3)

MICHAELS

National Science Foundation Panel Member: Perception, action, and cognition
National Science Foundation Integrative Graduate Education and Research Training
National Science Foundation Program Director, Perception, action, and cognition

DIXON

National Science Foundation Panel Member: Perception, action, and cognition

MARSH

National Science Foundation Integrative Graduate Education and Research Training
National Science Foundation Research Experience for Undergraduates for BCS
National Science Foundation Graduate Research Fellowship Program Evaluation

TURVEY

National Science Foundation Chair, Steering Committee on Integrated Cognitive Science

External funding:

In a tabulated form provide a listing of all external funding (from state, federal, foundation or other sources).

Agency Name	Project Title	Duration	Total Funding	Direct Costs
DARPA	Physical Intelligence	3 yrs (with 1.5 year Phase 3 possible)	$954,872	$642,171
(Carello, PI; Dixon, Frank, Kay, Kinsella-Shaw, Michaels, Shaw, Turvey, Co-I)				
NIMH	Robot child interactions as an intervention tool for children with autism	2 yrs (with 2-year Phase 2 possible)	$550,00	$404,639
(Bhat, PI; CESPA graduate student Gifford, Co-PI; Marsh, Co-I)				
NSF/MRI	Development of a Gesture Based Virtual Reality System	3 yrs	$782,039	
(Marsh, Co-PI)				
NSF	Haptic Perceptual Instruments	3 yrs	$404,431	$282,520
(Carello, PI; Frank & Turvey, Co-PIs)				
NSF	REU Supplement	1 yr	$4328	$3462
(Carello, PI)				
NSF	Dynamics of Rep'l Change	3 yrs	$350,000	$230,000
(Dixon, PI)				
NSF	A Natural-Physical Perspective on Perception-Action-Cognition	1 yr	$20,000	$20,000
(Carello, PI)				
NSF	Information for Learning	2 yrs	$187,000	$122,000
(Michaels, PI; Kay, Co-PI)				
NSF	Information for Learning	3 yrs	$402,419	$276,000
(Kay, PI; Michaels, Co-PI)				
Cure Autism Foundation	Assessing Synchrony as a Basis for Social Connection in Autism	1 yr	$9,967	$9,967
(Marsh, PI)				
NSF	Affordances for Cooperation as a Dynamical System	3 yrs	$327,750	$213,000

(Marsh, PI; Carello, Co-PI)

NSF	Synchrony	3 yrs	$194,886	$138,291
(Fowler, PI; Marsh, Co-PI)				
NSF	Coordination Dynamics	3 yrs	$400,000	$282,149
(Turvey, PI)				
UCRF/MREC	3-D Ecosync	1 yr	$238,000	$238,000
(Carello, PI; Bhat Dixon, Frank, Kinsella-Shaw, Co-I)				
Provost	Collaboratory for Rehabilitation Research	3 yrs	$400,000	$400,000
(Turvey, PI; Carello, Kay, Kinsella-Shaw, Michaels, Pellecchia, Co-I)				

Visiting scholars and Post-docs:

Miguel Moreno, NIH Post Doctoral Fellow (June 2005 - July, 2006)
Marisa Mancini, CAPES visiting scholar, Brazilian Government (June 2005 - July, 2006)
Sergio Fonseca, CAPES visiting scholar, Brazilian Government (June 2005 - July, 2006)
Cedrick Bonnet, Post doctoral Associate, CoRR, June 2006-Aug 2008.
Yoshi Kobayashi, Post doctoral Fellow, Japan Society for the Promotion of Science, 6 mos, 2010
Rodolfo Benda, Federal University of Minas Gerais, June 3-9, 2010
Harry Heft, Sabbatical scholar Dennison University, 2009
Bert Hodges, Sabbatical scholar Gordon College, Aug 2009-Sept 2010

4. Plans and direction for the future:

What are the unit's strategic goals for the next five years?

CESPA is a collection of scientists of varied training backgrounds, including not only psychology (social, developmental, and experimental) but physical therapy, physics, physical education, and philosophy. We are dedicated to understanding the behaviors of living systems at the intermediate ecological scale—the scale at which animals and their environments are defined. Just as the behaviors of natural, nonliving systems at the very large and very small scales are approachable in terms of very general principles so, too, are behaviors at this scale. As noted at the outset, the task of identifying general principles at the ecological scale poses new and exciting challenges to be met by the development of novel tactics within an interdisciplinary framework.

We are at the beginning of one of the most exciting phases in the 23-year history of CESPA. We have just begun two externally funded projects that bookend our goals. Whereas the Physical Intelligence Project (DARPA) is aimed at the deepest theoretical underpinnings of our approach,

Robot-Child Interactions as an Intervention Tool for Children with Autism (NIMH) addresses the most overtly practical and applied implications of that theory. But as research meetings for those projects demonstrate on a weekly basis, these two projects are intimately connected. The criteria by which one might determine a system, regardless of its composition, to be exhibiting intelligent behavior are not unrelated to those by which one might label a system social (and thereby encouraging of interaction).

During the next 5 years, we would like to build on these successes. Most immediately, we are working to ensure that both of these projects are funded for their next phases. More generally, the two endeavors funded by the University of Connecticut—the Collaboratory for Rehabilitation Research and Dynamics, development and Disability in Ecological Synchrony—have facilitated a give and take between theory and application and given it focus. They have allowed us to use these particular externally funded projects to leverage each other. The Autism Intervention Project provides a practical test-field for general principles when systems are not fluent. The Physical Intelligence Project encourages us to seek a thermodynamic grounding wherever possible and we have taken steps to document the thermodynamics of synchrony of the kind that may be measurable in inter-personal interactions. Interaction between theory and application, therefore, is an explicit goal.

We are also focusing on two formal goals. We hope to identify a minimal ontology that makes first principles explicit throughout our treatment of perception-action. And we really mean first principles: What roles are played by the first and second laws of thermodynamics; what is the status of the so-called fourth law? We are also directing efforts at formalizing the notion of a system for our kinds of problems (pattern-forming systems that are multistable, competitive, and spatially extended). What are the components, how are they organized, and how is the environment to be incorporated as part of the system (not just as an addendum)?

What would be the indicators that will determine whether these goals had been accomplished?

Even our abstract goals work at the interface between theory and implementation. If these goals are accomplished we will have *developed new research methods* to guide and constrain both our basic and applied research. We will be developing methods that continually measure the multi-scale organization of any system of interest, such that its development (and disability) can be monitored and manipulated via the properties of the ambient energy. This effort will call on all of our theoretical and technical expertise. But if successful, we will see it play out in *new directions* for our long-standing research endeavors (in dynamic touch and coordination dynamics) as well as in *funding domains that are new for us* (in rehabilitation, emotion and anxiety disorders). We expect to see thermodynamics explicitly represented in our publications, our grant proposals, our dissertations, and our hosted workshops. Success in meeting our goals will be demonstrated by making our meta-theory explicit.