# BOOK OF ABSTRACTS

SEVENTEENTH INTERNATIONAL CONFERENCE ON PERCEPTION AND ACTION

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# SYMPOSIA

SYMPOSIUM 1

# PERCEPTION AND ACTION DEVELOPMENT IN INFANCY AND CHILDHOOD

## Chairs: Cordovil, R. & Van der Meer, A.

### Presentation

During development infants and children learn how to move in different environments as their own perceptual and motor capabilities are changing. The process of learning to perceive affordances develops throughout infancy and childhood, and implies the motor and perceptual exploration of the environment. A better understanding of this developmental phenomenon is fundamental for the understanding of perception and action in general. The contributions to the present symposium will address the pickup of visual information, the actions performed by infants and children, and the estimation of their action capabilities by others in different tasks. Audrey van der Meer will talk about the development of visual motion perception in infants reporting studies with Electroencephalogram (EEG) in 3-4 months and 11-12 months infants. Rita Cordovil will present studies on children's behaviors and parents' estimation of children's capabilities in risk scenarios (water surfaces and real cliffs). Finally, Joanne Smith will talk about children's perception of their action capabilities in different tasks (stepping, forward jumping, overhead reaching, and overhead reach-and-jump). During this symposium some important questions will be discussed: how do infants perceive motion? How do children behave in risk environments? How do children perceive their own action capabilities? Do parents perceive the action limits of their children?

## FUNCTIONAL BRAIN DEVELOPMENT OF VISUAL MOTION PERCEPTION IN INFANTS

**Van der Meer, A. & Van der Weel, R.**
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Electroencephalogram (EEG) was used in infants at 3-4 months and 11-12 months to longitudinally study brain electrical activity as a function of perception of visual motion. The three visual motion paradigms used were optic flow, looming, and occlusion. Analyses of visual evoked potential (VEP) were performed on EEG data recorded with a 128-channel sensor array. Optic flow results showed that 1-year-olds differentiated between forwards optic flow, reversed optic flow, and random visual motion and showed shortest latencies in occipital and parietal channels for forwards optic flow, followed by reversed optic flow and random visual motion. A looming stimulus on collision course approaching the infants under three different accelerations produced such large brain responses that the data could be analysed on a trial-by-trial basis. Typical looming-related brain responses in occipital channels occurred about 900 ms before virtual collision in infants 3/4 months of age and in predominantly parietal channels about 650 ms before virtual collision in infants 11/12 months of age. Occlusion results revealed that infants showed more prospective gaze shifts across the occluder with age, and sources of increased gamma activation could be assigned to regions along the dorsal stream in 4/5-month-old infants and along the ventral stream in 11/12-month-old infants.
With locomotion experience and accompanying neurobiological developments infants around one year of age rely, more so than when they were younger, on structured perceptual information, they process time-to-collision information faster and in more specialized areas of the brain higher up the dorsal stream, and they show better prospective control of gaze and increased gamma activation along the ventral stream in occlusion situations. Whether preterm infants show the same functional brain development of visual motion perception will be discussed.

## CHILDREN'S BEHAVIORS AND PARENTS' EXPECTATIONS ON THE EDGE OF WATER AND REAL CLIFFS

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[2] CIPER, Centro Interdisciplinar da Performance Humana, Lisboa, Portugal

**Introduction**
Classical studies with the visual cliff apparatus show that soon after crawling infants avoid high visual drop-offs. More recently Kretch and Adolph [1] tested infants in a real drop-off but with an experimenter accompanying the child. Their study showed that infants require locomotor experience to behave adaptively at a real drop-off in that situation. On the other hand, "water drop-offs" or swimming pools are also risk scenarios for children because they do not afford locomotion but they afford fun experiences, so children are frequently attracted to water.
**Methods**
Two studies that investigated children's behaviors and parents' expectations in risk scenarios will be presented. In the first study [2], we used a swimming pool task (retrieving a toy out of the water). Children (1 to 4 year-olds) were in a swimming suit, an experimenter was in the water and the water was warm. In the second study we created an apparatus with a real cliff and a water cliff in the lab. Climbing equipment guaranteed the protection of the infants (crawlers) without having to accompany them in the edge of the water or real cliffs. Infants were dressed and the water was cold.
**Results**
In the first study most children fell in the water while attempting to grasp the toy beyond their reaching limit. Most parents underestimated their child's maximum reachability and nearly 80% correctly predicted their child's behavior when the toy was unreachable. Preliminary results of the second study indicate that parents tend to think that their infants will cross water or real cliffs more often than they actually do. On the other hand, different exploratory behaviors were found on the edge of the water and of the cliff and infants' reactions to water seem to be less aversive than to the cliff.
**Discussion/Conclusions**
Children's reactions to risk environments are task specific. Water surfaces seem to be more attractive to children than cliffs. Parents are usually cautious in predicting their child's behavior. A longitudinal design (crawling / walking) would help to clarify the effect of posture-specific locomotor experience in the perception of affordances [1].

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## INFLUENCE OF TASK CONSTRAINTS ON THE ESTIMATION OF PHYSICAL ACTION CAPABILITIES IN CHILDREN

**Smith, J., Hartman, E., Pepping, G.-J., & Visscher, C.**
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University of Groningen, The Netherlands.

**Introduction**
The ability to perceive action capabilities is an important perceptual-motor skill required to reduce the likelihood of accidents or injuries and to optimise performance in everyday tasks. In adults, a number of studies on affordance perception have examined upper and lower-body tasks such as overhead reaching, stepping, gap-crossing and dynamic jumping tasks. However, less is known about how this ability develops during childhood. Plumert [1] found that 6-8 year-old children overestimate their ability to perform reaching and stepping tasks and that in younger children this overestimation is related to increased accidental injuries. This raises the

question, whether this overestimation also occurs in older children? And whether it is general and occurs across all tasks, or whether it is task specific?

**Methods**

Forty children (21 girls, 19 boys) aged 8-12 years old were asked to complete a series of four tasks to compare their perceived and actual action-boundaries. The tasks (stepping, forward jumping, overhead reaching, and overhead reach-and-jump) were selected to contrast lower-body versus upper-body tasks, and static versus more dynamic (jumping) tasks. For each task children performed two estimations: one where the task was presented *moving away* from them and one *moving towards* them. All estimates were scaled to the child's measured maximal ability.

**Results**

In general, the children tended to underestimate, rather than overestimate their action capabilities on all four tasks. Clear effects of task constraints were found. Children's perceived ability in upper-body tasks was more accurate than on lower-body tasks, and static tasks were more accurate than dynamic tasks. Meanwhile, judgments made in tasks presented moving toward the child were more accurate than tasks moving away from the child.

**Discussion/Conclusions**

The children's perceived ability was highly accurate in the reaching tasks and lowest in the forward jumping task. Which may indicate that forward jumping is at an earlier stage of development than the other reaching and stepping tasks. Hence under/over estimation of action capabilities is task specific and may serve a functional role in the development of perceptual-motor skills.

**References**

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SYMPOSIUM 2

# SOCIALLY EMBEDDED PERCEPTION-ACTION

## Chairs: Meagher, B. R. & Marsh, K. L.

### Presentation

The ecological approach argues that perception entails picking up information that specifies *affordances*, the opportunities for action that exist for a perceiver. However, behavioural opportunities are constrained by more than simply one's own physical capabilities. Rather, actions are also guided by the interpersonal relationships and relevant sociocultural contexts in which perceivers are embedded. That is, perceivers frequently detect and actualize affordances that can be defined only in terms of cooperative social relationships and normative cultural practices. The goal of this symposium is to highlight the socially situated nature of affordances by bringing together research that has examined how perception and action are influenced by the complex dynamics inherent within dyadic units, places, and cultures. In the first paper of the symposium, Harry Heft will discuss the concept of places, which emerge from collective patterns of action among groups of individuals, and perceivers' ability to detect the affordances of them. Next, Benjamin Meagher will present research testing the applicability of an action-specific account of perception to cooperative social contexts. These results reveal that judgments of distance can be influenced by the anticipation of working jointly; however, the direction of the effect proves to be dependent upon the framing of the social context. Finally, Erik Rietveld will discuss how individual responsiveness to particular affordances is tied to the larger socio-cultural norms within which these behaviours are nested.

## THE AFFORDANCES OF PLACES

**Heft, H.**
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The emphasis within ecological psychology on the body-referenced character of affordances has tended to mask the significance of socially normative practices when individuals engage affordances. It is one thing to ask whether an individual can physically utilize an affordance, and another thing to ask whether the individual ought to do so, or even will experience some feature of surface layout as affording some action (in a socially normative sense). In short, the body in the context of social practices takes on an extended meaning that it is not usually accorded in affordance research. Recognition of the socially normative character of affordance utilization provides an opportunity to understand the affordances of places. The individual's participation in social settings likewise has a socially normative character, but in such cases, largely with respect to the individual's involvement in the collective actions that constitute such places. But do individuals perceive the affordances of places? Prior research (presented at EWEP12) suggested that the identity of place is recognizable from the collective patterns of movement displayed by participants – that is, perceiving structure from motion. However, that research indicated that some places are far more readily identifiable than others. We suspect that patterns of activity reveal the constraints operating with respect to socially normative possibilities in places. It is expected that those settings most readily identifiable in the prior research will also be perceived as affording a narrower range of permissible activities, and those least identifiable with be seen as having fewer constraints on action. Some preliminary data relating to this question will be presented.

## JOINT-ACTION-SPECIFIC PERCEPTION: DISTANCE ESTIMATES DURING COOPERATIVE TASKS

**Meagher, B.R. & Marsh, K.L.**
University of Connecticut, United States

A growing empirical literature has found that judgments of distance are influenced by the energetic costs associated with performing particular actions across it *[1, 2]. However, prior research has focused almost exclusively on the perceptual consequences of individual behaviour, despite the fact that* individuals regularly take part in cooperative social interactions. Across five studies, we tested the circumstances under which similar perceptual effects would occur when participants anticipated coordinating with another person.

**Method**

The general procedure for all studies was as follows: Participants were randomly assigned to either a solo carrying or a joint carrying condition. Joint carriers were told that they would be working as partners with a same-sex confederate to carry a heavy object to different locations, whereas solo carriers were told they would be taking turns carrying alone. Participants provided metric estimates and blind-walked to a cone placed 10 m. away that they expected to carry to.

**Results**

Surprisingly, in Experiments 1 and 2, joint carries reported farther distance estimates than solo carriers, Exp. 1: $F(1, 35) = 5.10$, $p < .05$; Exp. 2: $t(35) = 2.09$, $p < .05$. In Experiments 3, 4, and 5, these results were reversed when the difficulty of the solo task was emphasized to participants, either by informing them of the alternative experimental condition or by asking them to rate the difficulty of the task, Exp. 3: $t(38) = 2.52$, $p < .05$; Exp. 4: $F(1, 73) = 5.30$, $p < .05$; Exp. 5: $F(120) = 7.35$, $p < .01$.

**Conclusions**

Even though carrying with another person requires less physical effort, on certain carrying tasks participants judged distances to be farther when expecting help. These results highlight the limitations of purely effortful accounts of such phenomena. However, this effect was reversed by reframing to participants the benefit of working cooperatively, thereby demonstrating the unique ways in which social factors relevant to coordination can alter how people relate to their physical environments.

**References**

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## THE NORMATIVE ASPECT OF RESPONSIVENESS TO AFFORDANCES

**Rietveld, E.**
University of Amsterdam, The Netherlands

In many situations in our daily lives we act adequately, yet unreflectively. With certainty and fluency we turn the pages of a book, maintain an appropriate distance from the other people in an elevator, and without deliberation we stop the pedestrian next to us, who, while about to cross the street, does not notice an oncoming car. Often we are simply unreflectively responsive to affordances and normally this immediate action is adequate. The notion of normativity implied here is a very basic and situate one [1], namely distinguishing adequate from inadequate, correct from incorrect, or better from worse in the context of a particular situation.

Both humans and animals are selectively responsive to some affordance rather than others, in ways that are related to the individual's dynamically changing needs/interests and the concrete situation. This phenomenon of responsiveness to *relevant* affordances (in context) is crucial and can even be seen as a paradigmatic form of unreflective action.

It is quite amazing that even without explicit deliberation and in complex situations we normally act in ways that are appropriate from the point of view of socio-cultural practice. Wittgenstein's descriptions of architects and tailors at work contribute to a better understanding of the links between responsiveness to relevant affordances and socially constituted norms. He shows in his 'Lectures on Aesthetics' [2] that skill, emotion, and appreciation are crucial for understanding how expert craftsmen act correctly. My paper aims to contribute to a better understanding of the normative aspect of unreflective responsiveness to relevant affordances via a better understanding of how expertise works in specialised skill domains, such as tailoring or architecture.

**References**

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[2] Wittgenstein, L. (1978). Lectures on aesthetics. In Wittgenstein, L., *Lectures and Conversations on Aesthetics, Psychology and Religious Belief* (pp. 1-40). Oxford: Blackwell.

SYMPOSIUM 3

# PHYSICAL INTELLIGENCE

## Chairs: Dixon, J. A. & Carello, C.

### Presentation

Although intelligence is often considered the exclusive province of human beings, nearly all organisms show fundamental aspects of intelligence, such as goal-directedness, intentionality, and sensitivity to their environmental circumstances. The systems that exhibit intelligent behavior across the five biological kingdoms are extremely heterogeneous, suggesting that intelligence, rather than residing in specialized neural instantiations, may be better considered as a higher-order property of self-organizing physical systems (Turvey, & Carello, 2012). The present symposium develops intuitions presented at ICPA 16 (Carello, 2011) in terms of the question: What is the underlying physical basis of intelligent, goal-directed behavior? Our approach draws heavily on the long-standing ecological commitment to natural-law explanations of perception, action, and cognition. Dilip Kondepudi will highlight implications of modern thermodynamics for the emergence of physical intelligence. Nigel Stepp and Narayan Srinivasa will provide a formalization of autocatakinetics, expected to play a key role in understanding how intelligence arises from thermodynamic principles (Swenson & Turvey, 1991). J. Dixon and Bruce Kay will describe experiments with a self-organized foraging implementation (SOFI) that begin to instantiate some of these principles.

### References

Carello, C. (2011). *A natural-physical approach to perception-action-cognition.* Symposium conducted at the 16th International Conference on Perception and Action, Ouro Preto, Brazil.
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Turvey, M. T., & Carello, C. (2012). On intelligence from first principles: guidelines for inquiry into the hypothesis of physical intelligence (PI). *Ecol. Psychol., 24,* 3-32.

## MECHANICS, THERMODYNAMICS AND PHYSICAL INTELLIGENCE

**Kondepudi, D.K.**
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Mechanics and thermodynamics, two great pillars of physics, are fundamentally different. Mechanics is based on time-reversible laws, while thermodynamics is based on time-irreversible laws. Consequences of this fundamental difference and their impact on formulating a theory of physical intelligence are discussed. Two very different worlds that have emerged from our use of mechanics and thermodynamics are contrasted. It is argued that it is thermodynamics that has the necessary concepts for the description of physical intelligence (PI). The progress in thermodynamics in the 20th century is outlined with an emphasis on its ability to describe self-organization in nature (Kondepudi & Prigogine, 1998). However, further conceptual developments and experiments are needed for a thermodynamic theory of PI. Some possible approaches for the formulation of such a theory and the kind of experiments that are needed are discussed. Concepts of functional symmetry breaking and functional stability will be introduced. Such a theory will link basic physics to higher level complex phenomena such as action-perception process (Swenson, 1998; Swenson & Turvey, 1991).

**References**
Kondepudi, D., & Prigogine, I. (1998). *Modern thermodynamics, from heat engine to dissipative structures*. New York, NY: John Wiley.
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## STRONG ANTICIPATION

**Stepp, N.[1] & Turvey, M.T.[2]**
[1] HRL Laboratories, Malibu, CA, USA
[2] Center for the Ecological Study of Perception and Action,
University of Connecticut, USA

Physical intelligence (PI) entails agency, the ability to exhibit autonomy and control in one's encounters. As one of the pillars of agency, prospectivity—coordinating current control with emerging states of affairs—must follow from first principles if it is to characterize PI. Typical accounts of prospectivity, construed as anticipation or expectation in orthodox theories of perception, rely on loans of intelligence such as internal models (a strategy referred to as *weak anticipation* by Dubois, 2001). In contrast, we offer an account in which awareness of upcoming opportunities for action arises by means of systemic lawfulness (a strategy referred to as *strong anticipation* by Dubois, 2001). The key, shown via experiment and simulations (Stepp, 2009, 2012; Stepp, Chemero & Turvey, 2011; Stepp & Turvey, 2010), rests on delay coupling (Voss, 2000) which leads to anticipation by simple "slaves" (e.g., linear spring dynamics) of complicated "masters" (e.g., chaotic dynamics) and by complicated slaves of simple masters. An additional advantage of this tack is that the dynamics of delayed coupling may also encompass retrospectivity, a second pillar of the kind of agency entailed by PI.

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## SELF-ORGANIZING FORAGING IMPLEMENTATION (SOFI)

**Dixon, J. A. & Kay, B. A.**
Center for the Ecological Study of Perception and Action, University of Connecticut, USA

We present results of experiments with SOFI, our Self-Organizing Foraging Implementation. SOFI consists of a petri dish containing oil and steel ball bearings (Jun & Hübler, 2005; Kugler, 2007). A needle electrode, centered over the dish, creates a high voltage electron field; a circular, grounding electrode along the interior edge of the dish collects charge. The ball bearings are initially at random positions, but with the application of the electron field, a distinct morphology emerges: The beads form a tree-like structure. We show that this morphology increases the rate of entropy production. The system then uses this tree-like structure to forage for energy; when the branches deplete the electron supply in one area, they move to another

area. Interestingly, the foraging behavior of the system further increases the rate of entropy production over a slightly longer time scale. Additional experiments show that not only is SOFI sensitive to changes imposed on its environment, but SOFI can also alter its own environment in the service of entropy production. We discuss the implications of these results for an emerging theory of physical intelligence (Carello, 2011; Turvey & Carello, 2012).

**References**

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SYMPOSIUM 4

# PERCEPTION-ACTION DYNAMICS AND THE PERSON-PLUS-OBJECT SYSTEM

**Chairs: Wagman, J. B. & Higuchi, T.**

**Presentation**

Objects attached to the body create an integrated person-plus-object system with perception-action capabilities and control dynamics that differ from those of the person-without-object. First, objects attached to the body change a person's action capabilities and therefore change whether (and how) an intended behavior can be performed. In the first presentation, **Takahiro Higuchi and colleagues** will describe the locomotor strategies used by people attempting to pass through a narrow aperture while carrying a long object so as to safely accommodate the extended width of the person-plus-object system. Second, use of a tool to perform a goal directed behavior requires that movements of the body be transformed into movements of the tool despite that tool's unique control dynamics. In the second presentation, **Raoul Bongers and colleagues** will describe how people learn to use pliers that vary in hinge location to pick up a small object. Third, objects attached to the body not only change a person's action capabilities but also that person's perceptual capabilities. In the third presentation, **Jeffrey B. Wagman and Alen Hajnal** will describe experiments investigating perception of stand-on-ability of an unseen surface by means of an object wielded with different hand and grasp configurations. Perception and use of attachments to the body exemplifies several fundamental ecological concepts including (a) perception-action mutuality, (b) action scaling of affordances, (c) animal-environment mutuality, and (d) the soft assembly of smart perceptual devices. The presentations in this symposium will complement one another by exploring these aspects of attachments to the body.

## RULE FOR SCALING SHOULDER ROTATION ANGLES WHILE WALKING THROUGH APERTURES

**Higuchi, T.[1], Seya, Y.[2], & Imanaka, K.[1]**
[1] Tokyo Metropolitan University, Japan
[2] Ritsumeikan University, Japan

**Introduction**
When an individual is trying to fit into a narrow aperture, the amplitude of shoulder rotations in the yaw dimension is well proportioned to the relative aperture width to body width (referred to as the critical ratio value) [1, 2]. Based on this fact, it is generally considered that the amplitudes of shoulder rotations are determined in response to this ratio value. The present study was designed to determine whether the amplitude of rotations would be determined on the basis of another rule in which a minimal spatial margin is created at the aperture passage; this rule is beneficial particularly when spatial requirements for passage (i.e., the minimum passable width) become wider than the body with an external object.
**Methods/Results**
Eight young participants walked through narrow apertures of three widths (ratio value = 0.9, 1.0, and 1.1) while holding one of three horizontal bars (short, 1.5 and 2.5 times the body width). The results showed that the amplitude of rotation angles became smaller for the respective ratio value as the bar increased in length. This was clearly inconsistent with the general hypothesis that predicted the same rotation angles for the same ratio value. Instead, the results were better explained with a new hypothesis which predicted that a smaller rotation angle was sufficient to produce a constant spatial margin as the bar-length increased in length.

**Conclusion**
The results show that, at least under safe circumstances, the amplitudes of shoulder rotations were determined to ensure the minimal spatial margin being created at one side of the body at the time of crossing. This was new in that the aperture width subtracted from the width of the body (plus object) was taken into account for the visuomotor control of locomotion through apertures.

**References**
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*Acknowledgements.* This study was supported by a Grant-in-Aid for JSPS (Japanese Society for Promotion of Science)
fellows.

## LEARNING DIFFERENT AFFORDANCES WHEN GRASPING WITH TOOLS

**Bongers, R. M., Golenia, L., Mouton, L.J., & Schoemaker, M.M.**
Center for Human Movement Sciences, University of Groningen, University Medical Center Groningen, The Netherlands

**Introduction**
Making goal-directed actions with a tool implies that movements of the body are transformed to movements of the new end-effector, the tool. Tool properties determine how bodily movements translate to end-effector movements. Hence, tool properties affect affordances. The current study examined how participants learn to act on new affordances when objects have to be picked up with a novel pair of pliers. We manipulated the location of the hinge on the pair of pliers; when the hinge was located close to the digits the beak opened faster than the digits, whereas a hinge far from the digits decreased beak opening speed relative to the digits. Hence, changing hinge location varied grasping affordances systematically. We studied how participants learned to act on these changed affordances.
**Methods**
Three groups of 10 participants each (all university students) picked up a small cylinder with a pair of pliers for 100 times on two consecutive days. The pair of pliers was always 20cm long. One group had the hinge at 5cm from the fingers, one group at 10cm, and one group at 15cm. We measured kinematics of the beak. We analyzed standard prehension measures, such as hand opening time, hand closing time and maximum aperture.
**Results**
Interestingly, the grasping pattern with a pair of pliers showed a plateau phase, which is remarkably different from non-tool grasping showing a clear peak in the grasp profile. Importantly, this plateau time decreased over repetitions of trials. The fastest decrease in plateau duration took place in the first 20 trials. The plateau time went from 286ms to 270 ms over the days for the fast pair of pliers, from 205ms to 148ms for the middle, and from 424ms to 297ms for the slow pair of pliers. Note that using the same algorithm to analyze the plateau time for nontool grasping would give values around 150ms.
**Discussion**
The results showed that in pliers' grasping hand opening is decoupled from hand closing and that over learning they become more coupled, though they only reach a comparable level of coupling when the digit-beak mapping is one-to-one. Note that the affordances are more difficult to learn when the digit-beak mapping is not one-to-one

# PERCEPTION OF STAND-ON-ABILITY BY MEANS OF A WIELDED OBJECT EXHIBITS ANATOMICAL INDEPENDENCE

**Wagman, J.B.[1] & Hajnal, A.[2]**
[1] Illinois State University, USA
[2] University of Southern Mississippi, USA

## Introduction

Perception of properties of wielded objects is largely independent of the (configuration of) anatomical components used to wield those objects. For example, perceived length of a wielded object is comparable by hand and by foot [1]. We investigated whether perception of affordances *by means of* a wielded object also exhibits anatomical independence. Specifically, we compared perception of stand-on-ability of an inclined surface when it was explored with a rod held in the preferred or non-preferred hand (Exp. 1), one or both hands (Exp. 2), and different two-handed grasps (Exp. 3).

## Methods

Blindfolded participants explored a surface at seven different angles (15° - 45° in 5° increments). They reported (yes or no) whether they could stand on that surface and rated their confidence (from 1 to 7). In all experiments, each angle was presented three times in a random order.

## Results

Perceptual boundaries (the angle that received a yes response on 50% of trials) were comparable across differences in hand (31.3° vs. 32.3°), number of hands (29.5° vs. 30.5°), and grasp configuration (30.3° vs. 28.5°). Moreover, minimum confidence and maximum response latency occurred within the range of these perceptual boundaries.

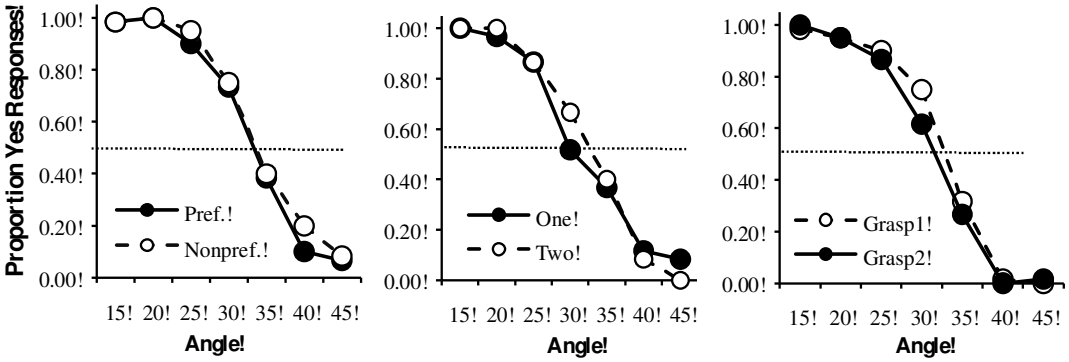


Figure 1. Proportion of yes responses at each angle in Exp. 1 (left), Exp. 2 (center), and Exp. 3 (right).

## Discussion

The results (1) suggest that perception of affordances by means of a wielded object is anatomically independent and functionally specific and (2) are consistent with a description of the haptic system as a smart perceptual instrument.

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SYMPOSIUM 5

# ODOMETRY OF HUMANS AND ANTS

## Chairs: Turvey, M.T. & Carello, C.

### Presentation

For legged animals that locomote with 2, 4, 6, or 8 legs there is evidence to suggest that their legged activity not only gets them from A to B but also provides a nonvisual measure of the distance from A to B. That is, legged locomotion functions as an odometer. Each of the different forms of *n*-legged locomotion can be classified by the group symmetry of the minimal network of identical differential equations (alias cells) required to model it. For human gaits ($n$ = 2), dihedral symmetry characterizes the so-called primary forms (e.g., walk, run), and a (lower) cyclic symmetry characterizes the so-called secondary forms (e.g., skip, gallop). In tests of human odometry (Turvey et al., 2009, 2012), the blindfolded reported distance equals the blindfolded measured distance when the symmetry of measure and report gaits is the same (e.g., walk, run) but not when it is different (e.g., walk, gallop).

In the symposium, Carla Pinto will present the basic notions behind the group symmetry analysis of gaits with a focus on the primary-secondary distinction in 2-legged and 6-legged gaits. Matthias Wittlinger will summarize the odometry capabilities of ants and the current theorizing on how those capabilities are realized. Lin Nie and Claudia Carello will summarize the experiments on human odometry, including experiments testing humans under conditions that have proven important to understanding how ants might conduct their distance measurements.

## SYMMETRY OF LOCOMOTOR MODELS FOR ANIMALS

**Pinto, C.**
Department of Mathematics, School of Engineering, Polytechnic of Porto

In this presentation, I will give the basic notions behind the group symmetry analysis of gaits. Animal gaits can be modeled by coupled cell networks that possess some degree of symmetry (Golubitsky, Stewart, Buono, & Collins, 1998; Golubitsky, Stewart, Buono, & Collins, 1999; Pinto & Golubitsky, 2006). This symmetry helps to distinguish between different gaits, such as walk and run in humans or pace and trot in horses. Symmetry can also be used to distinguish between two types of gaits, namely primary and secondary gaits, produced by a given n-legged animal. In particular, I will focus on the primary-secondary distinction in 2-legged and 6-legged gaits.

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## THE DESERT ANT ODOMETER

**Wittlinger, M.**
Institute of Neurobiology, University of Ulm, Germany

The ability to measure travel distances is essential for many animals, especially for those that employ path integration for navigating in their environment. The North African desert ant *Cataglyphis fortis* masters this challenge with amazing precision, employing a stride integrator and an optic flow integrator as distance gauges. The stride integrator has previously been demonstrated by altering leg length, and stride length as a consequence, in homing ant foragers. Ants that had their legs shortened on the homebound journey—walking on stumps—underestimated the distance to their nest by an amount that closely agreed with the actual shortening in stride length brought about by the leg shortening (Wittlinger et al., 2006; Wittlinger et al., 2007). Individuals walking on elongated legs—stilts—overestimated homing distance correspondingly. *Cataglyphis fortis* ants use tripod gait almost over the entire range of walking speeds. Only at walking speeds below 2 cm/s a metachronal gait is observed. However, when *Cataglyphis fortis* ants are on a foraging run, travel speed rarely lies below 10 cm/s. At higher walking speeds that span from 5 cm/s to 70 cm/s tripod, coordination is almost perfect. Even ants with missing legs that have their walking apparatus severely impaired and which are walking on only four legs try to maintain tripod gait, that is, the remaining legs are moved in the hexapodal tripod fashion.

Stride integration is complemented by a second mechanism, an optic flow integrator that uses self-induced visual flow fields generated by the translational movement on the ventral part of the compound eyes (Ronacher & Wehner, 1995).

Here I show that both integrators are working independently and can be used exclusively for the estimation of travel distance. In conflicting situations, when the input of the stride integrator and the optic flow integrator provide dissimilar inputs, the ants make errors in gauging the travel distance correctly.

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## HUMAN ODOMETRY, GAIT SYMMETRY, AND SMART PERCEPTUAL INSTRUMENTS

**Nie, L. & Carello, C.**
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The possibility of human odometry was first identified by Berkeley in his *Essay Toward a New Theory of Vision*. He asserted that a human measures distance by “the motion of his body, which is perceivable by touch” (1709/1948, p. 188). His intuition has been tested by a variety of simple homing tasks with blindfolded human participants. On any given trial, a participant goes from a fixed starting point *A* to a variable terminus *B*—signaled during locomotion by the experimenter—and then attempts to return to *A*. The manner of movement employed during *Measure* (the outbound traverse from *A* to *B)* and *Report* (the return traverse from *B* to *A)* can be the same or different. Berkeley’s Hypothesis holds for a variety of differences between *Measure* and *Report* (time, steps, gait) save one: The reporting and measuring gaits must satisfy the same mathematical symmetry group (Isenhower, Kant, Frank, Pinto, Carello, & Turvey, 2012; Turvey, Harrison, Frank, & Carello, 2012; Turvey, Romaniak-Gross, Isenhower,

Arzamarski, Harrison, & Carello, 2009). Apparently, the human odometer (and perhaps legged odometers more generally) is not a pedometer or a stride integrator. Understanding it may require a willingness to think more abstractly about the smart instruments manifest in dynamic touching. Namely, *Measure* and *Report* (of same or different symmetry) should be treated as coupled and forming a single haptic perceptual instrument.

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SYMPOSIUM 6

# MULTI-AGENT COORDINATION: ANALYZING AND MODELING COLLECTIVE BEHAVIOR

**Chairs: Warren, W.H. & Kiefer, A.W. (Part I)**

**Duarte, R. & Richardson, M.J. (Part II)**

## Presentation

It has long been argued that collective behavior in humans and animals emerges from local interactions between individuals via self-organizing dynamics. With the advent of large-scale motion-capture techniques and new analytic methods, theories of pattern formation in flocks, schools, crowds, and social groups are now making contact with rigorous empirical data. The purpose of this joint symposium is to bring together perspectives from different fields on recent developments in the analysis and modeling of multi-agent systems.

## Part I

Part I introduces perspectives from cognitive science, computer science, and physics. William Warren, Adam Kiefer, and Stéphane Bonneaud (Brown University, USA) will introduce the topic and describe how they are extending a local model of pedestrian behavior to account for the dynamics of human "swarms". Julien Pettré (INRIA, Rennes, France) is developing pedestrian models for multi-agent crowd simulation in computer animation, showing how collective behavior emerges from local interactions. The models are derived from data on human crowds and are based on an individual agent's viewpoint. Viktor Jirsa (University of the Mediterranean, France) brings a physical approach to the problem of pattern formation in multi-agent systems. He investigates the dynamics of coordination in team behavior from both a theoretical and measurement point of view.

This symposium aims to address such questions as: How should multi-agent coordination be measured (what are the order parameters)? Under what conditions does collective behavior emerge spontaneously or intentionally (what are the control parameters)? Can global patterns be explained by local interactions, and what is the minimal set of interactions necessary?

## Part II

Part II introduces perspectives from robotics, sport sciences, and psychology.
Tamara Lorenz and her colleagues (Ludwig-Maximilians Universität, Germany) study synchronization in human-human interactionsas a model for human-robot interactions. Ricardo Duarte (Technical University of Lisbon, Portugal) will present a series of field studies on the collective synchronization of football teams, using an adaptation of the Kuramoto model. Finally, Michael Richardson (University of Cincinnati, USA) will discuss recent research aimed at identifying the self-organizing dynamics of complex physical interactions among socially coordinated human agents. He will present a modeling strategy for capturing the behavioral dynamics of human multi-agent systems and describe how such models could be used for the design of artificial multi-agent systems.

This symposium aims to address such questions as: What are the fundamental and ubiquitous principles underlying multi-agent coordination? Is there evidence of mutuality and synergistic coordination in social collective systems? Can the innovative methods that have been developed for capturing and modeling the time-evolving dynamics of multi-agent systems in the laboratory, be applied in real world settings and for the design multi-agent human-machine systems?

## MODELING THE COLLECTIVE BEHAVIOR OF HUMAN CROWDS: A LOCAL+GLOBAL APPROACH

**Warren, W.H., Kiefer, A.W., & Bonneaud, S.**
Brown University

The collective behavior of human crowds is thought to emerge from local interactions between pedestrians. There are numerous pedestrian and crowd models in disparate fields, but few of them are based on experimental data. A *local → global* approach aims to show that an agent-based model can generate global patterns of behavior, but such models often make ad hoc assumptions about individual behavior. Conversely, a *global → local* approach aims to derive the local coupling from observed patterns of global behavior, but the same global pattern can be generated by many different local models. We are combining these approaches to converge on an empirically-grounded model of pedestrian and crowd dynamics (Sumpter, 2012).

First, experiments on locomotor behavior are used to map out the local coupling between neighbors and build a pedestrian model. Second, multi-agent simulations are used to identify the minimal model that is sufficient to generate characteristic patterns of crowd behavior. Third, data on human crowds are analyzed to constrain the local coupling, and to test and refine the model, using techniques inspired by work on coordination dynamics and collective animal behavior.

Thus far we have derived model components for steering to a goal, avoiding obstacles, matching a neighbor's speed, and are testing components for heading alignment and emergency braking. We describe naturalistic data on crowds (N=20) walking in different scenarios (12x20 m) while head positions were tracked: (1) *Grand Central Station* – participants criss-crossed an arena while avoiding 10 obstacles and each other. (2) *Swarm* – participants randomly veered left and right while staying together as a group. (3) *Counterflow* – two groups passed through each other, spontaneous forming lanes. Each global pattern can be simulated with a few model components. Importantly, in Grand Central and Counterflow opposing pedestrians must be treated as moving obstacles to form stable lanes, but neighbors cannot be treated so for a stable Swarm. Conversely, Swarm coordination is being analyzed with PCA, CRQA, UCM, and neighbor statistics.

The results support the view that crowd dynamics emerge from a few simple pedestrian interactions. We are currently investigating the details of the coupling, the *order parameter* of crowd coherence, *control parameters* for aggregation and pattern formation, and the upward and downward mechanisms of self-organization.

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## SYNTHETIC VISION-BASED CROWD SIMULATION

**Pettré, J.**
Inria-Rennes, France

Collective behaviour emerges from local interactions between individuals. Microscopic crowd simulation follows this perspective by basing simulations on local models of interaction.

A local model of interactions provides an algorithmic answer to these questions:

- Selection: which agent should interact with which agent?
  (notion of agent's neighbourhood).
- Combination: how several simultaneous interactions should be combined?
  (cumulative or successive effect in time).
- Influence: how interacting agents influence each other's motion?
  (kinematic model of interaction).

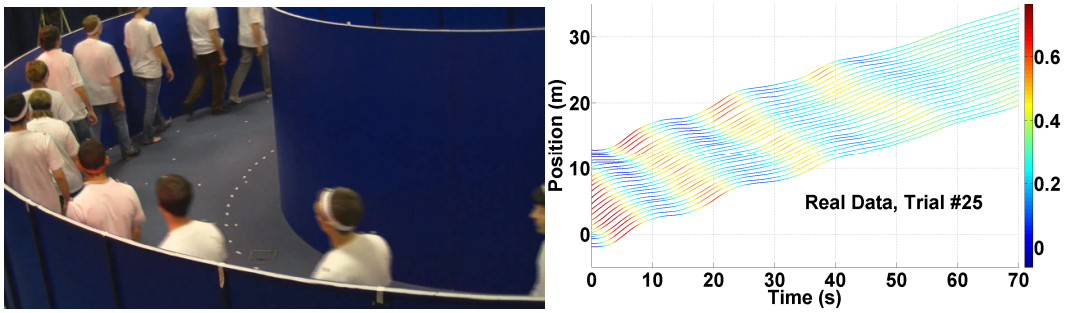


Fig. 1 – Example of experiments on collective behavior.

Our presentation focuses on our efforts to improve crowd simulation models:

- we strongly participated the development of a new generation of models taking into anticipation [1] (whereas previous models formulated interaction as a function of the *current* agents' state.
- we experimentally proved that our models were better matching real humans interaction [3], and acquired data both describing the microscopic and macroscopic aspect of collective motion (see figure 1 on stop-and-go waves emerging from 1D-traffic).
- we mathematically formulated our interaction from a set of perceptual variables and equipped agents with synthetic vision [2]. We designed the crowd model realistically simulating the human perception / action loop and showed its ability to simulate emergent collective patterns.

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## OBSERVER-INDEPENDENT DYNAMICAL MEASURES OF TEAM COORDINATION AND PERFORMANCE

**Jirsa, V.**
Institut de Neurosciences des Systèmes, UMR1106 Inserm, Aix-Marseille Université, France

**Introduction**

Although it is commonly accepted that team performance develops with time and experience, there is still much debate on how to quantify this evolution. Unlike individual performance, which focuses on acquiring task knowledge and applying it to problem-solving challenges, team performance emphasizes acquiring team coordination knowledge, which requires that individual team members learn each other's goal-related behaviors and, if necessary, adjust their own performance accordingly.

**Methods**

We propose that team dynamics can be represented by a low-dimensional task-dependent manifold. To gain insights into team coordination, we take the following approach: for a fixed set of parameters, a manifold in state space exists that captures a "perfect" team dynamics. By assumption, variations of the trajectories within the manifold will not affect the performance of the team, since by definition this manifold is composed of trajectories that correspond to perfect task execution. Deviations from the manifold, however, are a sign of reduced team performance

either via reduced skill or lack of coordination. We test our proposed measures against experimental data from realistic combat operations in urban settings. Three teams of different skill levels were studied.

**Results and Discussion/Conclusions**
With our task manifold based approach, we are able to derive objective measures of team performance while taking into account the high number of degrees of freedom in the task. Our approach allows quantifying and tracking important features of team dynamics, such as team coordination and team performance over time. Analyzing the coordination patterns within each team showed that the novice team relies more on nearest-neighbor coordination in the beginning of the trials than do intermediate and expert teams. This finding indicates that more advanced teams distinguish themselves by more homogeneous team coordination that extends across multiple team members and points toward heightened team awareness.

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## THE COLLECTIVE SYNCHRONIZATION OF FOOTBALL TEAMS

**Duarte, R.**
Spertlab, Faculdade de Motricidade Humana, Universidade Técnica de Lisboa, Portugal

Synchronization phenomena have been reported as the most familiar and natural mode of organization for coupled oscillators or mutual interacting agents [1]. Recent research on association football suggests that local coordination tendencies exploited by team players often result in high levels of collective synchronization [2]. However, clear evidence is needed regarding the importance and meaning of whole team synchronization levels for competitive performance. Are there any effects of the opponent level on team synchronization? Is team synchronization a feature of more evolved teams? Is team synchronization likely to be developed with practice? Here I will present a series of studies on dyadic and collective synchronization of football teams trying to shed light on these questions.
In overall, data showed that teams' collective synchronization: i) is associated to more evolved collective behaviors, such as the use of zone defense; ii) proportionally increased as a function of opponent team level; iii) is simultaneous high in attacking and defending phases, not varying with ball possession; iv) is higher in the longitudinal movements compared to the lateral movements; v) is able to be developed with practice.
These findings clarified that internal movement synchronization of football teams is an important feature able to discriminate their performance level. Relevant practical implications can be derived for coaching, namely for team tactical organization, in which synchronized collective movements should be incorporated in the planning of training sessions. Also, performance analysts can use measures of team synchronization as reliable performance indicators for analyzing and predicting performance in football.

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## BEHAVIORAL DYNAMICS OF JOINT ACTION AND SOCIAL COORDINATION

**Richardson, M.J.**
Center for Cognition, Action and Perception, University of Cincinnati, U.S.A.

A fundamental feature of social behavior is the face-to-face or co-present interactions that characterize everyday social activity. The success of such interactions, whether measured in terms of social connection, goal achievement, or the ability of an individual or group of individuals to understand and predict the meaningful intentions and behaviors of others, is not only dependent on the processes of social cognition and perception, but also on the between-person motor coordination that makes such face-to-face and co-present interactions possible. Understanding and modeling the dynamics of social motor coordination, including how it emerges and is maintained over time, as well as how its stable states are activated, dissolved, transformed, and exchanged over time, is therefore an extremely important endeavor. Here I will review a number of recent research studies aimed at uncovering and modeling the temporal and spatial patterns that dynamically emerge during a range of different discrete and continuous movement based multi-agent action tasks. In turn, I will describe a dynamical modeling strategy for capturing and understanding the self-organized behavioral dynamics of goal-directed physical activity among socially coordinated human agents. I will also detail how this modeling strategy could be used for the development of multi-agent human-machine systems.

## EXPLORING MOVEMENT SYNCHRONIZATION FOR HUMAN ROBOT INTERACTION

**Lorenz, T.[1,2], Mörtl, A.[2], Vlaskamp, B.N.S.[1,3], & Hirche, S.[2]**
[1] Experimental Psychology, Ludwig-Maximilians Universität, Germany; [2] Institute for Information-oriented Control, Technische Universität München, Germany; [3] Philips Research, Eindhoven, The Netherlands.

Human movement synchronization (MS) is a frequently emerging phenomenon that causes several positive effects such as increased interpersonal sympathy and predictability during interaction. Because of these positive effects, MS is interesting in the context of human-robot interaction (HRI). We studied human-robot MS in a goal-directed task in two experiments. First we investigated if humans naturally synchronize their movements to a non-adaptive robot. Second, the robot was enabled to synchronize its movements to those of a human. Here, the robot was controlled by a coupled-oscillators model identified from human-human MS [1].
In both experiments, human and robot were sitting at a table facing each other while performing goal-directed tapping movements; the robot motion was generated by minimum-jerk profiles. In the first experiment it moved at a constant frequency while in the second experiment, the robot moved according to the adjusted coupled-oscillators model [1] that modulated the robot's movement frequency via different couplings according to the human movement. Additionally, participants were asked to judge robotic MS behavior on different scales.
Relative phase data shows that humans do not synchronize their movements to a non-adaptive robot. If coupling was applied, MS emerges mainly in anti-phase relation. Subjective ratings do not reveal a difference in perceived safety; the degree to which people felt in control depended on the applied coupling.
These findings are important because MS provides a way to make HRI more predictable and thus safer. Moreover, because MS with humans comes with stronger mutual appreciation, being able to synchronize with a well-coupled robot may contribute to its acceptance. The fact that MS does not emerge naturally with a non-adaptive robot suggests that for synchronization to occur, people have to experience an effect of their own movements on the movements of the interaction partner. Both the robot's motion profiles and its appearance might cause mainly anti-phase MS with applied coupling.

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SYMPOSIUM 7

# VARIABILITY AND FRACTALITY

## Chairs: Diniz, A., Wijnants, M.L., & Riley, M.A.

### Presentation

An essential issue in many fields is the change of phenomena over time and the corresponding variability which reflects the flexibility of the systems. However, for a long time, variability was not seen as a research interest and was generally ignored. More recently, time series studies have focused on the evaluation of variability and of the dependence structure. In many cases, correlations in the successive performances of the systems have shown patterns typical of long-memory or fractal processes. The purpose of this symposium is to discuss several theoretical questions about long-memory or fractality and to present some empirical studies related to this matter.

Ana Diniz will address the evaluation of long-memory and some explanations about its presence, namely in regime-switching processes; an experimental study will also be examined concerning a tapping task with two target intervals. Maarten Wijnants will talk about fractal principles in coordinated systems. Michael Riley will present a relatively new fractal method, adaptive fractal analysis, and its applications to cognitive and perceptual-motor performances.

## LONG MEMORY AND REGIME SWITCHING IN RHYTHMIC TASKS

**Diniz, A.[1], Barreiros, J.[1], & Crato, N.[2]**
[1] Faculty of Human Kinetics, Technical University of Lisbon, Portugal
[2] Institute of Economics and Management, Technical University of Lisbon, Portugal

An important subject in numerous situations is the evolution of phenomena over time and its inherent variability. In this framework, the time series methods in the time and frequency domains are very useful, allowing for characterization and modelling. In several fields, such as hydrology, economics, biology, and psychology, time series studies have often revealed results typical of long-memory (i.e., long-range correlated) processes which exhibit a so-called fractality (i.e., similar fluctuations over various time scales). The wide occurrence of long-range dependence in a number of systems poses some interesting questions, in particular the origin of this type of phenomenon. This presentation focuses on the evaluation of long-memory and the search for explanations about its presence. One of the explored solutions is related to regime-switching processes with heavy-tail distributions for the regimes' durations. An experimental study is also presented involving a rhythmic task with two target frequencies. More precisely, the analyzed data refer to long series of inter-response intervals in a tapping task with target intervals of 800 ms and 1600 ms, performed by ten students of the Faculty of Human Kinetics of the Technical University of Lisbon. The Wing-Kristofferson model which decomposes the inter-response intervals into time intervals associated to a cognitive component and a motor delay is taken as a starting point. In this presentation, a new theoretical model with a biological interpretation is proposed, in which the process related to the cognitive component is modelled as a regime-switching process. For this model, the theoretical autocorrelation function and the spectral density function are derived. Finally, given the empirical series, the parameters of the model are estimated with a spectral-likelihood method.

## FRACTAL PRINCIPLES OF COORDINATION IN COMPLEX SYSTEMS

**Wijnants, M.L.**
Behavioural Science Institute, Radboud University Nijmegen, the Netherlands

Around two decades ago, observing 1/*f* noise in cognitive performances was considered an interesting oddity. More recently, it has become clear that 1/*f* noise is found in any repeated performances, and that its relative presence is experimentally controllable. As it turns out, 1/*f* noise and well-coordinated system behavior go hand in hand, and brain, body and cognition appear to share this common language. That said, mainstream cognitive science is yet to embrace the full implications of coupled activity across multiple scales. Ignorance aside, doubts about the relevance of scaling laws have been cast by premature linear models that are guided by post-hoc data fitting. If ARIMA models and short-range correlations were to seriously challenge the interaction-dominant perspective, however, testable predictions should be derived a priori, and a parsimonious theory should be formulated to explain the coherence of empirical findings. Since this is unlikely to happen, the often cited 'vagueness' and 'what-does-it-buy-us' arguments are starting to boomerang back at mechanistic approaches. Prospects are that attention may now shift to the true challenges ahead.

## PRESERVATION OF FRACTAL GAIT DYNAMICS USING NON-ISOCHRONOUS METRONOMES

**Marmelat, V.[1,2], Torre, K.[1], Daffertshofer, A.[2], Beek, P.J.[2], & Delignières, D.[1]**
[1] Movement to Health Laboratory (M2H), Montpellier-1 University, EuroMov, France
[2] MOVE Research Institute Amsterdam, VU University Amsterdam, The Netherlands

**Introduction**
Stride intervals (SI) fluctuations in self-paced walking present persistent, long-range correlations (LRC). The presence of LRC is a natural outcome of adaptive systems, and suggests that the behaviour is regulated by multi-scales interactions. During isochronous (ISO) paced walking, SI are anti-persistent, i.e. the fluctuations become fixed around the single frequency of the metronome [1]. Is it possible to use a metronome that preserves the healthy (fractal) gait dynamics? Recent works suggest that the organism is "sensitive" to the LRC in the environment [2]. We made the hypothesis that a fractal auditory pacing will preserves the fractal dynamic of stride intervals in healthy participants.

**Methods**
12 volunteers (28.08 years ± 5.82) walked on a treadmill in which single large force platform was embedded. They performed 6 trials of 6 minutes at their preferred walking speed, in each following conditions: self-paced (SPW), isochronous paced (ISO), and fractal paced with different coefficients of variation in the inter-onsets intervals (CV 0.5%, CV 1%, CV 1.5% and CV 2%). Detrended Fluctuations Analysis (DFA) was used to estimate the fractal exponents (α) of stride intervals and onset intervals series.

**Results**
α-DFA exponents were estimated to: 0.73 (SPW), 0.28 (ISO), 0.60 (CV 0.5%), 0.78 (CV 1%), 0.85 (CV 1.5%) and 0.85 (CV 2%). ANOVA showed a significant effect of pacing conditions on α exponents ($F(5,66)=36.34$; $p<.001$). SPW differed from none of the fractal paced conditions ($p > .05$). In contrast, ISO was significantly different of all the fractal-paced conditions.

**Discussion/Conclusions**
We show that using a fractal metronome preserves the natural, fractal gait dynamics. Further work remains to investigate the influence of the structure of onsets fluctuations on gait dynamics, but this result is a first step in direction of optimized protocols of rehabilitation using complex, fractal environments.

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# ADAPTIVE FRACTAL ANALYSIS OF BEHAVIORAL VARIABILITY

**Riley, M.A.[1], Kuznetsov, N.[1], Bonnette, S.[1], Gao, J.-B.[2], Coey, C.[1], Luberto, C.[3], & Wallot, S.[4]**
[1] Center for Cognition, Action, & Perception, University of Cincinnati, USA
[2] PMB Intelligence, USA
[3] Department of Psychology, University of Cincinnati, USA
[4] MINDLab/TESIS, Aarhus University, DK

**Introduction**
Human cognitive and perceptual-motor behavior exhibits complex, time-varying fluctuations that may exhibit scale-free patterns of variation, i.e., 1/*f* or fractal noise. Fractal methods are accordingly popular for analyzing such data. We present a relatively new method, adaptive fractal analysis (AFA). AFA uses an adaptive detrending algorithm to find globally smooth trend signals and then determines how the residuals of the fit of the original signal to the trend depend on the time scale at which the fit is made. We apply AFA to data from experiments on cognition (temporal estimation) and postural control.

**Methods**
Cognitive data were obtained by pressing a key to indicate the passage of 1 s. Trials with and without accuracy feedback were conducted. The effects of practice were examined by collecting 1 trial per day over 20 days (10 per feedback condition). Trials were ~20 minutes long and yielded >1000 estimates each. Postural data were center of pressure (COP) signals from 40 subjects recorded at 100 Hz using an AMTI force platform. Each trial lasted 3 minutes, yielding 12000 data points. Subjects stood relaxed with eyes open.

**Results**
The cognitive data exhibited two scaling regions. Over shorter time scales, conditions without feedback and before practice showed an essentially white-noise regime while with feedback and after practice there was a tendency toward anti-persistence. There was persistent fractal scaling over longer time scales, although practice with feedback reduced the length of this region. The COP exhibited three scaling regions rather than one as expected from pure fractional Gaussian noise (fGn) or fractional Brownian motion (fBm) models used commonly for COP signals. The fastest scale was anti-persistent but however was not very reliable, did not influence the overall dynamics strongly, and may only be resolvable using very fast sampling rates; the persistent intermediate region was the most reliable but it only contributed 6-11% of the total spectral energy of the COP and >50% of scaling exponents exceeded the theoretical range (0 to 1) for fGn-fBm processes; the slowest region was anti-persistent.

**Discussion**
The intrinsic cognitive dynamics of temporal estimation were altered by accuracy feedback and practice. For the posture data, AFA results suggested that the fGn-fBm framework may not be appropriate for COP signals. Analyses of both data sets suggested that both scaling region length and scaling exponents are valuable metrics.

SYMPOSIUM 8

# ECOLOGICAL DYNAMICS AND SPORT EXPERTISE

## Chair: Button, C.

### Presentation

Key properties of expert movement systems include multi- and meta-stability, adaptive variability, redundancy, degeneracy and the attunement to affordances [1]. In this symposium, the presenters will discuss some of the properties in relation to their research examining skill development in various sports. Empirical research on expert system properties indicates that skill acquisition does not emerge from the internal representation of declarative and procedural knowledge, or the imitation of expert behaviours to linearly reduce a perceived 'gap' separating movements of beginners and a putative expert model. Rather expert performance corresponds with the ongoing co-adaptation of an individual's behaviours to dynamically changing, interacting constraints, individually perceived and encountered. The functional role of adaptive movement variability is essential to expert performance in many different sports (involving individuals and teams; ball games and outdoor activities; land and aquatic environments). The main implications for sport clinicians and practitioners are to identify and manipulate key constraints to perturb and create emergence of appropriate behaviours rather than to encourage the imitation of a single response in reference to putative ideal expert model.

**Reference**

[1]. Seifert, L., Button, C. and Davids, K. (2013). Key properties of expert movement systems in sport: An Ecological Dynamics perspective. *Sp Med, in press*.

## TEACHING A TENNIS TASK IN SCHOOL: A NONLINEAR PEDAGOGICAL APPROACH

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**Introduction**

In parallel to pedagogical research, a potential theoretical framework from human movement sciences has emerged with great potential to improve our understanding of the development of game skills with a situated learning slant. Based on key ideas in nonlinear dynamics, it has been advocated that the emergence of movement behaviour occurs as a confluence of various interacting constraints in the learning context. Based on these concepts, Nonlinear Pedagogy has been proposed as a suitable framework to explain the acquisition of game skills [1]. The essence of a nonlinear dynamics approach to skill acquisition in physical education argues that educators need to understand the nature of the interacting constraints on each individual learner and how to manipulate key task constraints to facilitate the emergence of functional movement repertoires.

**Method**

For this programme of research, 24 students (aged 10 years old) in a primary school were taught a modified tennis task under Nonlinear Pedagogy and Linear Pedagogy conditions.

**Results / Discussion**

It was found that students taught with a nonlinear pedagogy approach (i.e., modification of task constraints, incorporation of variability in practice, focus on movement effect) benefited from the intervention and could successfully acquire the relevant tennis skills and movement behaviours within a 1v1 game setting. The implication is for practitioners to consider adopting an exploratory and facilitative approach to teach movement skills to students with an understanding of how the human movement system functions as a complex system.

**References**

[1] Chow, J. Y, Davids, K, Button, C, Shuttleworth, R, Renshaw, I, & Araújo, D. (2007). The role of nonlinear pedagogy in physical education. Rev Ed Res, 77(3), 251-278.

# METASTABILITY IN PERCEPTION AND ACTION DURING ROCK CLIMBING

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## Introduction

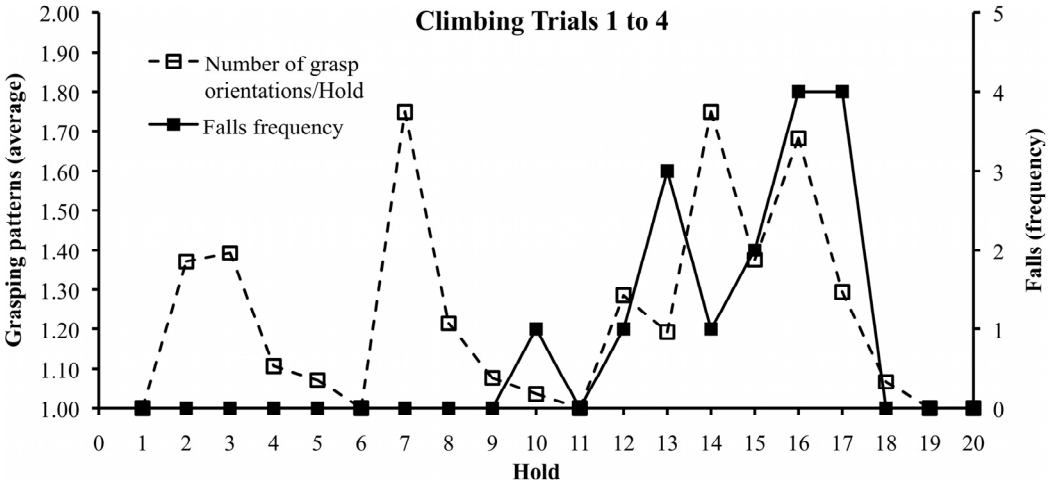
During periods of metastability, perceptual-motor systems undergo a process of reorganization from which new functional behaviours can emerge [1]. In order to explore the role of metastability on skill acquisition, previously induced in interceptive actions [2], this study evaluated movement patterns and performance outcomes in a complex perceptual-motor task (climbing). Specifically, hold orientations that enabled both side- and face-wall orientations were used with the aim to induce a metastable regime over repeated bouts.

## Methods

Seven participants (mean age 20.5±1.98 yr, SD, control stage) realized four ascents over four sessions (separated by two nights) at an indoor climbing facility. An identical ascent was used (10.3 m high) and comprised 20 holds - each affording vertical and horizontal grasping. Minimal instructions were given corresponded to a discovery learning approach. Behavioural data were determined (video) at each hold.

## Results

Over the four trials a clear and significant relationship emerged between the number of grasping patterns utilized at a given hold and the occurrences of falls (Graph 1); Kendall's $\tau$=0.37, p=0.048. Vertical grasping also increased over the four trials (Friedman's ANOVA, $X^2(3)$=13.05, p=0.005)) with falls significantly decreasing from the first to final trial (Wilcoxon's T=-2.00, p=0.46, r=-0.53).




Graph 1. Average number of grasp orientations and total fall frequency at each hold.

## Discussion / Conclusions

Data converged to suggest metastability can be manipulated through environmental task constraints to facilitate skill acquisition. Inducing metastability in learning design appears to be an effective approach for destabilising intrinsic dynamics [2], facilitating the emergence of functional behaviours that also improves performance.

## References

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[2] Pinder RA, Davids K, Renshaw I (2012) Metastability and emergent performance of dynamic interceptive actions. J Sci Med Sport 15: 437-443.

## THE LEVEL OF ENVIRONMENTAL CONSTRAINT AND DEGENERACY OF INTER-LIMB COORDINATION IN SWIMMING

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**Introduction**
Degeneracy is a property of complex system that requires the existence of different components that perform similar function under certain conditions, but yet can perform distinct functions under other conditions [1]. Several experiments have highlighted the existence of degeneracy in the organization of body limbs in activities where movement form is weakly dependent of the goal [2]. Conversely, in activities like swimming, movement organization could be highly constrained even though not prescribed. The aim of the study was to investigate the existence of degenerate properties in swimming where movement form is neither completely independent nor totally dependent on the task goal.
**Methods**
15 recreational swimmers performed the same task output, namely two swims at 70% and two swims at 90% of their individual maximal achievable speed. Inter-limb coordination between elbow and knee angles was calculated using Continuous Relative Phase. Cluster analyses were computed on participants' coordination parameters.
**Results**
Four distinctive clusters emerged at low environmental constraint (i.e. 70%) while two different clusters were found at high environmental constraint (i.e. 90%). Moreover, individuals showed distinct routes to adapt their behavior, as there was no correspondence in terms of group between the conditions, but rather a mix between groups.
**Discussion / Conclusions**
Despite high resistance of the water, different patterns of coordination were found among participants for an identical task outcome. Moreover, emergent adaptive behavior followed different pathways while the level of the environmental constraint was manipulated, highlighting the degenerate quality of neurobiological systems. Nevertheless, the lower number of patterns found at high velocity suggests that the environment plays an important role in the degenerate properties of motor systems by constraining the emergence of behavior. Degeneracy is a necessary prior condition for adaptation to both individual differences and environment properties.

**References**
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## AFFORDANCE PERCEPTION IN AN OPEN WATER ENVIRONMENT

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**Introduction**
In some extreme environments the capacity to estimate distance in relation to movement capacity can strongly influence the likelihood of survival (e.g., when stranded in open water). Yet surprisingly little is known about the capability of humans to estimate distance beyond their immediate egocentric space. Participants generally overestimate distances (by 230% on average!) when open water images are viewed on a large screen [1]. The aim of this study was to relate self-perception of distances in open water to actual swimming ability.

**Methods**

40 university students (25 female, 15 male) volunteered to participate. Each participant was taken individually via motorised boat from shore into open water (Otago Peninsular, New Zealand). At random points in the journey (within 50 m blocks) participants had to estimate the distance to shore. When participants felt they had reached their maximum swimming distance they were instructed to signal for the boat to stop and then attempt to swim back to the shore.
The participants' location was measured by a Global Positioning System watch. For comparison sake, distance perception was also tested in a controlled laboratory environment using images projected onto a large screen.

**Results**

Most participants (37 out of 40) were able to complete the swim back to shore using a variety of different swimming techniques. The distance estimates made from projected images were typically underestimated and less accurate (-27% ± 56) than those made from the boat (6% ± 50). The individual variability in the data was notable although participants tended to uniformly underestimate or overestimate regardless of distance. There was no significant relationship between distance estimation accuracy and swimming distance ($r = -0.19$).

**Discussion/Conclusions**

Distance perception was better in a real open water environment (compared to two-dimensional images) where the task was also influenced by the perception of action boundaries in swimming to safety. Individuals tend to perceive their maximal swimming capacity quite conservatively in open water presumably to reduce the risk of drowning.

**References**

[1] Lounsbury DS. Swimming Survival: Performance and Judgement in Cold Water: Thesis (M.Sc.), University of Toronto; 2004.

SYMPOSIUM 9

# THE DESIGN OF REPRESENTATIVE LEARNING TASKS IN TEAM SPORTS

## Chair: Travassos, B.

### Presentation

Successful performance in team sports is constrained by the ability of players to identify opportunities to act. Such affordances have been shown to emerge from the interactions of the locations of the goal, ball, defenders and attackers. In this symposium we aim to show how practitioners can direct learners towards opportunities for action by influencing the dynamics of player-task interactions through manipulating relevant performance constraints. By emphasizing players' opportunities to act, practitioners may increase the transfer of performance acquisitions to competitive behavioural settings. Bruno Travassos will start by showing a reliable measure of representative design for passing tasks of futsal based on the concept of action fidelity. Pedro Esteves will present how an attacker's success in dribbling past a defender in the 1v1 sub-phase of basketball may be constrained by the manipulation of the attacker and defender relative position to the scoring target. Finally, Luís Vilar will show how the relative number of outfield players of teams in small-sided football games modulates the opportunities for attackers to dribble past opponents, shoot the ball at goal and pass it to other teammates. During this symposium some important questions will be discussed: Which key principles should be considered in the design of learning tasks in team sports? Which constraints might practitioners manipulate during practice? What effects do different task constraints have on players' performances?

## REPRESENTATIVE DESIGN AND ACTION FIDELITY OF PASSING TASKS IN FUTSAL

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**Introduction**
A key issue for the design of futsal learning tasks is to represent players' opportunities to act, emphasizing the need for individual performers to explore the performance environment, as they would in competitive performance [1]. The aim of this study was to provide a reliable measure of representative design for passing tasks of futsal based on the concept of action fidelity [2].
**Methods**
Eight senior futsal players (26.25±4.33 yrs) divided in two groups were positioned in the corners of two squares (5x5m). Two balls were used in each group. The passing direction of the ball was manipulated in four ways: i) to the player in front; ii) to the player diagonally opposite; iii) to one of the players in front or diagonally opposite; iv) to any player that did not have possession of another ball. Ball motion trajectories were captured and digitized using TACTO software. Ball velocities in practice and in an actual match were recorded and submitted to $ApEn_{Ratio\ Random}$ analysis to establish performance regularity. Data in each condition were compared by repeated measures analysis of variance.
**Results**
Significant differences on Apen values were observed between (i) actual game and the first three conditions, (ii) the first and last two conditions, and (iii) the 3rd and 4th conditions ($p$<.05). Values in 4th and game conditions were not significantly different ($p$>.05). Mean ApEn values increased from the 1st to 4th passing condition. The game condition revealed the high mean ApEn value.

**Discussion**
Results showed that an increase on the number of opportunities to pass promotes an increased on the irregularity of ball velocity, making it similar to match conditions. This suggests that promoting contextual dependency of decision-making in learning tasks may increase the transfer of performance acquisitions to competitive behavioural settings.

**References**
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[2] Stoffregen, T., Bardy, B., Smart, L., & Pagulayan, R. (2003). On the nature and evaluation of fidelity in virtual environments. In L. J. Hettinger & M. W. Haas (Eds.), *Virtual and adaptive environments: Applications, implications, and human performance issues* (pp. 111–128). Mahwah, NJ: Lawrence Erlbaum Associates.

## EXPLORING ALIGNMENT TO THE OPPONENT AND SCORING TARGET CONSTRAINS SUCCESS OF DYADS IN TEAM SPORTS

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**Introduction**
In the 1v1 sub-phase of team sports, the attacker strives to dribble past the defender and approach the scoring target guided by spatial-temporal informational constraints [1]. To achieve this aim, the attacker should break the alignment with the defender and the goal by moving to the left or to the right. However, the information supporting success on the breaking of the alignment with the opponent remains unknown. In this study we examined how the exploration of the alignment between performers, according to their relative position to the scoring target, constrained an attacker's success in dribbling past a defender in the 1v1 sub-phase of a team ball sport.
**Method**
Four male basketball players, right-handed, played basketball 1v1 sub-phases on different relative positions to the scoring target. *Participant* movement displacement trajectories during performance were video recorded and digitized. All trials were categorized according to the performance outcomes of the dyad in the 1v1 sub-phase. The attacker-defender-scoring target angle (ADB) was also computed.
**Results**
Greater success of attacker movements past defenders towards the scoring target was observed when the dyad was positioned on the left side of the court ($F(2, 97) = 19.39$ $p < .01$, $\eta^2 = .29$; $M = 66.67$, $SD = 29.96$). To successfully dribble past the defender, the attackers spent more time exploring the left side by quickly increasing the relative angle to the opponent and scoring target (ADB), especially on the centre of court ($F(1, 48) = 45.43$, $p < .01$, $\eta^2 = .49$; $M = 76.16$, $SD = 72.12$).
**Discussion/Conclusions**
The process of goal-achievement of attacker-defender dyads appears to have been constrained by the exploration of a fast break of the alignment between performers relative to the scoring target. This evidence highlights the need for coaches to manipulate this task constraint in the training processes of team sports. Considering the role of the alignment of ball carrier with the opponent and the goal on the success of dyadic interactions may stand as an important feature to enhance performance.

**References**
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# THE EFFECT OF THE RELATIVE NUMBER OF PLAYERS ON THEIR POSSIBILITIES FOR ACTION IN SMALL-SIDED FOOTBALL GAMES

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## Introduction

A key-principle in constraint-led approach for coaching football is to emphasize the information that supports successful performance of players through the manipulation of task constraints. Previous research has shown that the distance of defenders to the passing or to the shooting line are key informational constraints in football [1]. This paper aims at providing evidence to coaches on how the relative number of outfield players of teams modulates the opportunities for attackers to dribble past opponents, shoot the ball at goal and pass it to other teammates.

## Method

Fifteen male football players (age: 19.60±1.99 years old) were grouped into three teams and played against each other different versions of small-sided football games. The relative number of players of teams was manipulated in three different conditions: 5v5, 5v4 and 5v3. Ball and players trajectories were captured and digitized using TACTO software, allowing to compute the interpersonal distance between outfield attackers and nearest defender (ID), and the relative distance of the defender to intercept a shooting ($RDi_{shot}$) and a passing trajectory ($RDi_{pass}$).

## Results

ANOVA revealed that the mean values of ID were significantly lower in 5v5 ($M$ = 4.96, $SE$ = .17) than in 5v4 ($M$ = 5.57, $SE$ = .17, $p$< .001) and 5v3 ($M$ = 6.58, $SE$ = .17, $p$< .001). In addition, the mean values of ID were significantly lower for 5vs.4 than in 5v3 ($p$< .05). ANOVA also revealed that the mean values of $RDi_{shot}$ were significantly higher in 5v3 ($M$ = 307.59, $SE$ = 41.17), than in 5vs.5 ($M$ = 171.84, $SE$ = 41.17, $p$< .05). Finally, ANOVA showed that the mean values of $RDi_{pass}$ were significantly higher in 5v3 ($M$ = 349.86, $SE$ = 47.82), than in 5v5 ($M$ = 63.49, $SE$ = 47.82, $p$< .001).

## Conclusions

This research presents major implications for designing learning environment through a constraints-led approach of practice. More precisely, coaches may increase the possibilities for dribbling if maintaining the same number of attackers than defenders, and increase the opportunities for players to perform shots and passes by decreasing the number of defenders relative to attackers. The manipulation of the relative number of players in small-sided and conditioned games may allow individuals becoming more attuned to specifying information sources and learning to calibrate such information to their own action capabilities.

## References

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# ORAL PRESENTATIONS

ORAL PRESENTATION 1

# ATYPICAL MOTOR DEVELOPMENT: A CASE OF DISRUPTED PERCEPTION/ACTION SYNERGY

**Wade, M.**

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**Introduction**
Typically developed (TD) individuals can reduce their postural motion as supra-task difficulty increases and this is confirmed in both adults and children [1].Two experiments are reported that investigate this in atypical populations; First (E1) children diagnosed with developmental coordination disorder (DCD), and second (E2) elderly individuals with mild cognitive impairment (MCI) and Alzheimer's (AD).The research question was ,can the atypical groups in E1 and E2 demonstrate the same postural changes as typical individuals in supra-task protocols?

**Methods**
Both experiments employed a visual task presented at two levels of difficulty while COP was recorded .Participants looked at two plain white 33x42cm boards, a blank (Inspection task), and on displaying a random stream of alphabet letters (Search task); participants counted the frequency of a designated letter. Participants completed three trials of 60 seconds for each task condition. Data were analyzed using variance analysis and post-hoc tests where appropriate

**Results**
Children with DCD recorded higher levels of COP; were less accurate, and unable to reduce COP switching from the Inspection to the Search task. Participants with AD recorded higher levels of COP and were unable to reduce COP in the search task. All reported differences were statistically significant.

**Discussion/Conclusions**
Both experiments support view that movement deficits are a possible marker of wider perceptual and cognitive deficits in atypical individuals, and the 'embodied' relationship between perception and action is disrupted in the atypical groups reported here. This disruption of the link between perception and action is further bolstered evidence that gait changes appear in dementia patients before evidence of memory deficits and confusion.

**References**
1. Prado, J. Stoffregen,T.& Duarte, M. (2007). Postural sway during dual tasks in young and elderly adults. Gerontology, 53, 274-281.

ORAL PRESENTATION 2

# SECOND-ORDER PLANNING IN THE REACH-TO-GRASP ACTIONS OF TYPICALLY DEVELOPING CHILDREN

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Perception and Motion Analysis (PuMA) Research Group, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK

## Introduction

Picking up an object is a seemingly simple and isolated task, however, research has demonstrated that adults plan such a movement on the basis of subsequent actions [1]. For example a greater deceleration period is seen in an initial reach movement preceding an action to 'place' an object compared to a 'throw' and between place actions with differing levels of precision requirements [2]. This second-order motor planning is also seen in infants [3] and toddlers [4] but has not be investigated past 21 months of age, therefore, the developmental time-course is unclear.

## Methods

Participants were 48 children aged 4-5yrs, 6-7yrs, 8-9yrs and 10-11yrs. Initial reach movements to pick up a small cylinder (7cm high) were recorded using an infra-red 3D VICON system. These movements preceded one of three onward actions: a place movement with high precision requirements, a place movement with low precision requirements or a throw movement. Data were analysed using two-way mixed ANOVA (age x action type).

## Results

All age groups showed some degree of second-order planning and a strong correlation was seen between the degree of second-order planning and age in months. The 4-5 yr-olds showed a elongated movement duration for both place actions compared to the throw action. In the older children the proportion of time spent decelerating increased from the throw action to the place actions. No discrimination was seen between the two place actions. When children did use second-order planning the onward place actions were more efficient.

## Discussion

The capacity for second-order planning increases with age but is not fully mature at 11yrs. This is in line with findings for development of planning for end-state-comfort [1]. These developmental effects may be explained by the relative weighting of costs involved in tailoring a reach action compared to the benefits of producing a more efficient onward action.

## References

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ORAL PRESENTATION 3

# EMERGENCE OF DIFFERENTIATED LIMB FUNCTION DURING INFANT EXPLORATORY BEHAVIOR

**Miranda, D.[1,2], Hsu, W.-H.[1,2], Young, D.[1,2], Goldfield, E. C.[1,2]**

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## Introduction

We conducted a longitudinal study of infant spontaneous arm and leg movements between 3 and 6 months when presented with an overhead mobile. Are differentiated functions of arms and legs evident before infants are capable of independent mobility and visually guided reaching (Adolph, Vereijken & Denny, 1998; Thelen, 1985)? What role does exploratory behaviour play? (Goldfield & Wolff, 2004)? Answers to these questions inform development of assistive robots for developmentally delayed infants (Goldfield et al, 2012).

## Methods

We used an 8-camera Vicon motion capture system to longitudinally record the spontaneous arm and leg movements of two typically developing supine infants at 3, 4.5, and 6 months of age. A segmented kinematic model was generated from the measured markers (see top panels of Figure 1), with shoulder and elbow flexion angles, and the distance between the shoulder and wrist for the arms (see lower left panels). For the legs, we generated hip and knee flexion angles, and hip-ankle distance (see lower right panels of Figure 1).

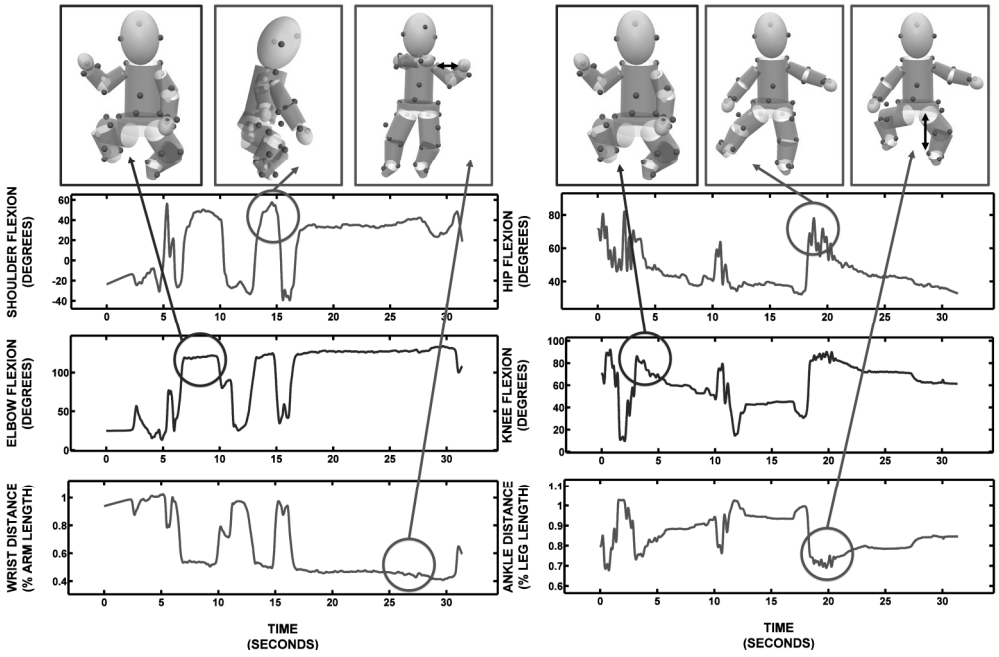


***Figure 1. The kinematic model and typical infant behaviour.***

**Results**

1. The initial session at 3 months indicated a tighter overall coupling of joint rotations of the arms and legs, e.g., $R^2$=0.433 for shoulder-elbow and $R^2$=0.489 for the left hip-knee. Thus, at 3 months, coordination may be achieved through synchronous joint rotations.
2. By the third longitudinal session at 6 months, the overall intra-limb synchrony of the arms decreased, e.g., $R^2$=0.04 for shoulder-elbow. Review of the supine posture kinematics indicates that by 6 months the arms remained elevated at the shoulder, while the elbow flexed and extended. This allowed for the movement of the hand(s) towards the overhead mobile. Thus, the more flexible coordination pattern may allow the infant to stabilize the arm at the shoulder while flexibly directing the hand at the elbow to try and touch the mobile.
3. For the legs, the overall intra-limb synchrony decreased by the third longitudinal session at 6 months. At the same time, hip-ankle distance, which is a measure of whole limb kinematics, remained relatively invariant to knee flexion between 3 and 6 months. So, by 6 months infants were using more flexible joint rotation compensations to maintain relatively invariant hip-ankle distance.

**Discussion/Conclusions**

Taken together, the joint rotation and limb kinematic data suggest a developmental trend between 3 and 6 months from an initial state of synchrony to a gradual decoupling and selective re-coupling of specific joint rotations for differentiated arm and leg functions, respectively. The opportunity for extended periods of exploratory behaviour may promote a process of de-synchronization and selective coupling of joint rotations. A soft, wearable robot suit for assisting exploratory behaviour by developmentally delayed infants will need to provide differentiated patterns of actuation to arms and legs.

**References**

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ORAL PRESENTATION 4

# COORDINATION, PERCEPTION AND THE CONSTRUCTION OF REALITY

**Vatikiotis-Bateson, E.[1], Fais, L.[2], Haber, G.[1], & Rubin, P.[3]**

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**Abstract**

For the past 30 years, the three co-authors over 30 years old have wrestled with how to use Gibson's ideas about sensory perception to understand the role of language in cognition and spoken communication. Briefly, our view is that Gibson's notion of unmediated, or 'direct', perception crucially accounts for the physical interface between organism and environment and provides the necessary infrastructure for biological coordination that enables communication at all levels of description. However, linguistic communication subverts the purely physical interface between organism and environment by creating a parallel reality whose fundamental structure does not obey the laws of physics. While the complication introduced by linguistic structure fuels the elaboration of cognition, memory, and the extension from what is to what is possible, the perception of reality is now necessarily mediated and probabilistic. To understand this more formally, we turn to C.S. Peirce, the 19th century American philosopher and statistician, who provided an elegant and suitably complex mechanism for dealing with the separation that language introduces between our representation and experience of reality. His semiotic engine presaged modern Bayesian approaches by iteratively homing in on veridical characterizations of reality. Peirce described this as a triad consisting of a name (linguistic object), the context of naming (observer situated in an environment), and the thing being named (the real object). However, there is a fourth, generally overlooked component, which Peirce called 'collateral experience' and claimed was essential to the success of the semiotic engine. Although Peirce provided few specifics, collateral experience is unmediated and, we believe, highly compatible with Gibson's direct perception.

In this presentation, we argue for integrating Gibsonian notions of sensory perception and Peirce's semiotic approach to linguistic mediation of the real world. We ground the presentation and discussion of these concepts in our own work on coordination, applied specifically to spoken communication. Our approach is novel and our hope is to use feedback from this presentation in preparing a more complete, written presentation to the community.

ORAL PRESENTATION 5

# HOW DO AFFORDANCES WORK IN DIALOGUE?

**Kono, T.**

Rikkyo University (Tokyo, Japan)

Recently, an important shift is taking place in social cognition research; Enactive approaches and the socially extended mind theory stress that social cognition is a dynamic, interactive process based on direct perception of other people [(1)]. This new trend coincides with the ecological approach of J.J. Gibson [(2)].

In my paper, I will develop a theory of social affordance and consider theoretically how affordances work in social interaction, especially in dialogue. The fundamental affordance which underlies dialogue is our responsiveness or "addressivity and answerability" [(3)]. Affordances can be defined as dispositional properties of the things in the environment which manifest themselves by the existence/ activity of an agent-perceiver; if so, my partner's speech is nothing but a kind of affordances which is provoked by my own addressing to him/her. The understanding of a speech is to know what a speaker affords to the listener when the listener enters into the speaker's context and addresses him/her. This means that there is no clear boundary between knowing a language and knowing other people's intention generally.

Moreover, ecological approach proposes a radical view about language rules. They can be thought of as an elaboration of the basic relationship of responsiveness. But, language rules should not be considered as a kind of habit which individuals are able to internalize. Rather, rules must always remain as exterior regulations from the authorities of language. Rules are in fact a set of interdependent affordances such as coercion and obedience, or teaching and learning which are distributed among language-users. We have to give up the idea of clearly defined shared structure of language which language-users acquire and then apply to cases [(4)]. I will conclude that dialogue is far from an encoding-decoding process, but is the process of coordinating and adjusting different intentions among interlocutors. Linguistic affordances are means to accomplish this process.

**Notes**

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ORAL PRESENTATION 6

# COMPLEXITY MATCHING IN DYADIC INTERACTION

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Conversation is a complex coordination of human behaviours (Riley, Richardson, Shockley, & Ramenzoni, 2011). Recent theoretical discussion of dyadic coordination has focused on issues of synchronization, entrainment, alignment, and convergence. All of these terms refer to a local matching of specific behavioural and linguistic events, such that members of a dyad coordinate by "doing the same thing." Though much research has studied dyadic coordination that goes beyond mere synchrony, few studies have analysed dynamics beyond synchrony and phase. Communicative behaviours tend to be highly variable, irregular, and heterogeneous, like most human behaviours. Therefore, it appears that there could be more complex temporal patterns, beyond local matching and into the management of more complex dynamics of interaction.

More complex patterns are often expressed by *heavy-tailed distributions* (i.e., heavier than an exponential fall off) that reflect variations across wide ranges of timescales. For instance, long-run variations in the acoustics of speech signals are known to follow a pattern of so-called "*1/f* noise"—irregular fluctuations in amplitude occur across a wide range of frequencies yet fall into a power law relationship with each other (Voss & Clark, 1978).

The term *complexity matching* was recently coined by West and colleagues to refer to the concept that interacting complex systems may become coordinated in a way that is reflected in distributional and temporal measures of their complexity (West, Geneston, & Grigolini, 2008). In particular, the statistical shapes of their complexities should have a tendency to match up. This tendency is hypothesized to be adaptive because models exhibit maximal information transmission between them when the complexities of their activities match up.

In the present study, we tested whether complexity matching can be detected between conversational partners and if different conversational contexts constrain the dynamics differentially.

**Method**

Twenty-eight undergraduate students from the University of California, Merced were instructed to freely discuss topics in one ten-minute argumentative conversation and one ten-minute affiliative conversation with another student. Experimenters determined the topic of argument by comparing survey answers participants had previously completed to identify the topic on which participants held strong but opposing views. Participants were instructed to convince one another of their opinion. For the affiliative conversation, dyads were instructed to discuss popular media both participants enjoyed. Conversation prompts were counterbalanced across the dyads. Conversations were captured on a Canon Vixia HF M31 HD Camcorder, mounted on a Sunpak PlatinumPlus 600PG tripod. Audio signals were simultaneously digitally recorded at 44 kHz (Paxton & Dale, under review).

Fifty-six audio files were recorded (four per dyad, two per participant) and imported into Audacity for removal of spurious noise artifacts (e.g., noise, cross-talk from other subject's acoustic signal), identifying sound (intensity above -30db), and generating onset/offset intervals marked as acoustic speech events - resulting in four event time series per dyad – two per conversation, one for each partner.

**Results and Discussion**

To extract both distributional and temporal complexities from a single measure of acoustic speech signals, series of inter-event intervals (IEIs) were computed for the former and a series of binary spike trains of speech events were computed for the latter.

**Distributional Analyses.** *Multi-model inference* (MMI; Burnham & Anderson, 2002) was used to test for heavy tails in IEI distributions. MMI results showed that the lognormal function was most likely to generate the observed IEI distributions ($n$=56 individual distributions, 100% lognormal). Lognormal distributions can be thought of as constrained, or sometimes truncated, power law distributions and can be characterized by a mean ($\mu$) and standard deviation ($\sigma$) under logarithm transformation. Because of the transform, $\sigma$ roughly corresponds to the heaviness of the tail.

The $\sigma$s for affiliative ($\sigma_{mean}$ = 1.48, $SE$ = .03) and argumentative ($\sigma_{mean}$ = 1.54, $SE$ = .03) conversations were significantly different from each other, $t(27) = -3.03$, $p$ = .005. Observing differences in $\sigma$ across different conversation contexts provides evidence that this measure of complexity in IEI distributions is sensitive to conversation type, rather than just low-level acoustic and articulatory effects.

**Temporal Analyses.** To estimate the properties of temporal complexity (e.g., 1/f noise) in speech event time series (see Figure 1a/b), we implemented the Allan Factor (AF) analysis (Allan, 1966). For AF, each time series is tiled with adjacent windows of size $T$, and the number of events $N_j$ is counted within each window $j$. The differences in counts between adjacent windows is computed as $d(T) = N_{j+1}(T) - N_j(T)$, and d(T) series are computed across the range of possible values of $T$ given the length of the time series, where $T$ is varied as a power of two. The Allan factor for a given timescale $T$ is the expected value of the squared differences, normalized by mean counts of events per window,

$$A(T) = \frac{\left\langle d(T)^2 \right\rangle}{2\left\langle N(T) \right\rangle}.$$

Poisson processes yield $A(T) \sim 1$ for all $T$, whereas power law clustering yields $A(T) \sim (T/T_1)^{\alpha}$, where $T_1$ is the smallest time scale considered, and $\alpha$ the exponent of the scaling relation. Point processes with $\alpha \sim 0$ are Poisson-distributed, meaning that events occur at random, independent points in time. By contrast, point processes with $\alpha$ near the upper bound of $\alpha \sim 1$ exhibit clustering that follows a power law distribution across timescales and can be considered fractal stochastic point processes (Lowen & Teich, 2005).

For the AF analysis, $\alpha$'s for affiliative ($\alpha_{mean}$ = .44, $SE$ = .02) and argumentative ($\alpha_{mean}$ = .55, $SE$ = .03) conversations were significantly different from each other, $t(27) = 4.70$, $p < .001$ (see Figure 1c).

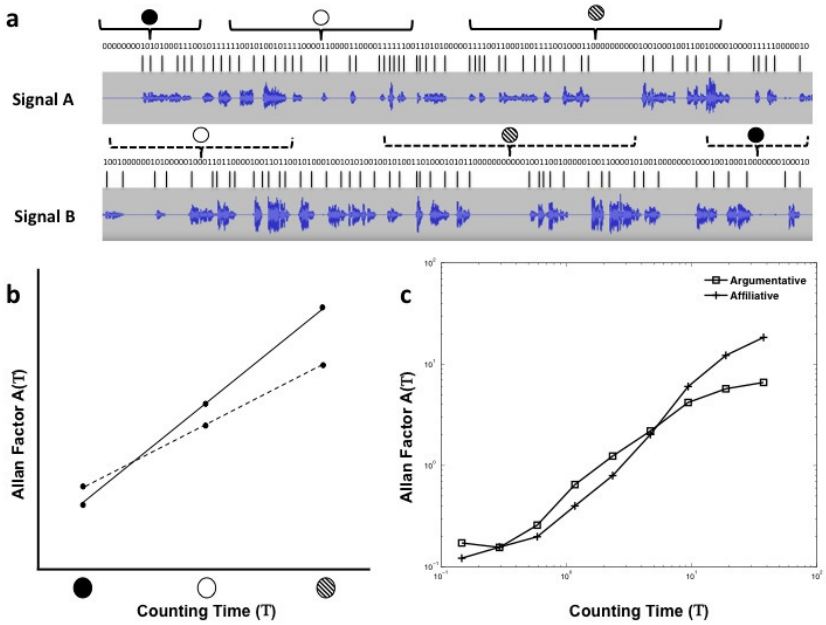


*Figure 1.* (a) .wav file to speech event point process to binary spike train. (b) Idealized plot of Allan Factor estimates for each window size, *T*. Note the differences in slope between Signal A and Signal B from 1a. (c) Aggregated Allan Factor functions by conversation type.

**Complexity Matching by Conversation Type.** To test for complexity matching between interlocutors, we compared differences of AF functions across conversations types. Each acoustic signal's estimated AF function was comprised of nine timescales. To compare two AF functions for a given dyad, we took the absolute difference of the two interlocutors' AF estimate for each of the nine timescales, and summed them to create an AF difference function value for each dyad in each conversation. AF difference function sums closer to 0 indicates more matching. The average sums of the AF differences for affiliative ($M$ = 21.21, $SE$ = 4.35) and argumentative ($M$ = 40.38, $SE$ = 6.43) conversations were significantly different from each other, $t(13) = 4.25$, $p = .001$.

**General Discussion.** Analyses of conversational data from Paxton and Dale (under review) indicated that acoustic speech events in dyadic interactions show properties of heavy-tailed distributions and power law clustering. Distributional and temporal measure of complexity, $\sigma$ of the lognormal and the AF function, respectively, were observed and found to differ as a function of conversation type. These differences indicated that the measures of complexity reflected aspects of conversation beyond low-level articulatory and acoustic effects. Furthermore, more complexity matching was observed in affiliative conversations relative to argumentative conversations. Complexity matching between interlocutor's speech events was constrained by conversational context.

The original formulation of complexity matching (West, Geneston, & Grigolini, 2008) suggests that a consequence of complexity matching is optimal information transmission. Future research in complexity matching of dyadic interaction should incorporate measures of performance that might suggest such optimality of information transmission and comprehension among interlocutors.

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ORAL PRESENTATION 7

# ON THE THRESHOLD: AFFORDANCES OF ONLINE TUTORIALS IN THE LEARNING OF THRESHOLD CONCEPTS

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## Introduction

According to *threshold concept theory*, in each academic discipline there exist concepts that once grasped allow new and previously inaccessible ways of perceiving and thinking about the subject to emerge [1]. Acquiring a threshold concept (TC) often resembles a phase transition as observed in other psychological perception-action dynamical systems [2]. Previous studies of student learning in introductory electronics have revealed areas where students get stuck [3]. In the present study we investigated the impact of multimodal, online tutorials on learning TCs.

## Methods

First-year analogue electronics students (120) took part in the study. A set of online tutorials, relating to specific concepts in the course, assessed students' previous and new knowledge (e.g., TCs). Multiple-choice questions had additional space provided for students to explain why they chose the particular answer. Links to related online resources were provided for each question and immediate feedback to answers was given. Students' trajectories through the virtual tutorials, their success in answering tutorial questions, and their results on midterm and final exams were analysed for evidence of learning based on "grasping the affordances" of the online environment.

## Results

The results from students' experiences and actions in virtual space provided insights into students' shifts in understanding as they mastered TCs. Importantly, they revealed that the affordances of *virtual* tutorials (or "metaffordances") provide *real* opportunities for exploration of multimodal materials in a way that best suits an individual's learning style and previous knowledge.

## Discussion/Conclusions

The relations between virtual spaces and learning suggest that the affordances of virtual tutorials can be perceived—and acted upon—in a similar but potentially more effective way as real tutorials, especially for the acquisition of difficult threshold concepts.

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*Acknowledgments*. Supported by a grant from the Teaching, Learning and Research Initiative (TLRI), NZ.

ORAL PRESENTATION 8

# PROBABILISTIC AND DYNAMICAL MODELS OF BELIEF UPDATE

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## Introduction

Most accounts of belief update focus on propositional or declarative beliefs [1]. My focus is belief-as-action. The reported experiments investigate how belief-as-action (i) evolves with changing circumstances, and (ii) contrasts with belief-as-assent. The Asch line-length judgment task [2] inspired Experiment 1. Asch's participants were successfully pressured to act as if they believed two lines of different length were in fact equal. They did not give degrees of assent or evaluate the declarative content of their judgments. In Experiment 1 participants simultaneously responded (an action) and rated their response confidence (a weight on the proposition "This judgment is correct"). Experiment 2 used the same methodology in a task where successful strategies are more easily cast in probabilistic terms, a version of the Monty Hall Dilemma (MHD).

## Methods

Stimuli were viewed and responses made on a MacBook laptop. In Experiment 1, participants chose which of two horizontal lines was longer. The Matlab-programmed stimuli was constructed so that over 650 trials participants would be biased via stimulus properties and a putative "score" to respond more to one side or the other. In Experiment 2, participants performed a Flash-based version of the MHD. The stimuli were constructed so as to bias participants to respond on one side or the other.

## Results

In Experiment 1 the proportion of correct responses and confidence were differently affected by the difference in line lengths, $p<.05$. In Experiment 2 participants using a "switch" strategy were more successful than those who did not ($p<.05$), but confidence did not vary with success. Dynamical analysis of Experiments 1 and 2 profiled the attractors of lateral response and MHD strategy, respectively.

## Discussion

The results indicate that belief-as-action and belief-as-assent are distinguished in the participant's behavior and treatable as separate, both theoretically and statistically. The broad implication is that belief updating conditioned solely on the degrees to which propositions are believed will be insufficient for understanding how agents' beliefs about situations guide their actions.

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ORAL PRESENTATION 9

# ANTI-PHASE SYNCHRONIZATION OF TAG-PLAYERS EVOLVED IN DISTANCE NOT TO LOSE

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In competitive sport game behavior, certain interpersonal patterns of movement coordination emerge even though each individual player only intends to exert their own strategy to win. In this study, we investigate this evolutionary process by modeling the embodied attractor layouts that are intrinsic to optimal solutions found in one-on-one sport contest such as those found in the martial arts.

**Method**

We asked 5 pairs of naive participants to engage in a play-tag game in which they had to remove a tag fastened to their partner's hip. Participants' 3D movement trajectories during trials were recorded (at 100Hz) using optical motion capture system with four cameras. We calculated the inter-participant distance (IPD) during each trial as well as the instantaneous relative phase between both participants' step toward-away velocity (for details, Kijima et al., 2012.).

**Results and Discussion**

Relative phase analysis indicated that anti-phase synchronization was observed from initial trials, in the 0.4 – 0.6 m IPD range (Fig. 1, left). Anti-phase was also observed in 0.6 – 0.8 m IPD range after about 8$^{th}$ trial (Fig. 1, right). The SD of relative phase increased as the IPD deviated from 0.4 – 0.8 m range, especially in 7th trial.

In summary, anti-phase synchronization was already self-organized in relatively early trials at the shorter IPDs, however, this synchronization pattern also became frequent at the relatively longer IPDs (i.e., 0.6 – 0.8 m) only in the later trials of repetition. These results suggest that the safety margin of each player may be extended in the later trials compared to the early trials. In other words, the players seem to acquire the "distance not to lose" strategy through the time course of the play-tag game.

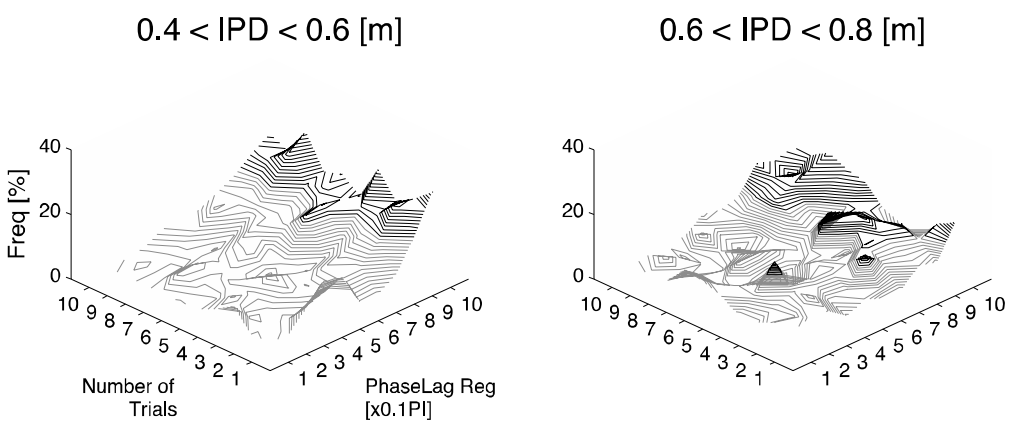


*Figure 1.* Distribution of relative phase between two participants' instantaneous phase (in %, mean of 5 pairs). Frequencies (in %) are plotted as a function of two variables: Number of trials and relative phase region. Data were calculated separately for short (0.4 – 0.6 m) and long (0.6 – 0.8 m ) IPD regions.

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*Acknowledgements.* This study was supported by a Grant-in-Aid for Scientific Research (20240060, 24240085) from the MEXT, Japan.

ORAL PRESENTATION 10

# INFORMATIONAL CONSTRAINTS TO THE DECISION OF PASSING A VOLLEYBALL SERVE

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Universidade Lusófona de Humanidades e Tecnologias, Portugal
[3] Center for Human Movement Sciences, University of Groningen, The Netherlands

## Introduction

An action is a "functionally specific movement directed at an object or a goal" [1] and, as Bootsma and van Wieringen [2] put it, the selection of a goal defines a mutual relation between perceptual variables and movement variables. Affordances constrain the environment-actor system to particular action modes [3]. In this study, we intend to analyze in a representative design setting the informational constraints to the selection of the action mode for volleyball passes.

## Methods

Five players received 144 volleyball services and passed these to a setter We analyzed pass quality (effective or non-effective), court side (left or right), ball's flight time, ball and player's displacements (lateral and front-back), and type of interception (overhand or underhand pass). Data was collected using two fixed digital cameras. Player and ball coordinates (3D) were attained using TACTO [4] and MATLAB. Until now, a descriptive analysis of the resulting plots has been performed. Further analyses are planned.

## Results

Ball flight time is longer in effective passes – 1 .04s (SD=0.2), than in non-effective passes – 1.01s (SD=0.1). In non-effective passes, players exhibited larger lateral displacements and more positional dispersion. The type of interception was constrained by the player's position and by the ball's trajectory: longer trajectories were passed using overhand pass and shorter ones were passed using underhand pass.

## Discussion/Conclusions

We have started studying the constraints that affect the passing of a volleyball service. Importantly, we have studied 3D-ball and player kinematics in a representative volleyball situation. Exploratory action updates the information for selecting the action mode of how to pass, considering the task constraints. Relevant constraints to the pass are time to intersect the ball, ball trajectory and player's displacement throughout the play.

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ORAL PRESENTATION 11

# INTERPERSONAL COORDINATION IN A BASKETBALL-RELATED WHOLE BODY MOVEMENT TASK

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## Introduction

For an athlete, expert performance comprises individual parameters such as speed or agility. For interactive sports however, teammates and/or opponents have to mutually adapt to each other. A high level of expertise thus implies certain interactive abilities, which we term 'interact-ability'. The aim of this study was to examine an individual's contribution to dyadic coordination in a basketball-related task as a step towards understanding interact-ability.

## Methods

Pairs of basketball players (n=11) had to simultaneously step from side to side, until a cue prompted them to attempt to switch to an anti-phase pattern. We assessed how these switches were mediated [1] by phase adaptations of each athlete under bidirectional (i.e., the pair facing each other) and unidirectional (i.e., one facing the back of the other) interaction conditions, indicated by the faces in figure 1.

## Results

Analysis confirmed the imposed coupling asymmetry in the unidirectional setting as shown by the significant differences for the Index of Coupling (see Figure 1). An index of 0.5 indicates equal contribution to the switch, while a value approaching 0 or 1 displays larger contribution of the left or right athlete, respectively.

## Discussion

These results concur an asymmetric coupling: the athlete that is better able to pick up pertinent visual information is more strongly coupled to the other athlete than vice versa. This study offered a first step towards analyzing interpersonal coordination dynamics in relation to an individual's 'interact-ability'.

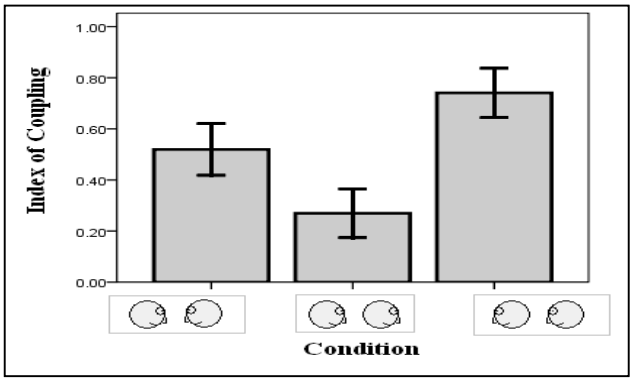


Figure 1: IC-values for different conditions, showing the asymmetry in coupling. Error bars indicate the 95% CI.

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ORAL PRESENTATION 12

# THE RELATIONSHIP OF THE VOLLEYBALL SETTER WITH THE ATTACKER NEAR AND FAR FROM THE NET

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## Introduction

Sport performers interact and generate goal-directed adaptive behaviours guided by informational sources of the game contexts (Fajen et al., 2009).

In Volleyball, deciding where and when to set the ball has been a major factor for success in team sports. In a volleyball game the setter is responsible to deliver the ball to the attackers in many changing conditions, far or close to the net, under varying spatiotemporal constraints. Setter's goal is that the attacker intercept the passed ball, in a zone near the net.

This exploratory study aimed to identify the opportunities for action for the attacker on setting in different conditions, namely close to the net and far from the net.

## Methods

Teams from the 1st Portuguese Volleyball League were observed during 3 games, in a total of 300 side-outs. The place of setting referenced to the net as well as the destination zone of the setting was registered using notational analysis methods with the DataVolley software.

## Results

Results show that the most solicited zone for the attack when the setting is done close to the net is the front middle of the net (zone 3), followed by zone 4 of the court. These 2 zones together have taken around 70% of the setter's allocation. When in condition far from the net, the setter tended to pass primary to zone 4 (near 50%) followed by zone 2 (near 25%), and zone 3 is not considered as an option when setting far from the net.

## Discussion

It seems the setter identifies different opportunities for success when interacting with the attackers. On the contrary, spatiotemporal constraints such as the central attacker moving on the same direction as the ball seemed to be a negative affordance for the setter to select a central attack.

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ORAL PRESENTATION 13

# A STEP UP IN LOGICAL TYPE AS SEEN IN "FIGURE-GROUND REVERSAL": AMBIENT SPACE REPRESENTED ON PAINTING SURFACES

**Goan, M.[1], Tsujita, K.[2], Ishikawa, T.[3], Takashima, S.[4], Kihara, S.[4], & Okazaki, K.[4]**

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**Introduction**

The purpose of this study is to explore ambient space by reconsidering the dichotomy of "figure and ground," as proposed by Gestalt psychology. Considering a space as "the ambient space," which is filled with the medium of the ambient optic array (Gibson, 1979/1986), the binary division into either figure or ground will be revealed as insufficient to express such a space. "Ground" is usually considered to be the expression of the medium and is behind the "figure," the expression of the object. However, according to the definition of ambient space, the medium surrounds the object, not only behind it but also to the fore, that is, the whole.

**Method**

A workshop was held in an art museum. Participants were directed to view some oil paintings and after that to copy them with pastel crayons by performing five tasks. The selected paintings were comprised of a hind layer of the figure and a fore layer of the ground, where the figure layer was painted first, and then marginal layers, perceived as background, were painted in the next step. A video recording was made of the participants' behaviors. Six raters were asked to identify two types of behavior categories, drawing or painting, using the video analyzing software ELAN version 4.1.2. Each video scene was analyzed by two raters.

**Results**

Correlation analysis for assessing inter-rater reliability revealed a high correlation between every pair of raters. For each task, the averaged rate of time duration for drawing or painting behaviors against the total time period of the task were calculated among all participants. Results showed that at the middle of the workshop, most of the participants drastically changed their method of reproduction from a drawing-based method to a painting-based one (Figure 1), the same as in the process of making the original works.

**Discussion/Conclusions**

Because the figure is the projection of the observer's differentiable codes, saying it can be understood as "figure-ground reversal" is not correct; rather, the term "figure-figure switch" may correctly express the phenomenon. In our workshop at the art museum, we showed that there could exist a way of perceiving the ground-ground switch, the perception of the surfaces' layouts, by stepping up from the logical type of figure-ground reversal perception – the figure-figure switch. Here we should note that learning theory proposed by Bateson (1972), the step up of the logical types, and Gibson's theory of perception are coupled with each other.

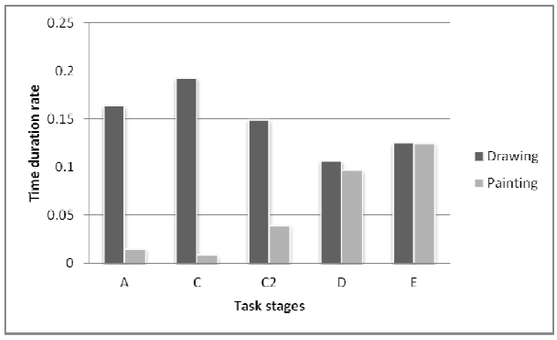


Figure 1. The transition of participants' behavior

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ORAL PRESENTATION 14

# ADAPTATION TO THE ENVIRONMENT IN SLANT PERCEPTION: AN ECOLOGICAL APPROACH TO NATURAL SCENE STATISTICS

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## Introduction

The ecological perspective emphasizes that perceptual systems develop to adapt to the environment. We have applied this perspective to natural scene statistics, which measures various physical characteristics of the environment to explore their relationships with perceptual properties. The present study especially investigates an upper-lower asymmetry in the perception of surface slants. We hypothesized that slant perception performance is asymmetric such that it corresponds to the probability distribution of environmental slants. To test this hypothesis, we conducted an environmental measurement and two psychophysical experiments.

## Methods

In the environmental measurement, we sampled 17 daily environments and measured their spatial layout with a 3D laser scanner. We calculated the probability distribution of the surface slant magnitude, which was analyzed for each upper and lower area with respect to eye level. In Experiment 1, participants seated themselves on a chair and observed a surface with a random-dot texture, which was presented in upper and lower viewing directions. For each direction, the participants performed two tasks: adjusted the surface slant to be perceived as vertical (i.e., wall-like) and horizontal (i.e., ceiling- or ground-like). In Experiment 2, we rotated the whole apparatus by 90° to change the direction of gravity. Participants performed the same tasks while lying on their back.

## Results

The environmental measurement showed that the probability of the horizontal slant was much higher than that of the vertical slant, but only in the lower area. Similarly, Experiment 1 showed that performance on the horizontal task was more accurate than that on the vertical task, but only for the lower direction. These results indicate a corresponding asymmetry between slant distribution and task performance. In addition, Experiment 2 showed that task performance generally decreased in the lying condition.

## Discussion

The results support our hypothesis and suggest that people are particularly sensitive to the horizontal slant viewed in the lower direction. The ground surface is a universal aspect of the environment and perceiving its slant is important for locomotion. In addition, gravity acts vertically to the ground and people often maintain an upright posture in relation to the environment. Thus, the upper-lower asymmetry in slant perception seems to be due to the adaptation of the visual system as well as the basic orienting system.

ORAL PRESENTATION 15

# ACTION SELECTION IS AFFORDANCE PERCEPTION

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## Introduction

Many actions are goal-directed—organized about a target and executed with respect to perceived opportunities for action, or *affordances* [1]. As natural environments are densely packed with affordances, the actions taken to a given goal are rarely fixed, but instead may adapt to circumstance, and exhibit equifinality (two paths leading to the same end) and exclusivity (both cannot be traveled simultaneously). It has been proposed that multiple affordances presenting alternate means to a desired goal gives rise to a "winner take all" competition [2] whose dynamics may reflect the relative attractiveness of each. Here, I present work that investigated how changes in the relative layout of multiple affordances influenced the selection and execution of an action, as well as transitions between behavioral modes [3].

## Methods

Participants moved an object from a start location to a target (all computer generated and projected) across a table. Paths to the target were obstructed by a barrier with two apertures; to reach the goal participants had to slide the object through one of the apertures. The target was placed behind either aperture, or a neutral position between them. Relative widths of the two apertures were manipulated across trials in random (E1) and sequential (E2) order, resulting in changes in the relative ease of passage and directness of route for each aperture. Behavioral data including response type and movement trajectory (MT) were collected.

## Results

In E1, both manipulations resulted in systematic changes in the distribution of selected apertures—participants were more likely to select the one that provided the more direct route to the goal, or in neutral conditions, the larger aperture. More, the confluence of aperture width and proximity to the goal influenced the evolution of action—movement trajectories showed greater spatial deflection from a straight line to the selected aperture in conditions where there was a conflict between ease and directness of route, suggesting an increase in the competition between afforded behavioral modes. In E2, a hysteresis effect was observed where relative proximity to the goal influenced the both the likelihood and point at which participants transitioned from selecting one aperture to the other when relative sizes were changes in sequential order.

## Discussion/Conclusions

The results demonstrate how the selection of action is systematically influenced by the relative layout of and competition between available affordances.

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ORAL PRESENTATION 16

# MODELING AFFORDANCE-BASED CONTROL OF VISUALLY GUIDED BRAKING

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Perceptually-guided action is commonly understood by the formulation of *control laws*, which describe how information modulates the animal-environment system's dynamics in service of a goal [1]. This approach has been termed *information-based control*. Although successful, it often ignores the limits faced by actors, leaving little room for affordances in understanding the continuous control of action. These criticisms have been addressed by the proposal of *affordance-based control* [2]. Under this account, actors move such that accomplishment of the task remains afforded given their action limits. This approach emphasizes the boundaries that separate possible from impossible actions.

The problem of visually guided braking has been instrumental in the development of both approaches. The optical variable $\dot{\tau}$ has been identified as specifying the sufficiency of the current deceleration for avoiding a hard collision [3]. According to an information-based control model of braking, actors decelerate to maintain a constant value of $\dot{\tau} \geq -0.5$ [1,3]. According to an affordance-based account, actors decelerate such that the ideal deceleration (that which results in $\dot{\tau} = -0.5$) remains less than the maximum achievable deceleration [2]. However, this account has not yet been modeled dynamically.

Here, we reconcile these two approaches by developing a control law for visually guided braking that satisfies the principles of affordance-based control. In our model, control parameters are modulated by the proximity of the system to its action boundaries. When the actor is far from the action boundary, the attractor for braking is weak and other factors such as comfortable speed may dominate. As the action boundary is approached, attractor strength for braking increases and eventually overpowers all other constraints. These parameter dynamics force the control law to respect the action boundary. This method generalizes easily to other visually guided actions.

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ORAL PRESENTATION 17

# TWO INSTANCES IN THE PROBLEM OF DECISION-MAKING BEHAVIOR EXPRESSED IN SPORT TASKS

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Decision-making behavior goes beyond perception and action. This problem has been scarcely addressed by ecological psychology researchers. But ecological psychology could address this topic by keeping it grounded on the existence of (detectable) specificational information (Travieso & Jacobs, 2009).

Fajen (2007) proposed that the affordance-based model explain how, throughout action realization, the actor remains sensitive to whether the current situation affords changing it (e.g., breaking), and the control of the action is modified if the situation approaches the limits of the participant's maximum action capabilities. This model claims that affordances are perceived not only before the action, in order to select the appropriate action, but also to monitor the control throughout the execution of the action. Therefore one instance of the problem of behavioral decision-making is solved: the selection and the regulation of action guided by the same affordance, which may include the transition of one action mode to another. However, another instance of the problem of decision-making behavior goes beyond the selection of the action mode. This second instance is the selection of the affordance itself. How this selection is made is not a clear issue. In this presentation I review the theoretical approaches to this instance of the decision-making problem, namely, those of Reed (1993), and Shaw (2001). These approaches contrast sharply with the traditional approaches to decision-making behavior (e.g., Kahenman, 2011).

We also suggest how complex sport tasks can create a research paradigm for addressing the two instancies of the problem of decision-making behavior as it happens in daily life. With, e.g., Passos et al., 2009, we show principled examples of transitions in modes of action in such complex tasks, and with, e.g., Correia et al., 2012, we show examples of affordance selection in noisy environments. Together these studies indicate some possible paths for congregating these two instances in a unique explanation.

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ORAL PRESENTATION 18

# COORDINATION DYNAMICS OF CREW ROWING

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## Introduction

It is generally accepted that crew rowing requires perfect crew synchronization. However, modeling a rowing crew as a system of non-linearly coupled limit cycle oscillators predicts instabilities in crew coordination at increasing movement rate, which would hinder rowing performance. Per contra, recently demonstrated *mechanical* benefits of *antiphase* crew rowing over conventional in-phase rowing [1] may increase with stroke rate (SR). Therefore, this study experimentally probed coordinative performance for in- and antiphase crew rowing at increasing SR.

## Methods

Twelve experienced male rowing pairs rowed in-phase and antiphase on two mechanically coupled Concept2® ergometers resting on 'slides' (allowing the ergometers to move back and forth as a single 'boat') in a steady state trial (2 min, SR = 30 $min^{-1}$) and a ramp trial in which SR was increased every 20 s from 30 $min^{-1}$ to as fast as possible in 2 $min^{-1}$ steps. There was sufficient recuperation time between trials. The ergometers' flywheel drag constant was set at $10^{-4}$ $kg{\cdot}m^2$, matching on-water blade resistance. Kinematics of rowers, handles and ergometers were captured (Vicon®, 200 Hz). Relative phase between rowers' center of mass and between handles was analyzed in terms of absolute error, variability and entropy measures over steady state bins (at least 9 strokes/bin).

## Results

Crew coordination was worse and less consistent for antiphase than in-phase ($F$'s > 10.0, $p$'s < .001) but was not systematically affected by SR. Also, no frequency-induced transitions from antiphase to in-phase were observed. For some pairs the highest achieved SR was somewhat higher for in-phase, but this was ascribed to the reduction of ergometer movement in antiphase [1], knowing that on dynamic ergometers higher SR can be achieved.

## Discussion/Conclusions

These results did not concur frequency related predictions from coupled oscillator dynamics. Closer examination of cycle harmonicity needs to be taken into account though, because it may confound relative phase interpretations (especially for antiphase). For rowing practice, this study indicates that it is no problem at all to maintain antiphase crew coordination at the exceedingly high SR as in international competition.

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ORAL PRESENTATION 19

# DYNAMICS OF SIMON SAYS: THE STRUCTURE OF RESPONSE BEHAVIOR DURING JOINT-ACTION

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Research investigating joint-action stimulus-response compatibility (JSRC) effects suggest that knowing what another person's task is during joint action is the means by which an individual can understand others' action intentions and points to *shared representations* as the basis of this integration or modulation process. Although this co-representation hypothesis is compelling, it is unclear how these co-representational structures are formed and how the causal processes involved in such representations actually modulate the movement dynamics of ongoing joint activity. Here we present data from several studies that examined whether JSRC effects can result from dynamic entrainment processes, whereby joint-action modulation is the result of the complex couplings that bind actors to each other and to their environment. Employing a number of standard joint stimulus-response compatibility paradigms (i.e., joint Simon type tasks), we examined the dynamic structure of joint response behavior using various fractal statistics and dynamical time-series methods. Collectively, the results provide evidence that self-organizing (interaction-dominant) dynamical processes of entrainment may underlie social stimulus-response compatibility effects and shape joint cognitive processes in general.

ORAL PRESENTATION 20

# KINESTHETIC EMPATHY AND SOCIAL COORDINATION

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## Introduction

The construct of empathy has been discussed in several disciplines such as philosophy [1], psychology [2] or neuroscience [3]. In an integrative approach of the concept of empathy associated with a focus on the role of the individual perception of his/her movement, the present study proposes to investigate how expertise modifies the ability of two people to engage in an "embodied cooperation" [4].

## Methods

We analysed 36 pairs from 3 groups (novice, intermediate and expert dancers). The joint action consisted of a situation where two people sat in front of each other where they freely move their forearm with no instructions (nor restrictions) about frequency, amplitude or phase. They were instructed to be tuned in to each other while moving their forearm (*Paired*). A complementary analysis of the individual motor signature completed the study (*Alone*).

## Results

The analysis of the movement characteristic for the *Alone* conditions revealed a significant greater overlap in term of frequencies and amplitudes for the novice and intermediate groups. In the *Paired* condition the expert groups revealed a wider motor repertoire (duration, cross-frequency, cross-amplitude and relative phase) while the other two groups tuned in to each other on a more restricted range of movements.

## Discussion/Conclusions

The join perception of our own movement and those of another person play a central role in social coordination. The cooperation's level and consequently the social coordination repertoire, emerging from the interaction between people, are affected by the individual expertise. The combined sensory-motor experience creates a unique kinesthetic empathy, modulated by the expertise level, between each pair of participants. This result puts in light the role of the embodied situated individuals in the understanding of motor coordination.

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ORAL PRESENTATION 21

# UNDERSTAND SCHIZOPHRENIA THROUGH SOCIAL MOTOR COORDINATION

**Marin, L.[1], Schmidt, R.C.[2], Varlet, M.[1], Del-Monte, J.[1,3], Salesse, R.[1], Raffard, S.[3,4], Capdevielle, D.[4,5], & Bardy, B.[1]**

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Past social psychological research on social interactions has demonstrated that people are not only coordinated in terms of their thoughts but also that the bodily movements of interacting people are tacitly coordinated *[1]*. Although we take little notice of this motor coordination in our everyday social interactions, everyone is able to notice a breakdown in the fluidity of an interaction when interacting with someone with a social disorder. Besides mental connectedness, this coordination breakdown also occurs in our bodily coordination with these patients. Paradoxically, although schizophrenia is characterized by social interaction deficits *[2],* this pathology has mostly been studied in terms of cognitive and emotional processes but scarcely in terms of motor impairments. However, past research has shown that those with schizophrenia have a deficit in manual gestures *[3]* and abnormal postures *[4]* during social (clinical) interactions.

In an interdisciplinary project we have been analyzing the motor signature of social interaction of that pathology in three different studies. For instance we have found that patients suffering from schizophrenia display less non-verbal gestures have intentional synchrony impairments and never lead an interaction. We will also demonstrate that it is essential to investigate this pathology in a social synchrony context. We will conclude by showing 1) how pathological mental states are embodied (pathology is understood through its motor aspects) and 2) that social motor synchronization is a significant paradigm that should be used to understand the complexity of any mental pathology.

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ORAL PRESENTATION 22

# THE COMPLEXITIES OF KEEPING THE BEAT

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## Introduction

Many human behaviors display fractal patterns of variation as they unfold in time. Recent theoretical work contends that such patterns are indicative of "interaction-dominant dynamics"; an empirical signature of behavior organized by many, interdependent processes. To further explicate this account, the current experiments investigated how manipulations of task constraints affected the fractal structure of different aspects of finger tapping behavior and their dynamical interaction.

## Method

Across three experiments, participants produced rhythmic finger taps on a Midi keyboard under a variety of constraints, including unconstrained tapping, tapping to a perfect, computer metronome, tapping to a recording of another participant's taps, and online interaction with another participant. In each experiment, different aspects of the tapping behavior are extracted from the recorded time-series and submitted to power spectral density and cross-correlation analyses.

## Results

Consistent with past research, results showed that the fractal structure of inter-tap interval (ITI) changed from a persistent pattern in continuation to an anti-persistent pattern in synchronization tapping. Additionally, the results of the current experiments showed that 1) that there exist long-term correlations between ITI and other aspects of the tapping behavior, 2) that the shift in the fractal structure of all aspects of the tapping behavior depend on the precise nature of the task constraints, and 3) that similar changes in tapping dynamics are found in the joint tapping task.

## Discussion

Collectively, the results of these experiments support and extend the findings of past research and contribute to the theoretical discussion concerning the meaning of fractal structure in human behavior. Specifically, these results support the notion that unconstrained behavior entails free interplay of the processes governing different aspects of the behavior, and that application of task constraints shows general effects on the dynamics of these different aspects. Broadly, these results support the notion that the fractal structure provides an important theoretical window into the processes underlying the organization of behavior in complex, animal-environment systems.

ORAL PRESENTATION 23

# A STUDY ON THE JOINT SYNERGY OF LOWER LIMBS IN HUMAN LOCOMOTION WITH PHYSICAL CONSTRAINTS ON THE KNEE

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## Introduction

Human bipedal locomotion is mobile and adaptable to variations in the environment. There has been a lot of research on the control mechanism of human bipedal locomotion. During rhythmic and steady motion such as straight walking, many joints and muscles are organized into a collective unit that is controlled as though it has fewer degrees of freedom (DOFs), even though it still needs to retain the necessary flexibility to adapt to changes in the environment. By analyzing the movement of the human body's joints during bipedal locomotion, significant coordination mechanisms have been found in terms of generating a periodic and steady motion pattern. This coordination mechanism is called joint synergy. Joint synergy involves many periodic motion components, that is, periodic modes, and organizes each mode consistently and adaptively against variations in physical walking conditions. In this study, we investigated human knee-constrained locomotion by mode analysis using singular value decomposition. The analyzed results show gait transition according to walking speed or ground inclination.

## Method

First, from motion-captured data of human locomotion, we extracted common basic movements and residual modes. The basic movements are common to all the test participants and express the movement of the center of mass, periodic inter-limb coordination, and knee-bending motions. The residual modes involve personal peculiarities or symptoms of motor dysfunction in locomotion. Walking conditions are given as typical walking and knee-constrained walking. In knee-constrained walking, participants' knees are physically constrained so they do not flex. By comparing features of periodic modes, the kinematical structures of walking patterns according to the walking conditions can be picked up.

## Results

Two types of walking patterns appeared in the spatial third modes in knee-constrained walking. One is the activation of the same side hip joint in external rotation and the ankle in inversion/eversion directions; this motion pattern is posture swaying. The other is the activation of the opposite side of the ankle in the plantar flexion direction; this motion pattern is standing on tiptoe. There walking patterns changes according to walking speed autonomously, and are not dependent upon the learned behavior or gender, but on the physical properties of the participants' bodies.

## Discussion

The experimental results imply that the two different patterns cause unconscious and dynamic gait transition in the region of typical walking speed for each participant. This causes a trade-off problem in the system, of how to keep the posture's stability and periodicity. Keeping both the walking speed and stable posture under increased walking speed causes a dynamic transition in the motion pattern. It is expected that by utilizing the results, we will be able to identify personal traits and run diagnostic check systems for applications.

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ORAL PRESENTATION 24

# RUNNING TO CATCH REAL FLY BALLS

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## Introduction

Cancellation of optical acceleration (OAC) might guide catchers of fly balls to the interception site. Relatedly, optical acceleration might inform these catchers about the right direction to start moving (forward or backward). The current study focuses on the initiation of running in the right direction to catch fly balls. The use of optical acceleration predicts specific patterns of running-initiation times. The first aim of the study was to show these predicted patterns of running initiation time. A next goal was to establish the exact optical variable that informs running initiation. For the OAC strategy, the information is in the fact that optical velocity is changing ('optical acceleration'). Several variables would indicate non-constant optical velocity [1]. We took data from real ball catching to identify the optical variable that our participants used to start their running.

## Methods

We performed 3 experiments in which a total of 28 participants ran to catch over 1600 balls, projected at them from a ball-launching machine along the sagittal plane. Launching distances were about 20 m, balls reached peaks of 6-10 m relative to average initial eye height, and passed at distances up to 6 m in front or behind the participants' initial position. We used video to reconstruct 2D position data of the participants' heads and of the balls.

## Results

Previously, we reported preliminary analyses showing that patterns of running initiation times qualitatively adhered to the use of optical acceleration [2]. Current analyses aim at building a quantitative case for the use of optical acceleration as information to start running in the right direction for an interception.

## Discussion/Conclusions

Initiation-time patterns of running to catch a fly ball were in line qualitatively with the use of optical acceleration as information about the direction to start moving. Several optical variables imply 'optical acceleration' (i.e., optical velocity not being constant). The current analyses aim to identify which of these variables is at the basis of starting to run in the right direction to catch a fly ball.

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ORAL PRESENTATION 25

# NEW ATTRACTORS IN BIMANUAL TAPPING: A DIRECT LEARNING APPROACH

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The theory of direct learning (Jacobs & Michaels, 2007) has proven useful in understanding the education of attention to variables in perception (Michaels & Romaniak-Gross, 2012) and learning to explore in dynamic touch (e.g., Michaels & Isenhower, 2011). In this presentation, we assess the usefulness of direct-learning concepts in helping to understand learning a coordination task, in particular, learning a difficult bimanual-tapping task. Twenty participants attempted to learn to tap with 2 index fingers at 2 Hz with a phase lag of 90°. There were 30 trials, each with 50 tapping cycles. Computer-screen feedback independently informed of errors in frequency and phase for each tap pair. An information/action space was identified which captured 1) the newly acquired attractors and 2) the degree to which they dominated intrinsic dynamics as captured by the Haken, Kelso, Bunz (1985) model. Techniques were developed to use frequency-phase scatterplots to determine the operative attractors and how they changed with learning. Participants differed dramatically in their success and in the nature of the attractors that described their tapping patterns: a frequency-only attractor, an interval attractor (125 ms lag, but with variable frequency), frequency-and-phase attractor, or frequency-and-interval attractor. Further, systematic changes in attractors were seen within participants over the course of learning. Learning was expressed as vectors in the information/action space, and we sought to determine the information that guided that learning.

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ORAL PRESENTATION 26

# EXPERIMENTS ON EXPERTISE AND DECISION-MAKING IN SPORT NEED REPRESENTATIVE DESIGN

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## Introduction

Expert decision-making in sport is predicated on processes of perception and action (Araújo et al., 2006), and has been investigated using distinct measurement methods and variables. A major issue for researchers concerns how to design more valid experimental protocols that allow participants to use processes of perception and action to functionally express their decision-making behaviours as they would in competitive performance environments. Here we sought to evaluate the influence of using different stimulus presentation methods and requisite responses as potential moderators on experimental outcomes reported in the literature on expertise and decision-making performance in sport.

## Methods

An electronic literature search was conducted and articles for analysis were selected according to prior defined criteria. Thirty one papers were considered for analysis involving 882 expert and non-expert participants. Effect sizes were calculated for 6 dependent variables typically reported in previous literature: verbalized knowledge, eye movement measures, decision time, response accuracy, movement accuracy, and movement time. Two moderator variables were also considered to assess effects of research protocols on the dependent variables: “requisite response” and “stimulus presentation”. A random effect model was used to calculate effect sizes.

## Results

Analysis of moderator variables ($Q_{(bet)}$) revealed an effect for requisite response for decision time and response accuracy and for stimulus presentation on response accuracy ($p < .05$). In addition, the Q-test for heterogeneity ($Q_{(within)}$) revealed homogeneity just for *sport performance* conditions in the moderating variable requisite response and for *in situ* conditions in the moderating variable stimulus presentation for all dependent variables ($p > .05$), with the exception of verbalized knowledge.

## Discussion

Results revealed effects of manipulation of stimulus presentation and requisite responses methods on decision-making behaviours in sport tasks. Expertise effects on decision-making behaviours were more apparent for “requisite responses” when participants were required to actually perform sporting actions and for “stimulus presentation” under *in situ* task constraints. The data demonstrate that experimental design in research on expertise and decision making in sport needs to be representative in maintaining the coupling between perception and action during task performance.

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ORAL PRESENTATION 27

# TIMING ACTION ON VIRTUAL RUGBY AFFORDANCES

**Correia, V.[1,2], Araújo, D.[2], Craig, C.[3], & Dessing, J.C.[3]**

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## Introduction

In team ball sports, such as rugby union, free spaces emerge and vanish in the defensive line for attackers. A previous study (Correia, Araújo, Cummins & Craig, 2012) using an immersive and interactive virtual reality environment simulated a rugby union task with 3 defenders and 3 attackers and manipulated visual information made available for the participants (ball-carrier attacker) and investigated its influence on players' reported judgments and actions. Specifically, the location of spaces opening between the defenders was shown to influence the actions. Actions were also influenced by rugby expertise. However, the spatiotemporal movement-information coupling of rugby attacks were not known. This study aimed to examine these couplings, which underlie emergent decisional behaviour of participants with different levels of expertise in rugby in a virtual simulation of a typical rugby task.

## Methods

A virtual simulated 3vs3 rugby task was performed by 9 Non Rugby players, 9 Recreational, 16 Intermediate and 12 Professional, from the perspective of the ball-carrier (attacker). A total of 108 trials were performed under controlled conditions: 2 defender Speeds x 3 final defensive Gaps x 3 defender End Positions. Participants, immersed in a rugby stadium, wore a head mounted display and were asked to perform as if they were in a real rugby situation. The action performed by the participants and its timing were recorded. Intersense trackers captured participant's head and hand movement and positional data of the virtual players were also obtained.

## Results

Preliminary analyses revealed Group, Speed, Gap and End Position effects on the action taken. Moreover they lead us to expect that the pattern of action as well as the timing of action differed as a function of expertise.

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ORAL PRESENTATION 28

# EXPERTISE DIFFERENCES IN INTERPERSONAL DISTANCE MANEUVERS IN KENDO MATCHES

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## Introduction

For the last two decades, researchers have conducted a variety of experiments to elucidate the variables that contribute to interactions between two actors engaged in cooperative tasks. However, many of the significant variables involved in interactions between two players engaged in competitive tasks such as games and sports remain unclear. For example, current studies do not address the impact of expertise differences on the ability of players to cope with changes in the environment and their opponents during the entire course of a match. We analyzed interpersonal distance (IPD) maneuvers in real kendo matches and tried to elucidate differences between six expert and six intermediate players, all of whom had more than 10 years of athletic experience.

## Methods

We observed IPDs during 12 expert-level and 12 intermediate-level kendo matches. We calculated the frequencies of the preferred IPD, the relative phase of the step toward–away velocities, and the step toward–away in each IPD region. We also measured the possible striking IPDs from which players could strike opponents with a brief and quick action (approximate 350 ms).

## Results

Intermediate and expert players preferred near and far IPDs, respectively (Fig.1). However, we found no differences in the relative phase in that phase transitions from anti- to in-phase occurred at the boundary of 2.85 m in both groups, which is consistent with findings of our previous research [1]. The step toward–away occurred at the boundary of 2.65 m, and the switching of experts was more precise than was that of intermediate players (Fig. 2). The possible striking IPD was about 2.65 m in both groups (Fig. 1).

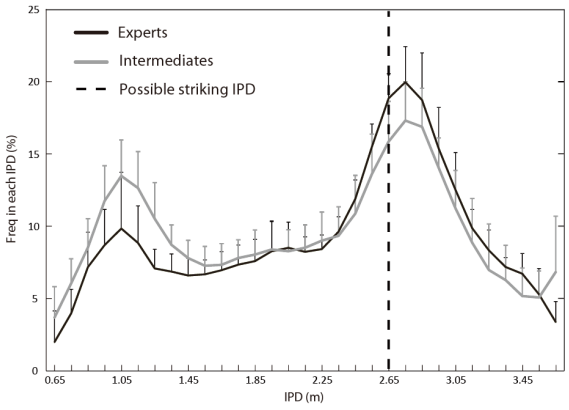


**Figure 1:** Frequencies of preferred and possible striking IPDs in each IPD region

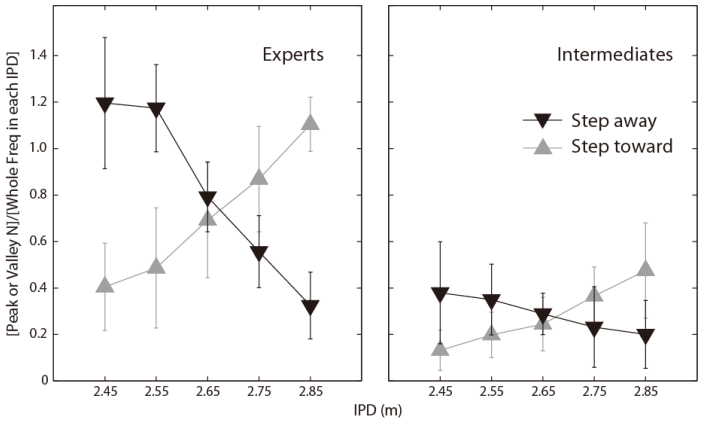


**Figure 2:** Frequency of the step toward–away in each IPD region

## Discussion

Possible striking IPDs reflect each player's offensive abilities in the context of the constraints imposed by his or her physical limitations and/or the task demands. It seems that this specific IPD (2.65 m) profoundly influenced all the other results. All players switched back and forth and executed subtle offensive and defensive maneuvers based on the IPD. Thus, although both expert and intermediate players could appropriately maneuver with respect to the IPD, experts may prefer and be more sensitive to the most important IPD.

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*Acknowledgments*. This study was supported by a Grant-in-Aid for Scientific Research (20240060, 24240085) from the MEXT, Japan.

ORAL PRESENTATION 29

# TAU-G GUIDANCE OF MUSICIANS' PERFORMANCE MOVEMENTS IN MUSICAL SKILL ACQUSITION

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## Introduction

The ancillary (non-sounding) movements made by expert musicians in performance can relate to the emotional and structural features of the music and audiences pick up expressive qualities of performance from them [1]. To be expressive, ancillary movements must be controlled as they unfold through time. This suggests that the temporal control of ancillary movements may be a skill that develops with musical learning. This proposition was investigated using General Tau Theory [2] as a model for the skilful control of temporal unfolding of movement.

## Method

Three intermediate-level clarinetists performed a previously-unseen piece of music over 5 separate sessions (4 performances per session). 1 expert clarinetist took part in a single session. Motion capture recordings were taken of participants' body movements during performances. Principal component analysis was carried out on the motion data and the first component signal was used for analysis. Tau analysis was carried out on individual movements, following [3]. Measures calculated were the percentage of each movement that was $tau_G$-coupled, and the coupling constant *k*.

## Results

Mean percentages of movement $tau_G$-coupled increased over the five sessions ($t_{(2)}$ = 11.5, p = .008). This indicated a significant increase in the strength of $tau_G$-coupling of ancillary movements as players learned the music. Mean *k*-values decreased over the five sessions ($t_{(2)}$ = 4.93, p = .039), indicating that the average abruptness of movements decreased with musical learning. Both measures approached those found for the expert musician.

## Discussion/Conclusions

The changes found in $tau_G$ guidance of musicians' ancillary movements in this study indicate that the temporal control of such movement is related to musical learning. There is still work to be done to understand how this might relate to expressive qualities of movement, as well as the musical sound. This relationship between musical learning and temporal control of ancillary movement may have implications for other forms of expressive movement, e.g. dance or speech-accompanying gesture.

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*Acknowledgments.* This research was supported by the SKILLS integrated project funded by the European Commission (FP6-IST, Proposal/Contract no.: 035005) and by the TEMPUS-G project funded by the European Research Council (210007 StIG).

ORAL PRESENTATION 30

# ON A POSSIBLE RELATIONSHIP BETWEEN FRACTALITY AND DEXTERITY

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## Introduction

"Minute inflow of stimulus energy does not consist of discrete inputs-that stimulation does not consist of stimuli. The flow is continuous. There are, of course, episodes in the flow, but these are nested within one another and cannot be cut up into elementary units. Stimulation is not momentary (Gibson, 1979, p.58)". Inspired by Stephen et al's (2010) hypothesis that fractality is the hallmark of the overt attention of active systems that resonate to the nested structure of the environment, we tested a possibility that the sensitivity to ecological information would be reflected in fractal and multifractal fluctuations in the movement of dexterous craftsmen, the degree of which would differ as a function of skill level.

## Methods

The current study is one of the series of studies on stone beads craftsmen in India (Bril et al., 2005). 6 craftsmen from the higher (HQ) and 6 craftsmen from the lower (LQ) quality workshops shaped parallelepiped roughouts made of two materials (5 carnelian and 5 glass—unfamiliar material) into ellipsoid preforms. 3D Euclidean displacement time series of the hammering hand in the first 30 seconds of the exploratory phase—calibration—was extracted from each trial. Fractal exponents and their heterogeneities across time of the time series and those of the shuffled, surrogate signals were assessed by DFA and Chhabra and Jensen's (1989) method, respectively.

## Results and Discussion

There was evidence of fractal and multifractal fluctuations in the hammering movement of both groups. Furthermore, the movement of HQ, when using the novel material, exhibited significantly greater degrees of fractality and multifractality compared to LQ. Combined with the previous result of the quality of the products (Bril et al., 2005), the present result seems to suggest the efficacy of the movement of HQ in the situation where the hunting for the ecological information matters more.

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ORAL PRESENTATION 31

# ODOMETRY ON THE TREADMILL: A METHODOLOGY FOR INTRODUCING A DYNAMICAL SYSTEMS ACCOUNT OF THE IMPACT OF GAIT SYMMETRY CLASSES

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**Introduction**
Distances travelled by legged locomotion are perceivable without benefit of vision. Bipedal gaits fall into two symmetry classes, primary (dihedral symmetry) and secondary (cyclic symmetry). When humans measure and report a distance using gaits from the same class, reported distance matches measured distance. Switching gait class between measure and report, however, compresses (primary to secondary) or inflates (secondary to primary) measured distance [1], [2]. A dynamical systems model based on the relative velocity between measurement and reporting locomotion is proposed that involves a key parameter δ [2]. The model predicts over- and under-estimating behavior for positive and negative values of δ. Moreover, δ can be estimated from relative velocity data.

**Methods**
With eyes open, 10 participants were asked to walk out (primary gait) or gallop-walk (secondary gait) out a target distance on a treadmill and, after a pause, to reproduce the same distance using a gait from the same or the alternative symmetry class. A wireless marker was used to capture body position data that were used to calculate relative velocity.

**Results/Discussion**
The treadmill experiment reproduced the pattern of results obtained previously [2]. Switching between gait classes induced over- and under-estimating behaviour. Moreover, the sign of δ changed consistent with the observed reporting error. The effects of gait synmmetry on reporting error and δ were both significant. We conclude that the treadmill paradigm offers a promising methodology for studying haptic human odometry within dynamical systems' theory.

**References**
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ORAL PRESENTATION 32

# PERCEPTION-ACTION COUPLING IN PARKINSON'S DISEASE: EFFECT OF MEDICATION AND DEEP BRAIN STIMULATION ON ACCURACY CONTROL

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**Introduction**
The clinical effect of antiparkinsonian medication and deep stimulation on reducing motor impairments in subjects with Parkinson's disease (PD) is clear. However, knowledge about the inter-dependence of medication and brain stimulation on accuracy control is not well documented. Moreover, an increased dependence on visual information for control of motor activity in PD has been largely investigated and is still debated. Thus, we proposed to manipulate informational constraints in order to study the circular causality between information and movement in PD.

Patients were instructed to perform a reciprocal aiming task aiming at (i) understanding the control of accurate movement and (ii) identifying the influence of informational constraints on the organization of movement according to different conditions of medication and brain stimulation.

**Method**
Participants were divided in two groups: patients with PD (8 men and 2 women, mean age: 62 yrs) and healthy age-matched participants (1 men and 9 women, mean age: 58 yrs). Participants performed a reciprocal aiming task on a graphics tablet where informational constraints were manipulated by changing the level of difficulty of the task (changing the accuracy constraints).

PD group performed the protocol in four different sessions according to medication state (Dopamine ON/OFF and brain stimulation ON/OFF) whereas control group performed the task in a control condition.

**Results**
Data obtained from the control group with healthy patients were in agreement with the literature on the speed-accuracy trade-off in the temporal domain: increasing task difficulty gave rise to a slowing down of the movement.

Whereas patients were able to perform the task in the four treatment conditions, results clearly showed a slower movement time for the condition OFF/OFF. Data collected in conditions ON/ON clearly showed that tremor disappearance gave rise to faster and more accurate aiming movements.

Informational constraints thus affected behavioural dynamics in both groups with two control mechanisms observed according to the task difficulty: a rhythmic movement for low level of difficulty and a concatenation of discrete movements for high level of difficulty.

**Conclusions**
This contribution focused on the understanding of accuracy control in PD. Overall, analyses performed in this study provided a framework that may be used in the future for the clinical assessment of patients with perception-action difficulties and various movement disorders.

ORAL PRESENTATION 33

# JOINT ACTION SYNTAX IN JAPANESE MARTIAL ARTS

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## Introduction

In response to various situations, people make instantaneous decisions and execute appropriate motor behaviors. Decision making has been viewed in terms of stochastic and symbolic dynamics. Human motor coordination has been studied in terms of entrainment of a nonlinear coupled oscillator, and this has been extended to interpersonal coordination. However, little is known about the dynamics underlying continuous abrupt switching behavior such as that required in martial arts. Here, we report that the intentional switching dynamics underlying continuous movement during interpersonal competition emerges from a simple syntax.

## Methods

We observed a time series of interpersonal distance between two players during 24 kendo matches. The subjects included 12 experts and 12 intermediate-level players. A return map analysis was applied to 346 sequences during the matches, and linear functions were fitted to the sequences. Second- and third-order state transitions were also analyzed.

## Results and Discussion

The results revealed six functions including linear functions with four different slopes: two attractors and two repellers, an exponential function, and a logarithmic function of intermittency. We found that 216 (62.4%) of all sequences could be fitted by all of the candidate functions using three to six points in each sequence. Moreover, we found 52 sequences that switched among two-to-four different functions in each sequence. The state-transition probability revealed differences in skill level.

The results of this study suggest that complex movements during interpersonal competition in a kendo match are generated by simple principles to attract or to repel the attractors. Switching among several attractors contributes to the complexity of movement during a kendo match. These findings suggest an intentional switching dynamic embedded in complex, continuous, interpersonal competition that can be regarded as a hybrid dynamical system consisting of higher discrete and lower continuous modules connected via a feedback loop (Nishikawa & Gohara, 2008).

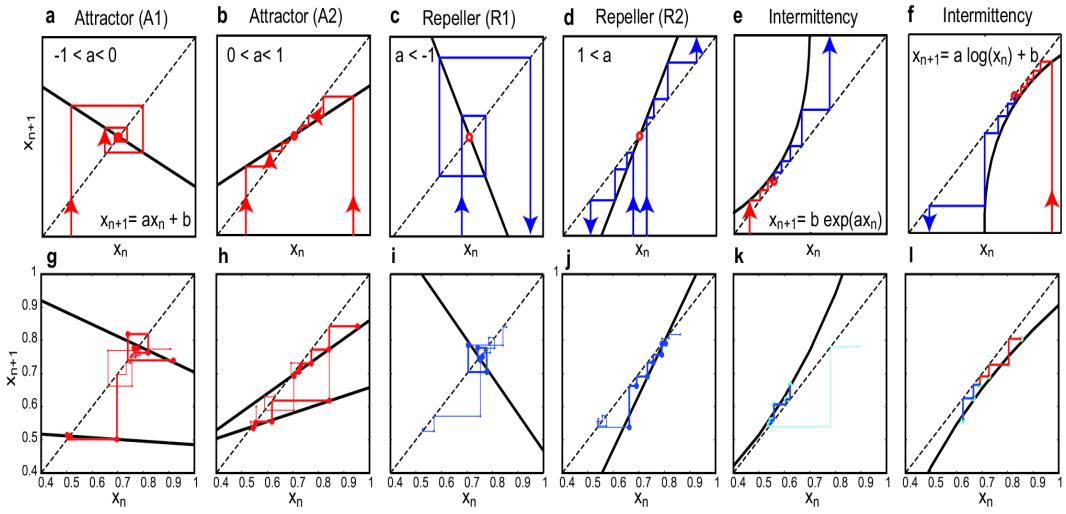


Figure 1: Candidate functions on the return map (a-f) and examples of fitted functions (g-l).

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*Acknowledgments*. This study was supported by a Grant-in-Aid for Scientific Research (20240060, 24240085) from the MEXT, Japan.

ORAL PRESENTATION 34

# THE COMPOUND EFFECT OF AGE AND EXPERTISE ON THE TEAM' COLLECTIVE BEHAVIORS OF FOOTBALL PLAYERS IN SMALL-SIDED GAMES

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**Introduction**
This study aimed to examine how the offensive and defensive team behaviors performed in 5 vs. 5 + GKs small-sided games (SSG) vary according to the age and expertise of young football players.

**Method**
Thirty male young football players of three different age groups participated in the study (U16 - playing experience: 6 ± 1,76 yrs; U17 - 7 ± 1,4 yrs; U19 - 8,7 ± 2,8 yrs). Each group was divided in two balanced teams, which played during 8 mins, with field dimensions of 33m x 60m (165m$^2$ per player). Ten GPS units (GPSports systems SPI PRO) were used to collect the 2D movement displacement trajectories of players. Attacking (101) and defending (101) episodes were noted manually. MATLAB software was used to calculate specific team behaviors such as: 1) team width; 2) team length; 3) surface area, and 4) stretch index [1]. The compound effect of age/expertise level on teams' collective behaviors was evaluated using One-way ANOVA.

**Results**
Data showed that older/higher experienced groups of players occupied significantly larger surface areas during attacking phases. In defense this trend was not consistent, despite the significant differences in team width between all the groups (Table 1).

Table 1. Mean (SD) of the teams collective behaviors according to age/expertise.

| | Attack | | | Defense | | |
|---|---|---|---|---|---|---|
| | U16 | U17 | U19 | U16 | U17 | U19 |
| Team width | 18,6 (5,1) | 19,4 (4,8) | 20,9 (4,5) | 15,8 (3,5) *# | 18,7 (5,1) * × | 16,9 (3,5) * × |
| Team length | 19,9 (4,6) | 19,5 (5,2) | 21,2 (4,8) | 21,4 (6,3) | 19,2 (5,2) | 21,2 (6,0) |
| Surface area | 176,4 (68,9) * # | 179 (64,3) *× | 213,3 (66,2) × # | 163,4 (65,8) | 176,2 (72,4) | 169,3 (52,7) |
| Stretch index | 9,3 (1,7) | 9,4 (1,9) | 9,9 (1,5) | 9,2 (2,0) | 9,1 (1,8) | 9,0 (1,4) |

** significant difference between U16 and U17(p≤0.05); # significant difference between U16 and U19(p≤0.05); × significant difference between U17 and U19(p≤0.05).*

**Discussion**

The age and expertise level seem to exert an influence on how the young football players manage the functional space during 5 vs. 5 + GKs SSG. Further research needs to evaluate the potential generalization of these findings to better understand whether these compound variables can be considered as reliable performance indicators in the monitoring of learning and performance during long-term soccer talent developmental programs.

**References**

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ORAL PRESENTATION 35

# CAPTURING ONLINE TEAM BEHAVIOR DURING COMPETITIVE ASSOCIATION FOOTBALL MATCHES

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[3] YDreams, Portugal

## Introduction

Ecological dynamics analysis of team sports have attempted to explain how the interactions between players in a team and information from the performance environment, constrain the emergence of collective patterns of stability, variability and symmetry-breaking [1]. Usually these analysis are performed after the matches, which imply that coaches can only use this information as feedback and not prospectively. Using invisible markers (infrared dyes), which absorb light in the infrared spectral region, players can have distinctive color features and thus, researchers may be able to capture their behavior online. The aim of this study is to develop the preliminary stages of a method to capture online team behavior during matches.

## Methods

After selecting an infrared dye and its optimal concentrations, we tested the solutions in fabric samples to assess the tones of gray and marker water resistance. T-shirts were soaked in the solutions created, and were used by football players in a 1vs2 task where we proceeded to extract the distance between the attacker and the defenders, and the distance between each player to the goal. The images were recorded using a digital video camera SONY DCR-SR36 equipped with a SCHOTT–RG850 filter.

## Results

In the first stage we created five different grey tones, distinguishable by visual inspection. In the experimental task of 1vs2, although we only managed to track short sequences, we succeeded in measuring the interpersonal distances. The results allowed verifying the capability of this tracking system to obtain performance data of players from each team. Further data is being collected at the moment.

## Conclusion

Findings showed how the video technology with invisible markers proved to discriminate and track each player. We concluded that, with the appropriate computer graphics' algorithms and methods, currently under development, it will be possible in a near future to capture team behaviors online.

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ORAL PRESENTATION 36

# EXPLORING THE REGULARITY OF INDIVIDUAL TACTICAL BEHAVIORS OF ASSOCIATION FOOTBALL PLAYERS

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## Introduction

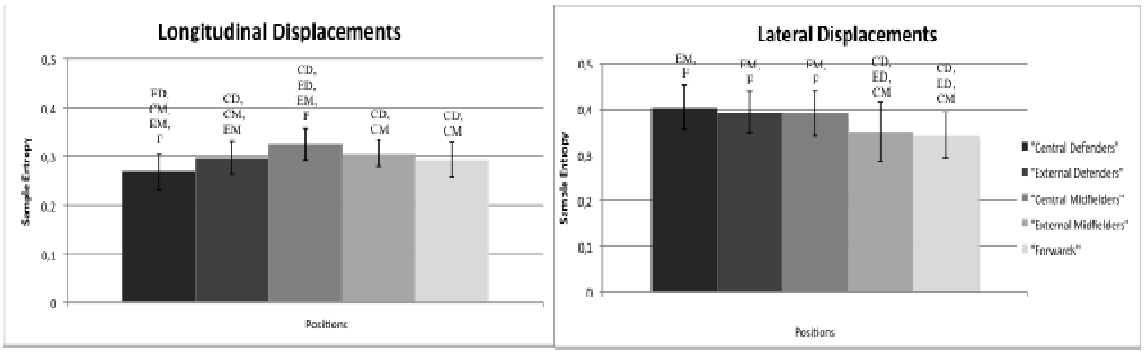
Recently, inspirational ideas and concepts from sociobiology have been applied to the analysis of sports teams [1]. Viewing teams-as-superorganisms support the notion that the division of labor between team players is based on a platform of complementarity and mutual benefits related to successful team adaptation to the match ecology. The purpose of this study was to evaluate the regularity of the players' movements according to their specific roles or playing positions in football matches.

## Methods

Positional data (2D) from 11 official football matches of the English Premier League were collected with Prozone® tracking system. A total of 112 players were distributed and analyzed for 5 playing positions [2]. The regularity of players' movements was measured in longitudinal and lateral directions, trough the use of sample entropy. Univariate ANOVAs were performed to analyze the effect of the playing positions. The k-means clusters analyses were also used to group positions in two levels of regularity.

## Results

Figure 1 shows significant differences in regularity between several playing positions.




Graph 1. Mean±SD values of sample entropy in the longitudinal movements (left side) and lateral movements (right side) for each position. Significant differences are marked with letters above the SD bars. Central Defenders (CD), External Defenders (ED), Central Midfielders (CD), External Midfielders (EM), Forwards (F).

Results from k-means clusters analyses for lateral movements revealed that cluster 1 (CD, ED and CM) was significantly more irregular than cluster 2 (EM and F). For the longitudinal movements, the two clusters were not significantly different - cluster 1: CD, ED, F; cluster 2: CM, EM.

**Discussion/Conclusion**

Results revealed that the regularity of players' movements varied according to their playing positions on-field. In lateral direction, groups of playing positions presented major differences between them. These differences may have emerged by the influence of specific space-time constraints imposed to players of each position. In overall, players exhibited large levels of irregularity in the lateral than in the longitudinal movement displacements, which reveals that teams-as-superorganisms have a different relation with their environment in terms of lateral and longitudinal displacements.

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ORAL PRESENTATION 37

# EXPLORING COLLECTIVE MEMORY EFFECTS ON ASSOCIATION FOOTBALL PERFORMANCE

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## Introduction

Individuals performing as a group may increase effective perceptual range and adapt to different contexts, matching their collective information-movement behaviors with the properties of their environment [1]. This study aimed to investigate whether the collective behavioral memory of football teams may discriminate the success and teams' dominant field location.

## Method

Positional data (2D) from a Premier League match were collected with Prozone® tracking system. A total of 180 sequences of open play were selected for analysis and categorized regarding team's dominant field location (i.e., retreated, intermediate or high block) and success of ball recovery. The team's length, width and stretch index were used as compound positional variables to capture the time-evolving dynamics of the teams' collective behaviors [2]. In order to analyze the memory (temporal dependency) of the collective behaviors, we performed a series of autocorrelations and extracted the slope (*m*) of the periodogram generated for each compound variable time-series. The effects of success and dominant field location on the *m* were analyzed using MANOVAs, separately for the attacking and defending teams.

## Results

The success of the defending team was associated to long-term behavioral memory in the width stretching movements, $F(1,89) = 4.857$, $p \leq .03$. On the other hand, dominant field location had significant main effects on team width, length and stretch index, both for attacking and defending teams (dg=1,89; $p \leq .008$). Bonferroni's follow-up tests revealed that all teams' dispersion measures in high block field location were associated with short-term behavioral memories (i.e., fast decaying slope values, see right panel of Figure 1).

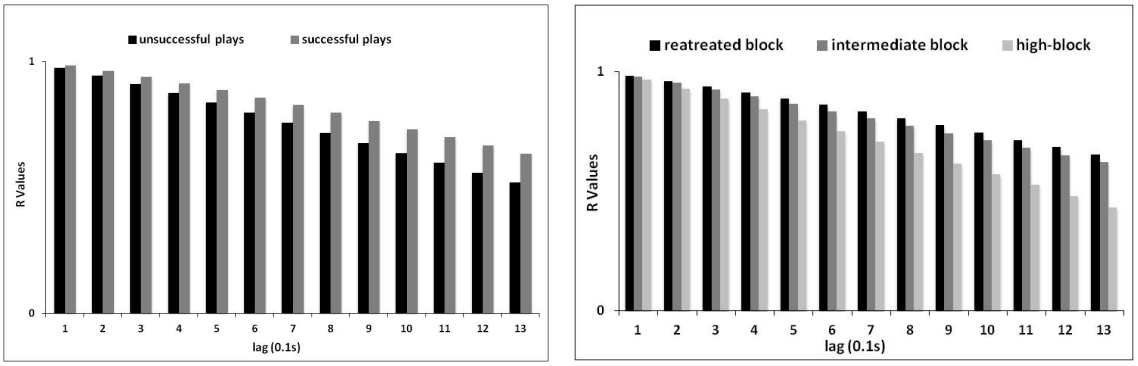


Figure 1. Periodograms of mean defending team width (left) and mean attacking team stretch index (right).

**Discussion**

Our findings suggest that teams should increase their stability during defensive phases of play as a key to succeed in recovery of ball possession. Contesting play in high block conditions seemed to imply significant less stable team's contraction and stretching movements. Teams should be prepared to quickly adapt their behaviors to changes in the performance environment, such as those related with dominant field locations.

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ORAL PRESENTATION 38

# THE INFLUENCE OF SUCCESS'S CRITERIA DURING THE ACTION OF A SPORTS TECHNIQUE, LEARNING TIME AND PEDAGOGICAL GOALS

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## Introduction

Pedagogical goals are very important for learning and development of techniques as well as the time required for set information retention of that knowledge. The "processing and storage" of information received are associated and was supposed to verify winnings between the levels of information and retention of learning gains.

## Aim of study

The influence of the standard technique during an execution will be determinant for success of a movement. We try to relate the learning gains retained by students from the 3rd cycle (groups of soccer – GA & GB and Gymnastics - GC) and consequently the success obtained in the assessment candidates (GD) for university in Sport Sciences (2012). The data obtained are focused on the success criteria of each motor action and defined by the standards implementation (soccer » shot on target; gymnastics » cartwheel; candidates » cartwheel and the sequence of movements floor).

## Methods

### Sample

The study covered 4 groups. 30 boys (soccer) divided into two groups (15 each one). A control group GA, has only Physical Education twice a week and the second group GB, has Physical Education (twice a week) and they are integrated in school sports with twice a week for training's.
Group C (gymnastics) evaluated 20 students. Group D (assessment candidates - 551).

**Statistical:** Descriptive and T Test.

### Procedures

To obtain data from GA and GB, they were asked to shot on goal at a distance of 10 meters in 3 zones, relationship with the center of the goal (front center; 45º - left side; 45º - right side). Each individual performs a shot from each zone. For group C and D, they perform the all the movements in sequence. It was observed the success criteria for each movement at each movement phase.

## Results

Data analysis shows us GA & GB, only significant differences in action/execution phase » *0,037* (p<0.05), for soccer groups;* the best side of shot is for both groups the right side (23/30 complete with the right foot), being the area where you met most part of the criteria for the success of this technique. The control group has less number of errors in the initial phase, whiles the trained group is the group that complies with a greater number of execution criteria in the whole movement. Group C (cartwheel), the largest number of errors was found in the initial phase (34/120» 28%).Errors found in the main action (32/80» 40. A total of 94/260 errors possible, points to 36.20% to the total success.

In Group D, 8.89% of candidates with notes of between 20% and 50%, achieved on average 39.66% (7.93/20), the total value of final score and failed 60.33% of success criteria. 23.60% of candidates with notes of between 51% and 70% obtained on average 60.57% (12, 14/20), the total value of final score, and failed 39.43% of success criteria. 31.94% of candidates with notes of between 73% and 100% obtained an average of 84.11%, of the total value of final score and failed 15.89% of the success criteria. Getting success for assessment candidates, the most successful was football with 98.36% and with less success was the gymnastics with 80.13%.

**Conclusion**

For soccer groups, the trained group does not show a relevant significant difference from the untrained group neither in the fulfillment of the execution criteria nor in the goals scores. Failing in meeting the execution criteria was related to a lower goal score. The largest number of failed success criteria can be found in the initial phase during the execution. Errors encountered in the initial phase of the two groups of 3rd cycle, are repeated in the same location as well the assessment candidates. Obtaining success seems to be directly related to the learning of techniques (success criteria at the beginning of the movement). In relation to the time of learning tasks, may not be optimal for the retention of information during the processes of learning.

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ORAL PRESENTATION 39

# FROM BEHAVIOR ANALYSIS TO ECOLOGICAL PSYCHOLOGY: EXPANDING BOUNDARIES

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Several researchers have recently highlighted the shared intellectual heritage of Ecological Psychology and Behavior Analysis. Alas, because of historic tensions between the disciplines, the collaborative potential created by this shared heritage has not been sufficiently explored. To highlight the potential, we will discuss a series of experiments examining the roll of affordances in operant conditioning paradigms. We have conducted experiments or rats and hamsters to assess the effect of lever height on lever pressing that was not explicitly reinforced. The comparative study revealed that the rate of lever pressing varied similarly for rats and hamsters as a function of lever height, when lever height was re-scaled relative to body size. The distribution of inter-response times showed that lever pressing was organized in bouts separated by pauses. These findings support an analysis of affordances in non-human species, and it provides an example context for collaborative work between behavior analysts and ecological psychologists.

ORAL PRESENTATION 40

# INFORMATION, PERCEPTION, AND ACTION: NEW HORIZONS IN THE CONTEXT OF INFORMATION TECHNOLOGIES?

**Gonzalez, M.E.Q.[1], Alves, M.A.[2], Gonzalez, J.A.Q.[3], & Broens, M.C.[1]**

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The objective of this paper is to investigate Gibson's (1986) ecological conception of information and its suitability for fully explaining perception-action in the contemporary context of information technologies. Considering Gibson's view of affordances as the fundamental kind of information available in the environment to guide the actions of embodied embedded active organisms, our central question is: in the rapidly increasing world of information technology that changes/directs/constrains our possibilities of action, does ecological philosophy need a complementary notion of information to contemplate human virtual interactions? According to Gonzalez et al. (2010), the action possibilities provided by information technologies create a new kind of affordances, the techno-affordances. We argue that this kind of affordance specifies properties of the human "intelligent environment" in such a way that the reciprocity principle, so dear to ecological psychology, does not always apply. Thus, for example, information available from a GPS system may direct one's action by indicating where to turn right or left, where the radars are, and so on, which sometimes induces naïve users to remain in an almost completely passive state. In the case of intelligent artificial systems that operate with ubiquitous information available concerning a person's preferences, techno-affordances may constrain creative and autonomous action. In this context, we propose a discussion about the need for a complementary approach to ecological information in order to allow a better understanding of the relation between perception and action in the context of technologies of information.

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ORAL PRESENTATION 41

# REFLECTIONS ON WHAT WE LEARN FROM THE HISTORY OF THE LAST 5 ICPA'S

**Mace, W.**

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# POSTERS

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POSTER

# THE MODELLING OF MEASURES OF GIBSON'S AFFORDANCES

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## Introduction

Suppose that we observe an output function *f(t)* in the time interval [0, T] from a human hopping comprising the subsystems of the leg spring, each one subject to differential equations with unknown parameters or, more specifically, with unknown stiffness. It is desired to determine the nature of the leg spring and, if we have control over the input, this may then be regarded as an adaptive feedback problem, in which the information gathered gives an indication of what input will now provide the most additional information. The objectives here are similar to those of Fel'dbaum in his dual control theory (Fel'dbaum, 1965).

## Methods

Eleven healthy, well-trained subjects (4 women and 7 men) gave their written informed consent to participate in this study. All the subjects performed a sequence of unilateral hops on her/his dominant lower limb until voluntary exhaustion. In order to solve inverse problems for identification of systems with unknown spring stiffness, the technique of Bellman-Quasilinearization (Kim and Voloshin, 1995) was implemented. This technique allows for the treatment of both observational data and design data in the same manner. The problem we wish to consider is how to determine both stiffness in the leg spring from observations of the vertical displacements of the individual limb segments during the stance phase of hopping.

## Results

The dynamic feedback controller will generate the control input as if it comes from an attached leg spring system, which in reality is a virtual system. One way to view a dynamic controller is that it is some dynamic system that takes the foot-surface system output as its input and produces another output that becomes the input to the leg spring controller system (Fig. 1). This mechanism illustrates that control was distributed to the leg spring model and environment (foot-surface). Human movement control can be seen as a process that is distributed over the performer-environment system i.e., rather than being localized in an internal structure of the performer (Gibson, 1979).

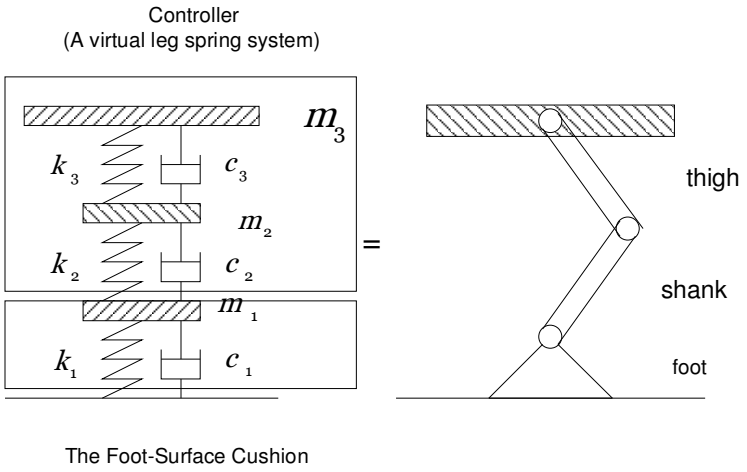


**Figure 1:** The three-degree-of-freedom leg spring model explains how the system can perform the vibration suppression function. The model consists of a foot-ground contact and two-degree-of-freedom in dynamic controller that is directly attached to the former. This feature stands in contrast to the muscle control optimization such as computed muscle control (Delp et al., 2007) in which the control gains do not necessarily have any physiological meanings. The second-order controller will generate the control inputs as if it comes from an attached system to the foot-surface.

**Discussion**

Feldbaum and Bellman (Bellman et al., 1976) gave the foundation for the dual control problem. The main idea is that in controlling an unknown system it is necessary to let the controller have dual goals. First, the human movement control must control the process as well as possibilities of actions (Gibson, 1979). Second, the controller must inject a probing signal to get more information about the unknown system. By gaining more information, a better control can be achieved in future steps. Therefore, during the hopping, we found about the complementarities between the perception of the surface and the co-perception of the self in terms of special posture (i.e. natural modes) because the two are inseparable for possibilities of natural shock absorber (Kim et al.).

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POSTER

# SELF-ORGANIZATION AND AFFORDANCES: A VIRTUAL REALITY MOTOR INTERVENTION PROGRAM FOR CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER

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## Introduction

Throughout development, some children show difficulties in the performance of motor skills of daily life and they can be identified as shown Developmental Coordination Disorder (DCD). In the present study, DCD children performed activities in a virtual environment. Affordances in this context stimulate children to create new perspectives in theirs possibilities for coupling with the environment. The properties enhanced by virtual reality allow for the selection and responses to affordances. The motor actions performed by the subject are not planned but they emerge from the intrinsic dynamic of his body and from the environmental information. The last generation of videogames like Xbox/Kinect allows to the subject to interact with his avatar and motor actions can be reproduced inside this virtual environment. The present study aimed to measure the efficacy of physical activity practice by children with DCD in motor tasks exploring affordances in the virtual environment. Furthermore, aimed to the identification of motor patterns that emerge from self-organization processes that have impact on motor coordination and dynamic balance.

## Method

A total of 28 children were assessed by the M-ABC2 test, 14 of them shown coordination problems were matched by age and gender with typically developing (TD) children. All participants were submitted to an intervention motor program developed in virtual environment with the videogame Xbox/Kinect. The intervention program was conducted throughout 5 sessions and each session lasted 20 minutes. The game chosen was Reflex Ridge by Kinect Adventures. This game was used to explore dynamic balance. The effect of intervention was assessed by the mean score reach in the game and by the KTK' test score prior and after the intervention. Mann-Whitney Test and Wilcoxon Signed Rank Test ($p < 0,05$) were performed for comparisons between and within-groups.

## Results

Analysis of the Kinect game´ score showed progressive increase from the first to the fifth session and significant difference between the TD and DCD groups. Statistical difference between KTK´ scores pre and post-intervention was showed only within the TDC group. Furthermore, analysis showed difference between groups pre-intervention but no difference post-intervention. All measures showed better results for the TD group compared with the DCD group.

## Conclusions

The Intervention Program using Virtual Reality had a positive impact in motor coordination and dynamic balance for DCD children. Affordances that emerge from Virtual Environments were explored by all children that participated in the study.

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POSTER

# THE RESEARCH ON THE SKILLS IN JAPANESE TEA CEREMONY: A CASE STUDY

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## Introduction

Tea Ceremony is one of Japanese most famous cultural traditions. However, there are few psychological studies concerned about it. In our study, we investigated skills of the master (expert)'s making tea.

## Method

To specify the difference between the teas made by the master and the novice quantitatively and qualitatively, we focused on making tea process of *Temae*, the manner in which the ceremony was performed. Two adults, one master (hereafter, expert) of Tea Ceremony and one novice were participated in this experiment. Expert has been engaged in Tea Ceremony for more than thirty years, while novice just for one year. Each participant was asked to make one bowl of tea in each trial, namely, they were required to stir a spoon of *matcha*, powdered green tea, into a bowl of hot water with a *Chasen*, tea whisk, in order to mix powdered tea with hot water. After finishing mixture, six samples (3 from bottom; 3 from middle) of each tea were picked up. Photos of samples were taken with a digital microscope. At the same time, sensory evaluations were conducted. Two judges who had many years' experiences of Tea Ceremony tasted bowls of tea made by the expert and the novice, and made scores in several adjectives from viewpoint of the condition of tea surface, flavor, and taste of tea.

## Results

As measures of mixture, numbers and sizes of grained tea powder in a bowl of tea were computed by analyzing micrograms of tea samples. Mean size of grained tea powder in the expert was finer than novice (Figure 1). As for sensory evaluation, scores of the tea made by the expert showed higher than the novice. The both of two tasters reported that tea of expert were more excellent than the novice.

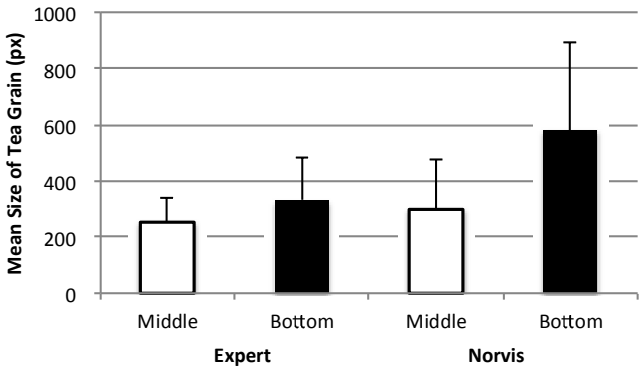


Figure 1. Mean size of tea grain in the whisked tea. Middle: samples were taken from the middle layer of the tea. Bottom: samples were taken from the bottom layer of the tea.

**Discussion**

The result of tasting, teas made by the expert was more satisfied than the novice. The quantitative image analysis of micrograms indicated that the expert's tea were full of fine grained tea powder while the teas made by the novice were full of large grained tea powder. Therefore, excellent taste of Japanese tea would be related to the size of grained tea powders. In the poster presentation, we will discuss properties of the skill in Tea Ceremony from the viewpoint of subjective tasting reports, qualitative analysis, and motion analysis.

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POSTER

# STRATEGY CHOICE AFFECTS ACTION DISFLUENCIES IN A SIMPLE MANIPULATIVE TASK

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## Introduction

This study investigates the influence of strategy choice on manipulative performance, especially on small action disfluencies called microslips [1]. Microslips have been studied in relation to task situations, repetition of tasks, and neurological damage, but have not been examined in terms of participant's strategy. The task in this study is to prepare the same two lunch plates containing five food items. In such a task, there are two probable strategies: the item strategy and the plate strategy. The item strategists put a food item on one plate, and then put the same item on the other in series. In contrast, the plate strategists complete one plate, and then go on to the other. Most participants are expected to employ either strategy. This study examines how different strategies produce different microslips.

## Methods

Twenty-two female participants were asked to prepare two lunch plates twice. Food items on the plates were not real but plastic fake replicas. Participants' behaviors were videotaped to be coded. Microslips were categorized with reference to reparandum, disfluency, and repair based on the Repair Interval Model [2].

## Results

Comparisons of 1st and 2nd trials revealed no statistical differences between them, thus they were grouped together. Most participants used the item strategy ($n$=13) or the plate strategy ($n$=7) on both trials, whereas two participants changed their strategies between trials. Frequencies of microslips with reference to reparandum, disfluency, and repair were compared between two strategies using Fisher's exact test. Distribution of reparandum and repair types between strategies were significant ($p$=.015, $p$=.027), but distribution of disfluency was approaching significance ($p$=.074). As shown in Table 1 and 2, the item strategists made more quality-resumption slips (e.g., fail to grasp, then re-grasp), whereas the plate strategists committed more target-substitution slips (e.g., change the target item on the way).

Table 1. Frequencies of microslips classified by reparandum type between two strategies.

| | Manner | Target | Quality | Commission | Omission | Adjustment |
|---|---|---|---|---|---|---|
| Item | 3 | 7 | 20 | 2 | 0 | 1 |
| Plate | 0 | 14 | 13 | 2 | 0 | 6 |

Table 2. Frequencies of microslips classified by repair type between two strategies.

| | Resumption | Convert | Return | Substitution | Shift | Others |
|---|---|---|---|---|---|---|
| Item | 21 | 1 | 1 | 7 | 0 | 3 |
| Plate | 13 | 0 | 3 | 14 | 5 | 0 |

**Discussion**

The difference of microslips between strategies can be made by dis/continuity of item selection. The item strategists could reach two items in a row. In contrast, the plate strategists had to locate each item one by one, thus they had more opportunities to select items, leading to many target-substitution slips. Meanwhile, the reason that the item strategists made more quality errors may come from their individual characteristics (e.g., their imprudence). Therefore, further research will be needed to solve this issue.

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POSTER

# EFFECTS OF A TENSEGRITY-BASED VEST ON THE HUMAN POSTURE AND MOVEMENT

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## Introduction

Within the musculoskeletal (MS) system there are extensive connections between muscles, capsules and ligaments, which supports the existence of myofascial force transmission (Carvalhais et al., 2013). In addition, the architecture of the MS system suggests that it shares several features of tensegrity structures (Chen & Ingber, 1999). Following the idea that the MS system is a continuous, tensegrity-like structure, a tensegrity-based suit was developed. This suit was biologically inspired and designed as a tool to optimize posture and movement. The objective of this study was to investigate the effect of the tensegrity-based suit on shoulder posture and on the kinematics of the knee and hip joints.

## Methods

Shoulder protraction and 3D hip and knee angular kinematics were assessed in 10 healthy adults, with and without the use of the vest. Initially, the subjects had their shoulder posture and lower limb movements evaluated by means of a 3D motion analysis system, during quiet standing and during single leg squatting, respectively. Further, the volunteers wore the vests, which were adjusted to produce scapular retraction and lateral hip rotation, and the measurements were repeated. Dependent t-tests compared shoulder protraction, and hip and knee angular displacements on the sagittal and transverse planes, in the conditions with and without the vest.

## Results

There was a significant reduction in shoulder protraction of the right ($p \leq 0.001$) and left shoulders ($p \leq 0.001$) with the use of the vest. In addition, the vest significantly reduced medial rotation of the hip ($p = 0.043$) and increased lateral rotation of the knee ($p = 0.041$)

## Conclusion

The tensegrity-based vest was effective in modifying posture and movement, by reducing shoulder protraction and control internal rotation of the lower limb. These effects are often the objective of rehabilitation programs designed to treat and/or prevent injuries. The vest increased the individuals' dynamic resources and enabled them to better deal with postural and task demands.

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POSTER

# SOCIAL CONSTRAINTS ON COGNITIVE PERFORMANCE: EFFECTS OF STEREOTYPE THREAT ON REACTION TIME VARIABILITY

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## Introduction

Stereotype threat proposes that the mere risk of confirming negative stereotypes about one's ability can lead to systematic underperformance by members of stigmatized groups [1]. The current study investigated whether performance under stereotype threat influences the 1/f scaling behavior characteristic of self-organizing interaction dominant dynamical systems [2]. Stereotype threat was manipulated to examine the structure of reaction time performance between sexes completing a two-choice mathematics task.

## Method

Eighty-seven participants (male=33) completed 600 trials in which they sorted numbers as prime or nonprime. Using detrended fluctuation analyses, the first 512 trials were used to estimate the fractal dimension (Hurst) for each participant's reaction time (RT) time series. Fractal estimates of randomly shuffled surrogate series were also calculated.

## Results

Hurst analysis for surrogate time series revealed no effects for condition or sex. For each condition and sex the mean Hurst calculated from real data was significantly greater than the Hurst calculated from surrogate data, indicating RT performance for participants in all conditions was fractal. More importantly, an analysis of the Hurst for real RT time series revealed effects of sex and threat, with RT times series of women under threat resulting in lower ('whiter') values, ($M \approx .65$), compared to men under threat, ($M \approx .75$) The effect of stereotype threat on the structure of RT variability was also related to accuracy.

## Conclusions

Overall, results indicate that stereotype threat impacts 1/f scaling behavior of participants. Since signal 'whitening' denotes imposed constraints in an interaction-dominant dynamical system, results also suggest stereotype threat is a system constraint. Results are discussed with respect to both the self-organizing interaction dominant approach to human behavior and the social-cognitive account of how stereotype threat influences performance.

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POSTER

# OBSERVATIONS OF ROLLING OVER BEHAVIOR OF BEETLES: THE EMERGENCE OF ENVIRONMENT-ACTION SYSTEMS

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## Introduction

Darwin, in his last book[1], showed that various parts of the environment share the same affordance by investigating the traces of earthworm's behavior. It was shown that earthworms discovered affordances for plugging up the mouth of the hole in various parts of leaves, petioles, pebbles, and tufts of wool and utilized them to prevent air from reaching down into the nest in order to keep their skins warm and moist. In the present study, taking our cue from Darwin's study, we went one step further to describe the actual process of the emergence of environment-action systems. Specifically, the emergence of rolling over behavior of beetles in relation to several objects with different properties was described in detail.

## Methods

A beetle (*Trypoxylus dichotomus*) was placed on the floor in a supine position and an object was set beside it. 14 objects were used in this study: (1) the trench of the floor, (2) a towel, (3) a fan, (4) a pan mat, (5) a piece of newspaper, (6) a toothpick, (7) a thin or thick ribbon, (8) a plastic string, (9) a sheet of tissue paper, (10) a T-shirt, (11) a perilla leaf, (12) a sheet of scratch paper, (13) a chopstick, and (13) the lid of a film case.

## Results and Discussion

The insect was able to roll over taking advantages of several environmental properties; an edge, the texture or the hole of the ground, the weight of an object which affords centrifugal force to insect's swinging motion and the gap between solid objects and the ground. Altogether, we found the emergence of three kinds of environment-action system: (a) a single limb-the ground system (see Fig.1a), (b) a soft object-multiple limbs-the round back-the ground system (Fig.1b) and (c) a hard object-multiple limbs-the round back-the ground system (Fig. 1c).

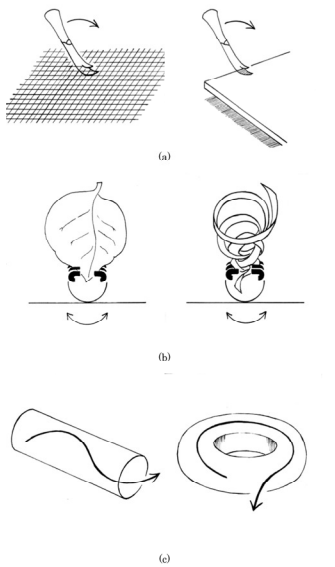


Fig 1.Three action-environment systems observed in rolling over behavior of beetles. a: a single limb-the ground system, b: a soft object-multiple limbs-the round back-the ground system, c: a hard object-multiple limbs-the round back-the ground system

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POSTER

# OBSERVING IDIOM-VARIATION THROUGH DYNAMIC ECOLOGICAL LENSES: LINGUISTIC PHENOMENA AS SHAPED BY THE ORGANISM-ENVIRONMENT INTERACTION

**Torre, E.**

Lancaster University, UK

Mainstream positions in linguistics and cognitive science see language and cognition as purely intracranial affairs (e.g. Fodor, 1975). Nevertheless, more recent approaches focus on them as flexible products of the constant interaction between organism and environment (e.g. Kelso, 1995; Gibbs, 2005). In the present paper, I will introduce the patterns of variation displayed by a selected sample of Italian idioms in comparison to a base-form, empirically detected with the aid of a cognitive-linguistic background (e.g. Croft, 2001; Fauconnier and Turner, 2002; Langlotz, 2006).

On the basis of what observed, I am going to argue that idiomatic constructions can be conceived as dynamic systems governed by a principle of causal circularity (both in ontogenesis and phylogenesis). Indeed, any idiom shows a bundle of formal, semantic/pragmatic, affective, and socio-cultural features working as an attractor (cfr. Cameron and Deignan's 2006 *metaphoreme*) and a motivation pattern functioning as a basin of attraction, which constrain the use of the idiom. Nevertheless, it also shows a trajectory which is constantly shaped by the bulk of interactions between formal, semantic/pragmatic, cognitive, socio-cultural, and contextual factors, in a self-organizing fashion.

I will thus propose that language can be seen as a huge soft-assembling network of interactive dynamic systems standing in a synergic relation of mutual influence with each other and with other facets of cognition, which displays a fractal structure.

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POSTER

# CAPTURING SOCIAL MOTOR COORDINATION: COMPARING THE MICROSOFT KINECT, VIDEO ANALYSIS AND WIRELESS MOTION SENSOR TRACKING

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Recent advances in video camera technology and computer hardware have resulted in a number of low cost gaming systems for remotely tracking human motor behavior. Companion open source code and software development kits that enable the development of recording and analysis software that meet the specific needs of researchers interested in obtaining wireless time-sires recordings of human movement has also made it much cheaper and easier to collect such data. The degree to which these systems can replace expensive 'high end' motion tracking systems, however, is likely to be task and behavior dependent. For instance, differences in the spatial and temporal resolution of low cost systems in comparison to high-end laboratory grade systems could significantly influence the outcome of study. Here we present a comparison of video and skeletal data recorded using the Microsoft Kinect to data obtained using modern video analysis algorithms and data recorded using a high-end Polhemus Latus wireless motion tracking system. By comparing data recordings of various intra- and interpersonal motor coordination behaviors obtained from a study on social motor coordination in typically developing children and children with ASD, we objectively detail the effectiveness of each system for studying joint action and social motor behavior.

POSTER

# CAN PERCEPTION OF AFFORDANCE FOR APERTURE CROSSING IMPROVE IMMEDIATELY AFTER EXPERIENCE?: DISSOCIATION BETWEEN WALKING AND WHEELCHAIR USE

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**Introduction**
Franchak et al [1] demonstrated that experience walking through apertures facilitated perceptual judgment for aperture cross-ability. This was inconsistent with previous research which failed to show an immediate effect of experience during wheelchair use [2]. Franchak et al. explained that perceptual judgment could be improved immediately if actual passage provides opportunities to detect fine differences between passable and impassable apertures (i.e., high-resolution experience). The present study was designed to investigate this explanation under walking (Exp. 1) and wheelchair-use situations (Exp.2).

**Methods**
Forty-nine (Exp.1) and 37 (Exp.2) young adults were randomly assigned to one of three (or four) groups: high-resolution, low-resolution, or control (two controls in Exp.1). For actual passage, they tried to pass through while walking and holding a 69-cm horizontal bar (Exp.1) or while using a wheelchair (66 cm in width); the minimum aperture width was similar in both experiments (about 70 cm). Seven different aperture widths, including their minimum passable width, were presented with 1-cm or 5-cm intervals for the high- or low-resolution conditions, respectively. A fixed, 90-cm aperture (i.e., much wider than minimum passable width) was presented for the control group, whereas for another control group seven different widths with 1-cm intervals (87-93 cm) were presented. Accuracy of perceptual judgment of passable/impassable widths was measured before and after actual passage.

**Results/Conclusion**
The results of Exp.1 showed that perceptual judgment was improved after passage both under the high- and low-resolution conditions. In contrast, no improvement was observed in any condition in Exp.2. These findings seemed to suggest that perceptual judgment improved immediately after actual passage using a familiar form of locomotion.

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POSTER

# RATS PASSING THROUGH APERTURES: A COMPARATIVE ANALYSIS OF AFFORDANCES

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## Introduction

Organisms perceive the actions afforded by the environment (Gibson, 1979); therefore foragers perceive the constraints and opportunities of each situation while searching for food. One constraint is the size of a patch entrance (e.g. a hole) relative to the own body size (e.g. an adult rat). Our hypothesis is that if the aperture of the patch is large enough to go into it, or too small obstructing the entrance, animals will not hesitate to select or to reject that patch respectively. Nevertheless, if the aperture is close to the subject's critical size, animals will inspect that patch before trying to pass through it. The present experiment evaluated the rats' exploration and selection of patches with different low clearance entrances.

## Method

Four male albino rats searched for food within a Radial Arm Maze (RAM). The entries to arms were apertures of different clearances (randomly ranged from 0.4 to 1.8 inches). In order to go into the arms, rats had to squeeze their body and walk through the gap.

## Results

Subjects preferred patches with higher clearance than with lower clearance (Figure 1 left panel); however, subjects inspected more often the patches with low clearance (Figure 1 right panel).

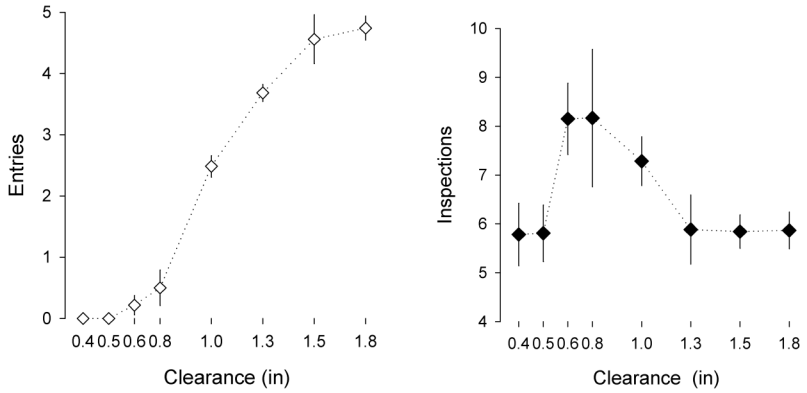


Figure 1. Left panel shows the average number of entries as a function of clearance height, right panel shows the average number of inspections made before choosing a patch.

**Conclusions**

Results confirmed the hypothesis that animals explored more often the entrances close to their absolute critical size (0.6, 0.8, and 1.0 inches), than those narrow gaps impossible to go through them (0.4 and 0.5 inches), or those high clearances that allowed pass comfortably (1.3 to 1.8 inches). These results obtained with non-humans animals extend the findings and theoretical implications described by research about affordances for humans (e.g. Warren & Whang, 1987).

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POSTER

# PROPIOCEPTION AND SPATIAL MEMORY IN TODDLERS

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## Introduction

In the sandbox version of the A-not-B search task, children observe a sandbox surface while searching for an object previously buried at two different locations (A and B). Searching for a hidden object in the absence of visual cues would show how children use propioceptive information in this type of task, a topic that has not been investigated so far.

## Method

In the present study, a group of 41 two-year-old children (mean age = 30.2 months, SD = 2.1) reached six times for a toy buried at location A and then one time for the same toy burried at location B (A-B Condition). A curtain was placed in front of the children's eyes to prevent the use of visual cues while searching. Another group of 20 two-year-old children (mean age = 30.7 months, SD = 2.7) searched for the toy once at location B (B-only Condition). After a 10-s delay, in a final trial children from both groups were encouraged to reach under the curtain and find the buried toy.

## Results

In the A-B Condition, the response distribution showed three main peaks: a major peak toward the midline, another peak close to location A, and a third peak between the midline and location B. In the B-only condition, the response distribution showed one major peak close to the midline of the sandbox. In no case were responses observed at location B (see Figure 1).

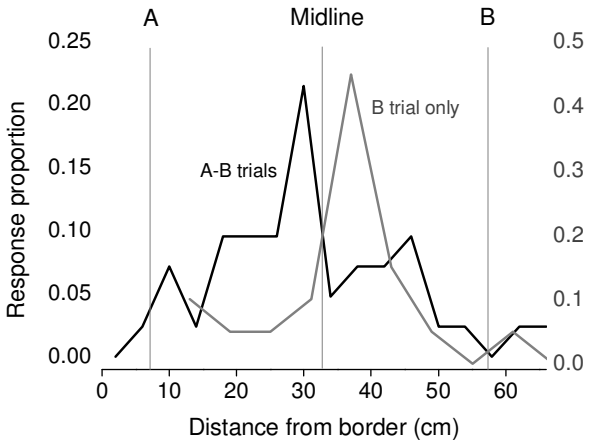


Figure 1. Response proportions in the A-not-B sandbox task. The black curve indicates the response distribution from the A-B Condition (corresponding to the left y-axis). The grey curve indicates the response distribution from the B-only Condition (corresponding to the right y-axis).

**Conclusions**

1. Most two-year-old children responded toward the midline between A and B.
2. Children did not respond at location B. In a previous study with two-year-olds and the same sandbox, but in which search responses were visually guided, the response distribution showed a major peak around B [1]. Thus, our results suggest that in the absence of visual cues, children do not use the propioceptive information provided by their responses around B to remember that location.
3. A response peak close to A was observed, which suggests that the six successive reaches for the toy at location A generated propioceptive information that permitted some children to return to this location.

**References**

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POSTER

# EFFECTS OF PEN DESIGN ON GAZE AND POSTURE IN HANDWRITING

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## Introduction

The design of writing implements is important to handwriting because it affects not only the control of hand movement but also eye gaze and body posture [1]. In this study, I manipulated the position or availability of a rubber grip for participants writing Japanese Hiragana or Arabic letters, and analyzed eye gaze and head posture during the task.

## Methods

Four right-handed adults (2 men and 2 women) participated in this experiment. Each participant was asked to sit behind a desk and trace examples of Arabic or Hiragana letters. An eye tracker (EMR-9, nac Image Technology) was placed on the participant's head to record eye gaze, and 12 infrared cameras recorded their head orientation.

## Results

Figure 1 shows examples of eye movements while tracing Arabic and Hiragana letters. The fixation point in Arabic moved along the letter, whereas the fixation point in Hiragana was on the center of the letter. A letters (Arabic/Hiragana) × grip position (bottom/center) × availability of rubber grip (with/without) ANOVA for head orientation was performed. Participants' heads seemed to be rotated more to the left in writing Hiragana letters when the grip was in the center position compared with the bottom grip position ($F(1, 3) = 8.23$, $p < .10$) (Figure 2).

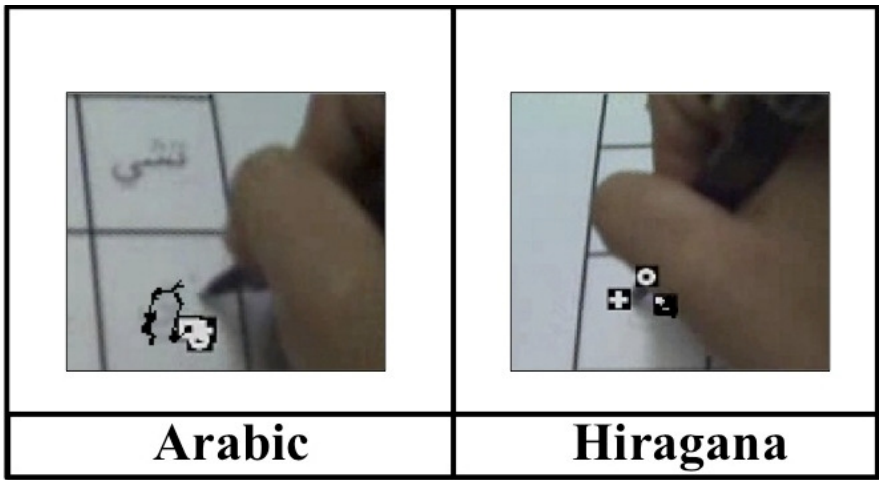


Figure 1. Examples of eye movement during letter tracing

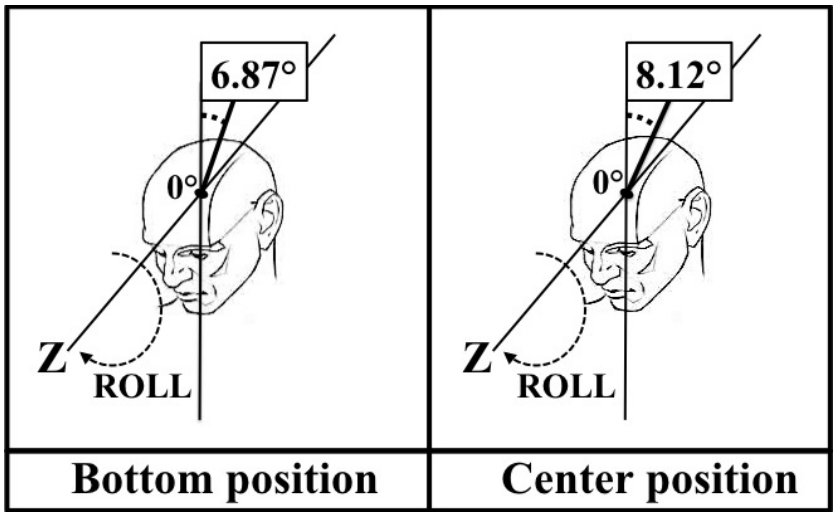


Figure 2. Head rotation while tracing Hiragana.
Left: the rubber grip on the bottom of the pen shaft.
Right: the rubber grip in the center of the pen shaft.

**Conclusions**

Gaze and head posture seem to be influenced by the design of writing implements.

**References**

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POSTER

# PERCEPTUAL-MOTOR LEARNING AND SENSORY SUBSTITUTION

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## Introduction

Sensory substitution devices are designed to transform information of one perceptual system into information for another perceptual system. Most of these devices use visual to tactile transformations and are directed towards visually-impaired people. Earlier devices such as the TVSS were aimed at object recognition but later most devices have been developed to solve the mobility problem in the blind. With a visual to tactile device, Díaz et al. [1] showed, first, that it is possible to detect a platform one meter away and second, that exploratory movements allow more accurate performance. The main goal of the experiment presented here is to know: (1) if it is possible to step on a ground-level target wearing a partly-virtual sensory substitution device on the leg, (2) if performance increases with training, and (3) if different training conditions have a different effect on performance.

## Methods

The sample was composed of twenty participants divided into two groups. They wore a device on the lower leg, consisting of a vertical array of 32 actuators that vibrated as a function of the distance to the first-encountered object. A four cameras motion tracking system (Qualisys, Inc.) detected the position and orientation of participants. The task consisted of walking through an exploration area until participant encountered and stepped on the target obstacle. Six distances and six heights were used for the obstacles. Both groups performed the pretest and the posttest blindfolded. One group could see during the four training sessions but the other group trained also blindfolded.

## Results

The percentages of successful trials were of about 50% or higher for all groups, in pretest and posttest. The amount of successful trials increased after training and kinematic variables such as the average velocity and fluidity during the last step improved from pretest to posttest ($F(1) = 17.644$, $p < .001$ and $F(1) = 5.031$, $p = .038$; respectively). In the posttest, the amount of errors was greater in the vision training group.

## Discussion

We conclude that it is possible to answer affirmatively to (1), (2) and (3). Although our device is useful for performing the task, technological features have to be improved (portability, accuracy, etc.) to be an extended aid to mobility for the blind.

## References

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*Acknowledgments*. The research reported here was supported by the Spanish Ministry of Economy and Competitiveness via project FFI2009-13416-C02-02.

POSTER

# SOCIAL AFFORDANCES: LAW-LIKE INVARIANTS OR SELF-ORGANIZED LONG-TERM HABITS?

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The aim of this work is to investigate possible contributions and potential problems arising from use of the concept of social affordance in the ecological approach to social interaction. By social affordance is meant the dispositional properties of niches, namely the possibilities of action provided to organisms by other organisms that share common evolutionary histories (Gibson, 1986; McArthur & Baron, 1983). According to McArthur & Baron (1983), in the same way that the perception of a windmill reveals structural and transformational invariants, the anatomy of agents, their physiological properties, and the dynamics of actions also reveal invariants. Here, the structural invariants of social affordances are the bodily form of the species and the characteristics of the niche that enables its survival. The transformational invariants of such social affordances concern perception of the dynamics of movement of the organism in activities such as nurturing, friendship, and response to threat. However, if the concept of social affordance supposes the existence of law-like structural and transformational invariants, what might be its explanatory capacity when faced with complex context-dependent social situations? In the case of human social affordances, in addition to basic manifestations of emotion (such as fear, happiness, or anger), the meaning of which is directly perceived, there are facial expressions and gestures that are culture-specific, whose meanings can differ between cultures. We argue that the Theory of Self-Organization (TSO) can enrich the ecological approach to social action. From the perspective of TSO, such action may result from self-organized processes, whether by means of primary self-organization (Debrun, 2009), from which emerges a spontaneous dynamic interaction of distinct elements, without the control of an external supervisor, or due to secondary self-organization, which occurs when a system acquires stability and increases in complexity as a result of learning, creating collective habits with different duration and plasticity.

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POSTER

# SEARCHING FOR THE UNAMBIGUITY OF ACTION AND INFORMATION IN THE PENALTY KICK

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## Introduction

To succeed in time in the penalty kick (PK), goalkeepers need to guide their actions with information detected before ball contact. The orientations of the non-kicking foot and hip of the penalty taker are reliable sources of local information for the horizontal ball direction[1,2]. Diaz et al. also reported global or distributed information as being useful. Penalty takers try to reduce the usefulness of such variables by means of deceptive actions. Interestingly, some features of the kicking action are needed to accomplish a specific ball direction. The inability to produce a completely deceptive movement is sustained by the principle of non-substitutability of genuine action[3]. This study aims to determine (1) the usefulness of local and distributed kinematic variables and (2) the influence of deception on the usefulness of these variables.

## Method

Participants were 12 professional and semi-professional penalty takers ($M_{age}$=21.2; *SD*=4.6) and 5 goalkeepers ($M_{age}$=17.4; *SD*=0.9). A 2 (left vs. right shot direction) x 2 (deceptive vs. non-deceptive condition) experimental design was applied. Each penalty taker took 60 PKs. Penalty takers' kinematics were registered. The 3D coordinates were exported to MatLab and the values of the kinematic variables were computed from 1.5 s before until 0.5 s after ball contact. Correlation and regression analyses were applied to determine the relation of the kinematic variables with the horizontal direction of the ball.

## Results

Several lower-body kinematic variables (e.g., the orientation of the non-kicking foot) showed substantial correlations with ball direction ($r$=0.7). Multiple regression models correlated higher with ball direction than individual variables (up to $r$=0.9). Kinematic variables related to the upper body (e.g., shoulder angle) were influenced by deception, with lower correlations in the deceptive condition.

## Conclusions

Useful sources of local information can be found especially in the lower-body kinematics. Moreover, distributed variables have superior predictive capacity than local variables. Although penalty takers can disguise their action, they are unable to do so for some local kinematic variables at the final moments before ball contact. This supports the principle of the non-substitutability of genuine action.

## References

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POSTER

# EXPERT EXERCISERS CREATE SETTINGS THAT CLAIM FOR EXERCISE BEHAVIOR

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Universidade Técnica de Lisboa, Cruz Quebrada Dafundo, Portugal

According to Nigg et al.[2], Physical Activity (PA) maintenance is an active process, requiring individuals to actively utilize strategies and techniques for continued adherence to PA. These authors presented the PAM model to better understand the long term PA maintenance. Even though, this model tries to integrate individual and environmental aspects, the explanatory power of behavior is centered mainly on the individual.

The aim of this research was to identify how the behavioral habits and personal strategies of PA are supported by environmental properties. This exploratory study followed an interview method that combined both the variables of the PAM model with environmental features that characterized the PA behavior settings[3]. In a preliminary study both intrapersonal fidelity and interview script validity were tested. To calculate the content and construct validity we asked to an expert panel to assess the coherence between the concepts and the variables operationalized by the script.

The interviews were carried out face-to-face to 4 exercisers: healthy adults, employed, physically active for over 10 years of deliberate practice[1]. The interviews lasted for 60 min maximum.

Preliminary results show that expert exercisers find strategies to overcome family, working, social and environmental barriers and in the most case anticipate them to get exercised.

We observed that expert exercisers do not recognize barriers as such but rather as mishaps to overcame. Exercisers coordinate daily routines, the commitments of work and family to perform maintain their practice. It seems that there is a correspondence between the behavioral and psychological strategies and the circumstances that claim for them.

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POSTER

# INTERPERSONAL SYNCHRONIZATION IN A TRIADIC BALL BOUNCING TASK

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## Introduction

Studies of dyadic interactions have shown that actors spontaneously synchronize their movements even when not specifically instructed (Schmidt et al, 1990). These linked perception-action systems use information transfer to soft-assemble the coupling (Riley et al, 2011). At present it is not clear how different information modalities affect coupling strength and what effects on coupling the presence of additional actors have.

## Method

30 participants randomly assigned to one of ten triadic groups took part in the study. Participants were instructed to bounce a standard basketball in five different conditions: 1) EIG: participants bounced on their own, 2) NOAU: participants wore headphones emitting white noise, 3) NOVI: no visibility of other participants, 4) NOAUVI: NOAU + NOVI, 5) FREE: participants could hear and see each other. Syncrograms for each condition and participant combination were calculated (Pikovsky et a., 2003) and the number of synchronous bounces was assessed.

## Result

Syncrogram plots suggested that periods of dyadic synchronization alternated with desynchronized periods. Only a single instance where all three actors were synchronized was observed. Statistical testing indicated significantly greater synchronization during FREE compared to all other conditions. Further, differences between NOAUVI and EIG, NOAUVI and NOVI reached statistical significance.

## Conclusion

The present results show that actors in triadic interactions spontaneously synchronize their actions with each other similar to dyadic interactions. The interactions are soft assembled and vary over time depending on the available information resources. Thereby, constraining information resources results in decreased synchronization. In contrast to dyadic interactions however, during triadic interactions synchronization does not spread across the whole group but time-varying sub-groupings are assembled. Thus, synchronization phenomena observed during dyadic interactions may constitute a special case and further research with more actors is needed.

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POSTER

# DOES EXPERIENCE AND FUNCTIONAL CONTEXT INFLUENCE HAPTIC PERFORMANCE?

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**Introduction**
Fencing is a sport that involves aiming at a target (eg. the opponent's body) using a hand held tool (eg. the sword). During the performance of such task, vision is typically directed to targets, making the perception of the tool´s extent by dynamic touch critical for the organization of appropriate strategies in order to meet the action's goal. The aim of this study was (1) to assess whether fencers, compared to untrained individuals, have better abilities to judge the extent of rods without visual aid and (2) to assess whether the context in which this perceptual ability is evaluated affects the performance.

**Methods**
Eleven fencers and twenty non-fencers subjects performed two perceptual tasks. A total of nine wooden rods with lengths varying from 70 to 110 cm were used by the participants during the performance of the tasks. In Task 1, participants were asked to hold each rod, without seeing it, move it and estimate its length, without a specific functional purpose. In Task 2, still without seeing the rod, participants simulated a fencing attack with a clear functional goal: to align the tip of the rod to a target presented in their visual field. The dependent variable was the error in the judgment of the rods' length, computed in Task 1, as the deviation of the rods' actual length and, in Task 2, as the distance from the rod's tip to the target.

**Results**
Analysis of variance revealed no differences in perceptual performance between groups in both tasks ($p > 0.05$). However, participants achieved better results in Task 2 compared to Task 1 ($p < 0.001$).

**Discussion/Conclusions**
Level of expertise in a particular skilled activity involving aiming at targets does not seem to improve the accuracy of length perception. Experience with the many everyday, mundane activities involving manipulation of objects seems to be sufficient to fully develop and refine this perceptual capability. On the other hand, accuracy of length perception improved when awareness of this object property had direct functional relevance to action organization. This result suggests that contextual constraints influence perceptual performance.

POSTER

# BIOMECHANICAL FACTORS AND TURNING PREFERENCE IN CHIILDREN

**Covarrubias, P., & López J.O.C.**

Laboratory of Comparative Cognition and Behavior, University of Guadalajara, Mexico

## Introduction

Turning preference is mainly related to genetic factors (i.e. laterality). However, the contribution of biomechanical variables on turning behavior in the childhood has not been investigated so far. In this study we compared biomechanical (balance, and strength) and genetic factors (handedness, and footedness) as predictive variables for directional preference (turning right or left).

## Method

Participated forty, 4-year-old children (50% girls) (mean age = 53 months, SD = 3.8 moths). We measured the strength of each leg, and the time that children were standing on each leg (balance). Additionally, we registered two dimensions of lateralization: handedness and footedness. Then, children were asked to run by a 5.4-m length runway, and return to the starting point by the left or the right side of the runway.

## Results

Figure 1a shows that a higher number of children turned left when their strongest leg or that with the greatest balance was the right leg. Figure 1b shows that a greater number of right-handers and right footers children preferred turning left than right in the runway. However, this was not the case for non-right-handers/footers.

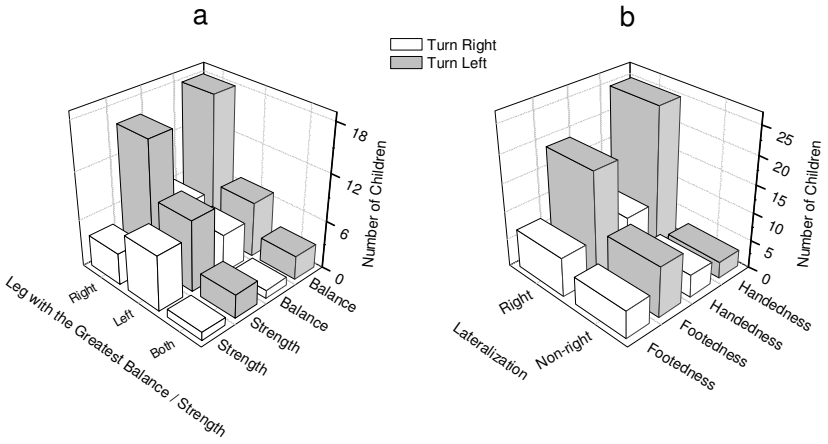


Figure 1a. Number of children turning left or right as a function of the leg with the greatest balance or strength. Figure 1b. Number of children turning left or right depending on their handedness or footedness.

**Conclusions**

1. In this task, children preferred turning left than right, which extend the generality of the leftward bias under a running situation previously reported with adults [1, 2].
2. Both, biomechanical and genetic variables were related to children's turning preference.
3. Results are discussed in terms of the perception of opportunities for action (affordances).

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POSTER

# THE CONTRIBUTION OF SENSORY INFORMATION ON THE UNINTENTIONAL SYNCHRONIZATION OF SIDE-BY-SIDE WALKERS

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## Introduction

When people walk side by side, lower limb kinematics often become unintentionally synchronized. This interpersonal coordination can be modelled by weakly coupled oscillators (i.e., dynamical systems). The coupling strength is partly determined by perceptual information, wherein visual seems to dominate over auditory input (Demos, Chaffin, Begosh, Daniels, & Marsh, 2012). No differences were found between auditory and visual input when synchronizing during walking. Yet, most studies focused on few parameters, gathered walking samples on treadmill, and manipulated sensory input insufficiently (Nessler & Gilliland, 2009). Considering findings of intentional synchronization (Repp, 2004), auditory and visual input should affect gait parameters asymmetrically. The scope of our study is to understand the effect of sensory information provided by the partner's gait on unintentional synchronization of side-by-side walkers.

## Methods

Ten naive participants walked 9 meters by an experimenter's side with preferred velocity and cadence. The participants could hear (i.e., auditory condition), see (i.e., visual condition), hear and see (i.e., bimodal condition) the experimenter walking, or walked alone (i.e., baseline condition). Entrainment (i.e., frequency, phase, and amplitude locking) was assessed and analysed as a time series.

## Results

We expected that seeing leads to more entrainment than hearing. Most importantly, we expected that seeing affects spatial parameters (i.e., stride length) and temporal parameters (i.e., cycle time) while hearing has additional effects on temporal parameters.

## Conclusions

Besides illustrating the contribution of unimodal input and benefits of multimodal integration for strengthening coupling between oscillators, our findings could have implications for the development of rehabilitation methods that use sensory synchronization for improving gait dynamics.

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POSTER

# VIRTUAL PARTNER INTERACTION: A TOOL TO STUDY THE DYNAMICS OF INTERPERSONAL COORDINATION BY MANIPULATION OF VISUAL INFORMATION

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When coordinating one's movement with others, coordinative patterns quickly reach a high level of complexity. Interpersonal coordination therefore requires complex motor control. Continually interacting with another person typically demands online adaptation, and this capacity is based upon an individual's ability to find and couple to the affording information with pertinent response. The underlying dynamics of motor control and skill acquisition for interpersonal coordination have received limited attention to date, arguably due to the lack of a suitable theoretical framework through which one can conceptualise such behaviour.

The framework of ecological dynamics is an ideal lens through which the dynamics of interpersonal coordination can be studied. From this starting point the methodology for the virtual partner studies has been developed [1]. Balancing controllability and repeatability versus experimental manipulation, whilst conforming to the framework of ecological dynamics, has proven a challenging task. A proposed programme of studies involves a 'follow-the-leader' task with a real person [2], a virtual partner and an animated shape. The aim of the task is to attune to the leader's movements, adopting aspects of interpersonal coordination comparable to many 1 vs. 1 sport situations (e.g., man-to-man defence). Maximized controllability and repeatability are secured by creating virtual images to interact with. Additionally, it provides the opportunity to experimentally manipulate the sources of information an individual can attune its movements to [3]. For example, the optical expansion rate can be manipulated, in order to explicate its role for interpersonal coordination. Preliminary data will be included to support the relevance of the methodological framework.

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POSTER

# THE GOALKEEPER AS A PERTURBATION ON DYADIC SYSTEMS IN THE TEAM SPORT OF FUTSAL

**Corrêa, U.C.[1], Silva, S.L.[1], Denardi, R.A.[1], Davids, K.[2], & Tani, G.[1]**

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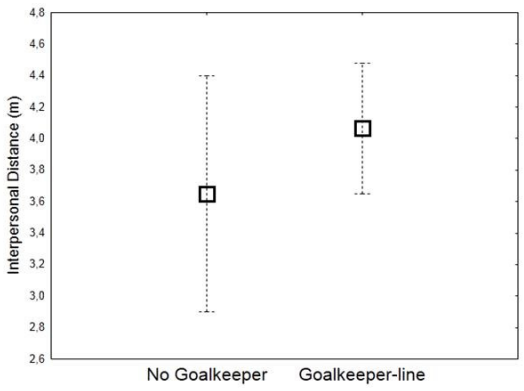
In team sports, the dynamic of the game is a consequence of the attackers' attempts to increase the discrepancy of their actions with those of defenders, while defenders seek to do the opposite (Corrêa et al., 2012). The coupling of the actions of attackers and defenders characterizes a dyadic subsystem in team sports, as a basic unit of analysis for investigating the spatiotemporal dynamics of competitive performance (McGarry, 2009). This study sought to investigate the dynamic of dyadic subsystems in the team game of futsal by considering the goalkeeper's actions. It is common in the final moments of competitive games that a losing team's goalkeeper plays as an outfield player in order to provide an overload in attack. We sought to understand how this information affected the players' behaviors in a dyadic subsystem.

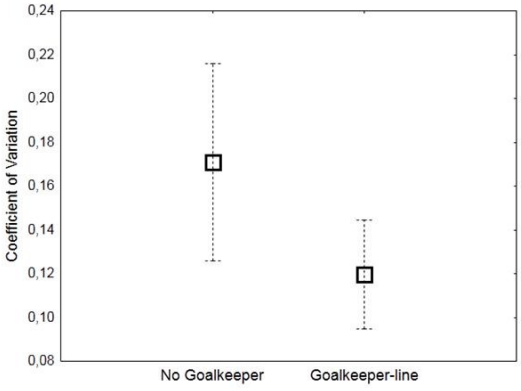
**Method**

All attacking moves involving goalkeeper (n = 30), and the preceding and proceeding attacks (controls) (n = 8) were selected from digital video footage of the final of the Futsal League in Carapicuiba, SP-Brazil. Twenty-three male amateur players (M = 26.24, SD = 3.34 years of age) participated in this game. The players' displacements were analysed by TACTO software. Interpersonal distance values between attackers and defenders (mean) and their variability (coefficient of variation) were used as intra-dyad measures.

**Results and Discussion**

Results indicated that when a goalkeeper played as an outfield player, the value of interpersonal distance increased and its variability diminished in dyadic systems on court. It seemed that the presence of a goalkeeper perturbed dyadic subsystems and led them to reorganize themselves into a different dyadic pattern.



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POSTER

# PREVIOUS EXPERIENCE IN LOCOMOTION WITH BABY WALKER DO NOT IMPROVE DE PERFORMANCE OF TODDLERS TO CLIMB SLOPES AFTER INDEPENDENT GAIT NSET

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## Introduction

Exposure to environmental information is central to the acquisition of independent gait (Gibson & Pick, 2000). In addition to the development of motor capabilities, gait acquisition involves perceptual learning, which is specific to the action being performed (Adolph, 1997). Early experience of upright mobility as well as locomotion-related visual information can be gained with the use of baby walker, prior to the acquisition of locomotion (Dogan et al., 2009). The aim of this study was to investigate whether the use of baby walker prior to gait acquisition impacts positively on toddlers ability to climb slopes, compared to toddlers that were not exposed to such experience.

## Methods

Using Karen Adolph's ramp climbing experimental paradigm, 32 toddlers concluded this longitudinal study (16=baby walker group; 16=control group). The task of climbing slopes of different inclinations (angles) was assessed monthly from gait acquisition up to six months after gait onset. Data were analyzed using two ratios: (a) the success ratio (SR), which divides the number of toddlers' success in climbing slopes of different angles, by the total number of trials, and (b) the go-ratio (GR) representing the number of trials that the toddlers tried to climb, with success or failure, divided by the number of trials. Also, groups were compared on the maximal degree (angle) they were able to climb.

## Results

Results did not show differences between groups, but toddlers' changes across time (time effect) reached significance in the SR and degrees.

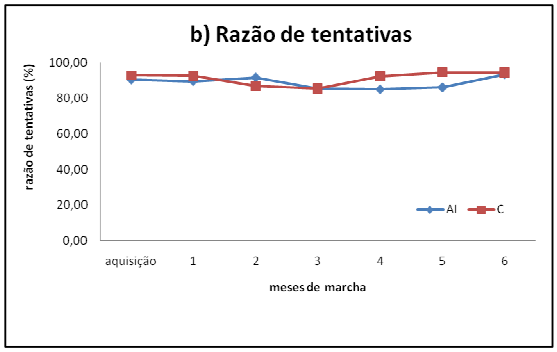


Figure 1: Group comparison on go-ratio

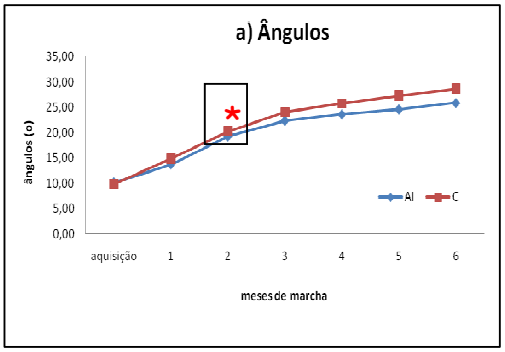


Figure 2: Group comparison on angles

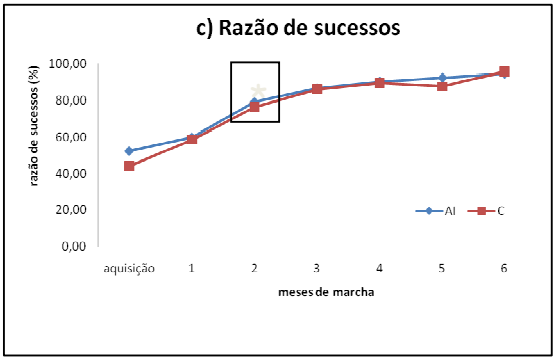


Figure 3: Group comparison on success ratio

## Conclusions

Our results help support the specificity of experience for the development of locomotion. Upright transversal the environment prior to gait acquisition by means of baby walker use does not contribute to climbing slopes of steeper angles.

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POSTER

# AN EXAMINATION OF RETROACTIVE AND PROACTIVE INTERFERENCES IN OLDER ADULTS

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## Introduction

Research in young adults has shown two kinds of transfer of learning for sequential motor tasks: *retroactive interference* in which learning a new motor pattern influences performance on a previously learned pattern, and *proactive interference* where a previously learned motor pattern affects the learning of a new pattern [1]. This study has two aims; i) to assess transfer of learning in a real-life repetitive assembly task; ii) to assess transfer of learning in older adults (given decline of memory functions with ageing [2]).

## Method

20 young and 20 older adults practiced to assemble an object consisting of five components. On the next day, they practiced a similar object with the same reorganized components. Finally they assembled the original object again. Accuracy and movement time served as dependent variables.

## Results

ANOVAs show that only among the older adults accuracy of assembling the first object was degraded after having learned the second object. In fact, the younger adults were faster in assembling the first object after learning the second object. After practice, both age groups were faster in building the second object than in building the first one, but showed slightly less accurate performance for the second object.

## Discussion

First, the younger adults did not show retroactive interference; if anything performance on the earlier learned motor pattern benefited from learning a new pattern. It might be due to nonsequence-specific motor learning being more important (and lasting longer) in real-life tasks than in the previously investigated task [1]. Second, older adults showed strong retroactive interference, which might be related to decline of memory functions. Finally, proactive interference was negligible among the young and older adults.

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POSTER

# EXPERIENCE IN THE CLAY TOPOS REFLECTED IN CHILDREN'S DRAWING

**Maeshima, H.[1], Nonaka, T.[2], & Kimura, S.[3]**

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## Introduction

The first author has installed 0.8 tons of soil clay in a room—called "the Clay Topos" in June 2007 in a nursery in Japan (Takahashi Chuo Nursery), where children can play freely with a large quantity of clay throughout the year. One of the goals of the Clay Topos is to to encourage the imagination and spontaneous activities of children through free play surrounded by the vast amount of soil clay. Currently, infants from 0 to 6 years old are participating in the project. In the present study, we asked what affords the imagination of children, and compared the pictures drawn by children in different settings.

## Methods

16 children (5 years old) participated in the study. We compared the imaginative pictures drawn by children between the following three conditions: (1) after playing in the Clay Topos with 300 kg of clay, (2) after playing with the small amount (1 kg) of oil clay, and (3) without playing with clay. In the two clay play conditions, before playing, the teacher asked children what kind of bread there are at the bakery. After playing, children were encouraged to draw what kind of breads are at the bakery. In the without clay play condition, teacher simply asked children to draw what kind of breads are at the bakery.

## Results

Three kinds of drawings showed different characteristics. (1) After playing with 300kg soil clay in the Clay Topos, the picture often included the child herself as a baker, taking one's place among the depicted things. (2) After playing with 1kg of oil clay, the picture tended to be drawn from a rather objective point of view. (3) In the without clay play condition, pictures of the bread tended to be flat, stereotyped, and conceptual and the agent of bread making was often absent.

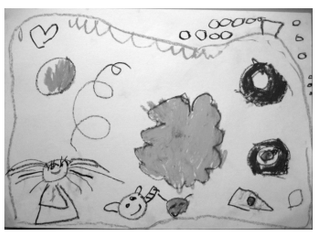

Figure 1. 300kg soil clay.

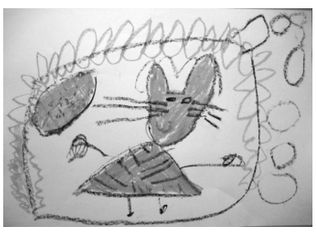

Figure 2. 1kg oil clay.

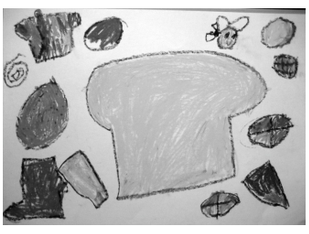

Figure 3.No clay play.

## Discussion/Conclusions

The results of the present study suggest that the imagination of children may be grounded in concrete experience[1]. The study implied the possibility that what child experience in the world may encourage the rich imagination of children.

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POSTER

# SELECTION AND DIFFERENTIATION OF PLACES BY TODDLERS DURING FREE PLAY IN THE CLAY TOPOS

**Nonaka, T., & Maeshima, H.**

Kibi International University, Japan

## Introduction

We all fit into the substructures of the environment in our various ways. [1] Through selection and differentiation of these substructures that occur different temporal scales ranging from behavioral to evolutionary scales, our everyday life has been increasingly structured into diverse meaningful patterns. In the present study, we studied the nature of the forces that cause such structuring of activities and differentiation of places by different activities at the micro temporal scale of toddlers' free play. The study was conducted at "the Clay Topos", where 0.8 tons of soil clay was installed in one of the rooms of a nursery (Takahashi Chuo Nursery, Japan), in which children can play freely with a large quantity of clay.

## Methods

Three square-shaped lumps of soil clay (90 cm by 90 cm, 15-cm thick) were placed in a row on the floor approximately one meter apart from each other in the Clay Topos. A group of children (consisting of 10 to 15 children) were invited in the room to play freely. Nursery caretakers interacted with children as they normally do. The activity of children was observed twice: the first-time experience with the Clay Topos and the 6 months after. The three age groups participated in the study: (1) 5 - 17 months old, (2) 14 - 26 months old, and (3) 26 - 38 months old at the time of the first observation. The streams of activity during the first 30 minutes of play were coded in terms of (1) place where a child plays, (2) change of place, (3) affordances of clay realized, (4) interaction with caretakers, and (5) interaction with other children, using ELAN software (www.lat-mpi.eu/tools/tools/elan).

Figure 1. The 14-26 months-old group in the experiment.

**Results and Discussion**

The preliminary observation of the second group (14 - 26 months old) found that change of place that occurred during play often accompanied locomotion toward a caretaker and transportation of objects, through which the place where the object (clay) is retrieved (e.g., a lump of clay or the location of a caretaker) and the place where the object is transported got gradually differentiated. Interactions with other children were rarely observed before 26 months old.

**References**

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POSTER

# MOBILE AUGMENTED-REALITY APPLICATION FOR CHILDREN'S DAILY ENVIRONMENT DURING THE FIRST YEAR OF LIFE

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## Introduction

One of the basic human requirements is the need to adjust to daily situations—a central human act comprising complex and unique human activity and that involves motoric, perceptual, and conceptual processes. This paper presents a functional approach toward visualizing the developmental resources available in children's indoor environments during the first year of their lives.

A novel method for infants to perceive and interact with the world will be made possible through a mobile application that uses augmented reality (AR). First developed over forty years ago, AR is a type of technology that enables virtual content to be seamlessly merged with the real world [1]. AR enhances a user's perception of and interaction with the real world [2]. Further, AR for mobile phones is one of the biggest and fastest growing research areas in AR [1] [3]. While mobile AR has become commonplace, there is a need for more research on adapting this technology to daily and basic experiences.

In this study, mobile AR is used in a psychological context to assist in designing layouts for indoor environments. This psychological approach is based on Gibson's theory of affordances [4] [5], which unites our understanding of action, awareness, and knowledge between the self and the environment. The purpose of this study is to create an AR application on the iPhone and iPad that will demonstrate the affordances of children's indoor environments in the first year of life.

Gibson [4] [5] defines the law of surface layout as the size and level of environmental enclosures and environmental objects. As he points out, differently shaped enclosures afford different possibilities of inhabitation. Moreover, differently shaped solids afford different possibilities of behavior and manipulation. This prototype application examined children's perceptions and actions toward objects and room layout in floor plans, by creating a mobile AR iPhone and iPad application. In the form of short animations, it displays children's actions toward various objects by placing a marker in any real floor plan and capturing the activity on a mobile phone camera. This application will provide the foundation for anyone interested in researching and designing children's environments.

## Methods

*Development process*: Marker design and mobile application development
The development process is divided into two phases: (1) Designing the marker recognition using OpenCV. The marker is 15 mm × 15 mm and is illustrated using Adobe Illustrator. (2) Writing the iPhone and iPad application using Objective-C. The application's GUI and user interaction were developed using Objective-C.

*Augmented images (animation)*: Augmented images were created from the longitudinal observations of two healthy, male Japanese infants. Both were observed in their respective houses in Japan during their first 18 months. Each family used a digital video camera (DCR-TRV18K; Sony Corp.) to record their child's home environment on a weekly basis. There were no specific tasks or controls imposed on the infants during this recording. In this study, the observation period extended from 4 to 12 months. For K and D, the total recorded time was approximately 45 hr and 31 hr, respectively. Sketches were made from the videos of the two infants' daily actions in their home environments for 12 months, and these sketches were

scanned and converted into line drawings using Photoshop CS5; they were saved as 448 px × 336 px images. The sequences were animated in Photoshop CS5 using the Animation Timeline and exported as QuickTime Movies.

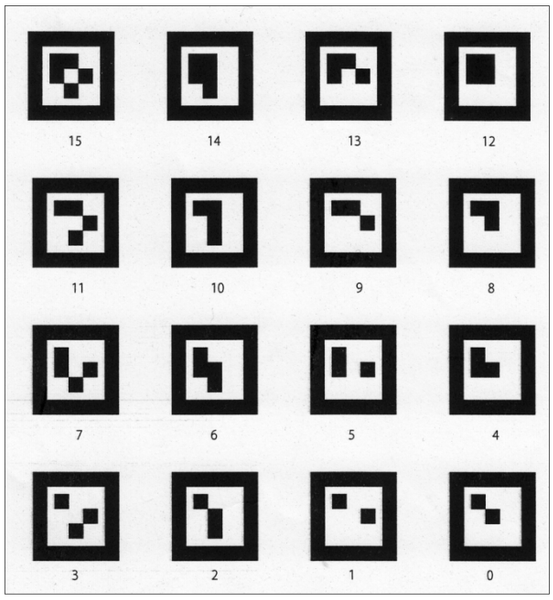
**Results**

This study proposed an AR application prototype for iPhones and iPads that can visualize the affordances of children's indoor environments in the first year of life. On the basis of the observations, we extracted two pattern objects: detached objects and attached objects related to the room layout in the houses (Table 1). In this prototype application, we extracted five pattern objects—sofa, table, door, wall, and cabinet—as samples.

Table 1. Classification of components in a house

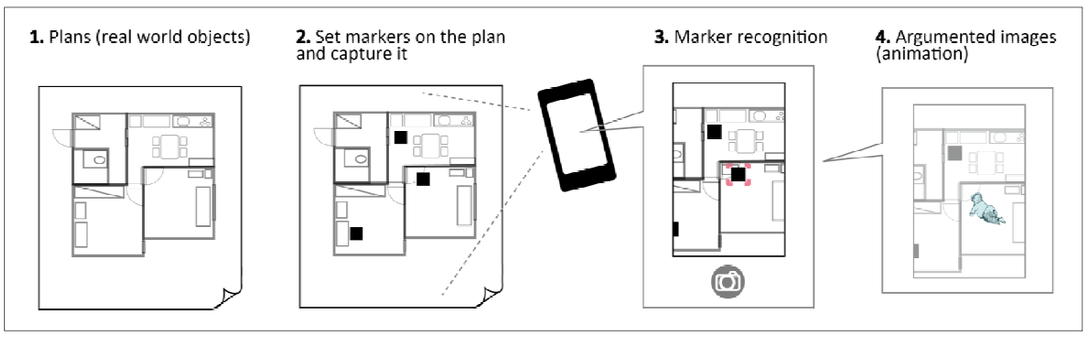
| Type of object | Name | Detail |
|---|---|---|
| Detached object | furniture, equipment | Sofa, table, chair, stove, TV, refrigerator, cabinet, closet, cupboard, curtain, sheet, towel, mat, cushion, carpet, futon, quilt, tatami mat |
| Attached objects | enclosures, corners, aperture, steps | Door, window, threshold, rail, wall, bathtub, steps, sink |

With regard to marker recognition, we utilized a 2D matrix marker—a square-shaped dot (2.5 mm × 2.5 mm)—that could identify an object on a plan using a combination of markers and the iPhone or iPad camera. We created 15 pattern-marker codes (Graph 1) that could be attached to real-world objects on plans at virtually no cost, since the marker codes can be printed using regular laser or ink-jet printers.




Graph 1. Fifteen pattern markers (sample)
Marker size is 15 mm × 15 mm (inside dimension: 10 mm × 10 mm).

The overall information flow of the system is illustrated in Graph 2. The marker uses a square-shaped barcode dot that can identify 216 different objects. The AR system recognizes these codes from the captured camera images.




Graph 2. Overview of the proposed AR mobile application prototype
The procedure was conducted in four phases: (1) Set an architectural plan, (2) Set markers on the plan and capture them using the iPhone or iPad camera, (3) Recognize a central marker, and (4) Create an animation on the basis of the 12 months' data.

**Discussion/Conclusion**

Augmented reality, with its ability to combine real and digital information, is being studied and implemented in medicine, marketing, museums, fashion, and numerous other areas [6]. This AR application prototype can be based on any plans including private housing, housing projects, senior residences, and commercial buildings. Furthermore, if there is enough room to paste markers, users could paste real objects at any place within the plan. This prototype application presents the possibility of expanding a user experience within an educational field, particularly the study of design from the context of ecological psychology.

From a usability perspective, a marker-based system would be more suitable for users in different situations. It is also necessary to gather more data about children's actions by sharing this prototype. The goal is to create AR applications for children that allow users to gather augmented information as they capture the surrounding real objects (furniture, door, steps, etc.) without any markers in their daily lives.

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POSTER

# AGE AND AFFORDANCES IN ARM REACHING

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## Introduction

Several studies reveal that with aging there is an increase in biomechanical constraints affecting daily activities of the life of older adults, such as when reaching for objects with the arms. This experiment assessed the effect of aging on the preferred critical boundary of reach actions.

## Method

Sixteen older adults and 16 college students (mean age 70 and 19 years old, respectively) reached for a plastic block placed on a table at different distances in a discrete trials procedure. The distances to which the block was placed were defined in terms of every actor's absolute critical boundary. Trials were videotaped and the action modes used by the actors when reaching were registered.

## Results

As expected, reaching modes changed their distribution orderly as a function of the distance of the block. The reaching mode changed from using only arm extension to using the shoulder or upper torso at closer distances than each actor's absolute critical boundary, replicating previous results. Older adults changed the distribution of their reaching modes at closer distances than college students (see Figure 1).

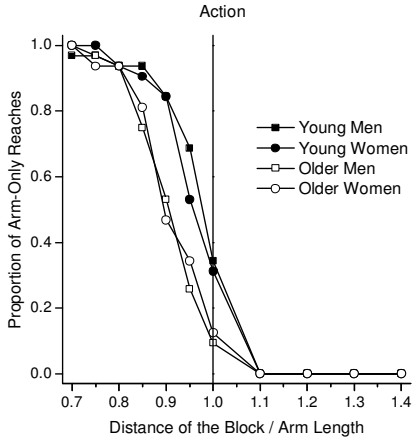


Figure 1. Proportion of arm-only reaches as a function of the distance of the block expressed in π numbers.

## Conclusions

These results support the conclusion that the choice of the reaching mode is influenced by the actor's arm length, muscular strength, and joint flexibility. Future studies should propose models that account for biomechanical differences in reach actions. These data could be useful for the development of standards for sizing work surfaces for older adults.

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POSTER

# HAPTIC PERCEPTION OF PHYSICAL AND FUNCTIONAL PROPERTIES OF RACKETS TABLE TENNIS AND BADMINTON IN CHILDREN AND ELDERLY

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The haptic perception affords detection of physical and functional properties of a sport instrument actively sustained without visual information [1, 2, 3, 4]. However, the objects' length estimation increases with its weight [8]. The eigenvalues are values that can represent the resistance to the action of lifting and moving an object wielded. These values are obtained via a symmetric 3x3 matrix, whose large diagonal quantifies the moments of inertia, reflecting the possible asymmetric mass distribution of the object [5], and, consequently, instrument properties haptically detected by the actor.

The purposes of this paper is: i) to analyze eigenvalues expression for different rackets properties and actors morphologies; and, ii) to verify the influence of rackets' weight and length in the participants' estimations.

**Method**

The sample consisted of 57 children (8.82 ± 0.38 years, 31 boys and 26 girls) and 64 elderly (71.3 ± 4.46 years, 19 men and 45 women). Informed consent was obtained from elderly and relatives of children, and, assent was obtained from children. The sample was divided in two groups, one for analyses of weight influence, another for analyses of length influence.

The protocol was similar to [3]. Participants held in their right hand rackets, hidden by a curtain, with the forearm supported, and, estimated two locations: i) the length of the rackets; and, ii) at what distance they would hit the ball (Figure 1).

Figure 1. Experimental context.

Each participant performed one trial per condition with three rackets: a *light* Tennis Table (length - 26,2cm, weight - 97g, percussion – 18,1cm), a *heavy* Tennis Table (length - 25,7cm, weight - 176g, percussion – 18cm), and a Badminton one (length – 66,3cm, weight - 95g, percussion – 54,2cm). The light Tennis Table and Badminton rackets had similar weights. The participants did not know what object they sustained. The order of presentation of rackets and estimates of the locations were

alternated between participants. The pulse width and depth of each participant, and the distance of the joint center to the center of mass of each racket were collected. Based on [5, 6, 7] the eigenvalues were estimated.

**Results and Discussion**

Eigenvalues obtained sustained the theoretical model of [2] (Table 1and 2). Moments of inertia, products of inertia and consequently eigenvalues were different in the two age groups; which highlight the interaction between intrinsic and extrinsic constraints.

Table 1. Eigenvalues estimated for length of Table Tennis and Badminton rackets.

| **Weight Factor** | | | | | | |
|---|---|---|---|---|---|---|
| Racket | *Light* Table Tennis | | | *Heavy* Table Tennis | | |
| *Eigenvalues* | $I_1$ | $I_2$ | $I_1$ | $I_2$ | $I_3$ | $I_3$ |
| Elderly | 11629,4 | 8414,4 | 3815,9 | 13896,3 | 11661 | 5265,5 |
| Children | 9678,6 | 7155,2 | 3120,5 | 10116,6 | 8479,4 | 4261,2 |
| **Length Factor** | | | | | | |
| Racket | Badminton | | | *Light* Table Tennis | | |
| *Eigenvalues* | $I_1$ | $I_2$ | $I_3$ | $I_1$ | $I_2$ | $I_3$ |
| Elderly | 19495 | 15679,6 | 4146 | 10802,7 | 7703,7 | 3494,8 |
| Children | 13321,4 | 10685,8 | 2959,8 | 9120,4 | 6690,3 | 2803,6 |

The eigenvalues reflected topological differences between rackets, sustaining the hypothesis of differential contributions of each eigenvalue for the perception of the topology of the racket [5], e.g., the eigenvalue $I_1$ is greater for Badminton racket than for the Tennis Table ones, and $I_2$ increases with weight and with the Badminton racket (Tables 1 and 2).

Table 2. Eigenvalues estimated for center of percussion of Table Tennis and Badminton rackets.

| **Weight Factor** | | | | | | |
|---|---|---|---|---|---|---|
| Racket | *Light* Table Tennis | | | *Heavy* Table Tennis | | |
| *Eigenvalues* | $I_1$ | $I_2$ | $I_3$ | $I_1$ | $I_2$ | $I_3$ |
| Elderly | 9514,7 | 6889,9 | 3225,6 | 12698,2 | 11067,1 | 4596,2 |
| Children | 8156,7 | 5845,9 | 2907,8 | 8348,2 | 7653,8 | 3162,2 |
| **Length Factor** | | | | | | |
| Racket | Badminton | | | *Light* Table Tennis | | |
| *Eigenvalues* | $I_1$ | $I_2$ | $I_3$ | $I_1$ | $I_2$ | $I_3$ |
| Elderly | 15072,1 | 11425,3 | 3977,3 | 8974,1 | 6497,4 | 2872,5 |
| Children | 9344,7 | 6888,2 | 2780,8 | 7624,2 | 5422,1 | 2575,6 |

Children and the elderly differently estimated length and center of percussion. The weight induced overestimation of the length and the location of center of percussion [cf. 8], particularly in the elderly (Table 3).

Table 3. Estimates (cm) (average ± standard deviation) for Tennis Table and Badminton rackets (light, heavy), by age group (children, elderly) and by location (length; center of percussion).

| Racket | Light Tennis Table | | Heavy Tennis Table | | Badminton | |
|---|---|---|---|---|---|---|
| Group | Children | Elderly | Children | Elderly | Children | Elderly |
| Length | 26,2±7,85 | 26,46±9,3 | 27,4±5,78 | 31,4±6,96 | 34,0±10,82 | 42,0±9,16 |
| Center of Percussion | 22,3±8,33 | 21,6±8,69 | 22,2±7,98 | 27,8±10,61 | 26,7±7,19 | 34,0±11,70 |

The present study extended to children and confirmed in the elderly, the results found with Tennis Field rackets [3, 4], with rackets not tested before. The results indicate that the elderly maintain the capacities of haptic perception.

The eigenvalues may be a valid tool for definition of physical properties of sport instruments, allowing better adjustment to different motor development stages.

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