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ANNUAL MEETING 1989

Election

Eight people were elected to the Board at the Dartmouth meeting last October (1989). Current Board members are:

'88–'90	'89–'91
Alan Costall	Rainer Guski
Eleanor Gibson	Margaret Hagen
James J. Jenkins	Claes von Hofsten
Ulric Neisser	Bill Mace
Edward S. Reed	Len Mark
Sverker Runeson	Claire Michaels
Esther Thelen	Robert Shaw
	William H. Warren, Jr.

Dartmouth Talks

The morning session at the Annual Meeting was devoted to the arts, in accord with sentiments expressed at the ICEPA5. We were fortunate to have Margaret Hagen and two guests, Paul Vincent-Davis and Daniel Davidson agree to speak. Vincent-Davis is a puppeteer who works professionally in Brookline, Massachusetts and Davidson is a painter from UCSD. The morning arts package consisted of talks by Vincent-Davis, Hagen, and Davidson. Davidson's painting shares many of the concerns Hagen had in writing her book, *Varieties of Realism.* He gave her a great deal of credit both for making explicit ideas that had implicitly guided him and for stimulating him further. Because of this, Hagen presented a quick summary of her system of classifying types of realism as a way of introducing Davidson. Put very briefly, she showed that several styles of oriental painting, as well as Northwest (U. S.) Indian art, could be treated as just as projectively "correct" as western Renaissance art (e.g. Vermeer or Caneletto), and hence just as "realistic." The obvious major differences in these styles can be attributed to variations in parallelism: 1. between object and image planes and 2. of the projection lines. The differences do not have to be attributed to one style's being projective and another style's not. I will not summarize her talk here because you can read about it in her book and you really ought to buy it (Cambridge University Press). And we're running short on space in this issue.

The other events on the day's program were 1. Bob Shaw's presentation of John Pittenger's ideas about multiple specification from the last newsletter (in preparation for the evening discussion), 2. Bill Warren's review of approaches to the analysis of optic flow, 3. McGowan and Fowler on acoustic information in speech, and 4. Cathi Best's talk on speech perception in infants. In the evening there was a two hour discussion of the multiple specification issue.

Everything, including the evening discussion, is on audio tape and copies are available from Bill Mace.

The "abstracts" of the Vincent- Davis and Davidson talks are reports based on listening to audio tapes of the talks. The Davidson report will be in the next newsletter. Anything that misrepresents either speaker is the fault of the transcriber / editor (Bill Mace).

The Meaning of Movement in Puppet Theatre

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[*In what follows, keep in mind that the puppets referred to are hand puppets, not marionettes. In the question period following the talk, Vincent-Davis was asked to comment on the difference between the two. He answered, "Marionettes are hard to make but easy to use, hand puppets are easy to make but hard to use."*]

Many of the standard problems of theatre are shared by puppetry but with the added challenges of moving the puppets to make them convincing "actors" and "actresses." Indeed, movement easily can be viewed as the essence of a puppet. It is not hard for puppeteers to imagine plays without words, but a play without movement is inconceivable. Some puppeteers even believe that the human voice is too big for small puppets. "It is natural for a puppet to move, but unnatural for it to speak."

To say that it is natural for a puppet to move refers to the requirements of effective drama, not the ease of achieving it. Conveying convincing action to an audience requires a host of very specialized skills. Puppeteers must learn to use their whole body, especially the hands, to make puppets move "properly" in the eyes of the audience.

One might begin thinking about a character and a show with a puppet that is no more than a nerf ball on the end of a finger. Many of the basic problems can be illustrated with this. How does a puppet walk across the stage? First, we note that in most cases, the puppeteer works standing up, holding the puppet over head for maximum freedom of movement. But if the puppeteer were merely to hold up the puppet so that the audience could see it, and walk across the stage, otherwise holding the puppet still, the puppet would not seem to be walking across the stage, but would look like it is being dragged across. How does one move the puppet to make it look like an active agent, walking in this case?

There are several standard "walks." One involves rhythmically bobbing the puppet up and down in what is called the "piston" movement. Another is a back and forth called the "swivel". Then there can be combinations of "piston" and "swivel." The skill of "walking" the puppet is something the puppeteer learns by drill, practicing over and over until such movements are automatic. At the level of professional performance, the puppeteer never thinks about the mechanics of such movements, but concentrates on the emotions and character that needs to be conveyed.

Transitions into and out of movements are critical. Every movement has to have a beginning, middle, and end. With respect to walking, for example, one has to ask, "How do you start moving a puppet?" Four example beginnings are: the upsurge, the downward start, the hesitation start, and the push start.

To make a puppet look like it is sitting down one cannot just pull it straight down. That would look like it stepped in a hole. To make the puppet look like it is performing an act of sitting down, one has to have it look at the chair, lean over, and then sit down, somewhat exaggerating the components to clearly distinguish sitting from being pulled down or falling. One has to convey the energy it takes to stand and sit. Extending the case, suppose a character had just been running in the woods. When it gets to the end of the run, if it just stopped and delivered its lines, the sense of effort expended in the running would be undermined completely. The puppet's movements must carry on consistently to convey fatigue and gradual recovery.

Some movement requirements of puppets seem to be the opposite of mimicking the "real" motions they are meant to convey. Swans seem to glide in the water. But a puppet swan that is literally made to "glide" will look like it is being dragged. It will not look alive. Some other back and forth motion has to be added to make it look alive to the audience. According to Vincent-Davis, one person who saw the performance objected, "But swans don't swim that way." He answered, "Yes, but I'm not selling swans, I'm selling water."

In Macbeth, actresses playing the sleepwalking Lady Macbeth work hard to learn to glide, especially down stairs, to convey a sense of unreality. A puppet doing that, as mentioned before, would appear to be dragged. The solution for puppets is to put legs on Lady Macbeth and make every step on the stairs very careful, deliberate, and obvious to the audience. The overall effect of eeriness can be successfully conveyed this way, but the means to the end is the opposite. Actresses try to take all the bounce out of their body, holding their head as level as possible on the descent. Puppets are bobbed up and down on every step. Thus puppet movement is not chosen to mimic human movements but to show what needs to be shown. Vincent-Davis said "A lot of movements are realistic, a lot of them are very stylized, and a lot of them are absolutely the opposite of reality."

Beyond these basic movement problems lie the more specific physical characteristics of individual puppets and the dramatic requirements of the plays themselves, all having implications for puppet movement. Each physical puppet has its own ways of moving which must be mastered and taken advantage of in the interest of the character being developed. Vincent-Davis showed an Androcles puppet from "Androcles and the Lion." Androcles was given legs, which were weighted with fishing weights in the heels. The puppeteer's fingers extend through to the palms of the puppet's hands and the legs hang free. The neck is rigid to allow room for the puppeteer's hand. This is very different from a Jim Henson muppet character. With muppets, much of the puppeteer's focus is on moving the mouth. With these, one learns that it makes a difference if the puppet's mouth is opened by moving the top or the bottom. If the top is moved, the audience sees too much of the top of the mouth. Because this effect is undesirable, Henson teaches that only the bottom should be moved. With each new puppet, a great deal of "play" and experimentation is necessary to discover the best ways to control its movements.

Now consider the case where one puppeteer has two puppets on stage. Attention has to be paid to the movements of each. In particular, the most attention has to be paid to a puppet who is ostensibly listening. If the puppeteer were to concentrate on the speaker in a speaker - listener pair, apparent inattention or lifelessness on the part of the listening puppet would break the effectiveness of the dialogue as an active engagement of two characters. Accordingly, the bulk of the puppeteer's attention needs to be given to the listening and not to the speaking puppet.

What if the two puppets are walking together? What if one gets a piston walk and the other a swivel walk? It is not difficult to see how the complexity escalates for the puppeteer.

Finally, there are the dramatic requirements. In Jack and the Beanstalk, who is Jack? Is he a lazy, good for nothing? Why does he trade a cow for a few beans? If he's not bright, how can he compete with the giant's wife later on? Who is jack's mother? What is their relationship? Why are they on the farm in the first place? The answers to a host of such questions must be plotted out by the puppeteer even if they never explicitly arise for the audience, because they all will affect how Jack and his mother move. The movements must consistently express the characters as conceived by the puppeteer.

What Is Optical Flow? (Or, What I Did on My Sabbatical)

Bill Warren
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The "optical flow field" we all know and love – the instantaneous 2D velocity field – is only one possible representation of optical flow. Introduced by Gibson in 1947, it has become so prevelent that it is what AI people mean when they talk about "computing the optical flow." But the velocity field is only a partial representation of the change in structure of the optic array at a moving point of observation, with some important limitations. To wit:

1. No intensities: Gibson defined the optic array as having "different intensities in different directions," and a more basic description of optical flow would be as a changing intensity field, from which optical velocities would have to be extracted. Horn & Weldon (1988) have shown that egomotion can be determined directly from changing intensity without an intermediate velocity field, but the model assumes continuous fields and is biologically dubious. Nevertheless, it's an open question whether the visual system is extracting velocity or change in intensity.

2. No deformations: Gibson (1966) pointed out that the vectors in his diagram "represent the velocities of points" rather than deformations of the visual solid angles of the optic array: "Every form undergoes a transformation, but this fact is not shown by the graph." This was remedied by Koenderink & van Doorn's (1976) description of spatial derivatives of the velocity field such as div, curl, and def. However, these terms assume a continuous velocity field, and the notion that the visual system extracts these components is under question.

3. Continuous: To be formally analyzable, velocity fields must be continuous, corresponding to an assumption of smooth surfaces in the environment. Gibson (1979) noted that a cluttered environment does not "project a continuous flow pattern to the eye." We have good evidence that the visual system does not require continuous fields, and thrives on discontinuity.

4. Instantaneous: Most importantly, the velocity field is instantaneous. It doesn't represent higher-order temporal derivatives like acceleration, or spatiotemporal element trajectories. Consequently, the velocity field is inherently ambiguous: Longuet-Higgins (1984) pointed out that identical fields are generated by translation toward a plane and translation parallel to a plane plus a rotation. Similarly, identical fields are generated by movement on a circular path and translation plus a rotation about a vertical axis. Both of these are resolved by successive velocity fields, accelerative components, or the evolution of optical flow over time.

In a series of experiments on the perception of heading, we have found evidence that challenges assumptions 3 and 4. Observers viewed moving random-dot displays and judged whether it looked like they would pass to the left or right of a target in the scene. With pure observer translation, heading judgments had an accuracy of 1 deg of visual angle with movement over a ground surface, toward a wall, and through a 3D cloud of dots. With displays that simulated the effects of observer translation plus eye rotation, observers had an accuracy of 1.5 deg with a ground surface and a 3D cloud, but with a wall they always reported heading toward the fixation point. These results with the cloud, which yield a highly discontinuous flow field, demonstrate that the visual system does not require smooth fields. In fact, the failure with the wall suggests that relative motion produced by neighboring elements at different depths, which is prominent in a cluttered environment, is essential to decompose translation and rotation from optical flow.

To examine the issue of instantaneous fields, we created 3 sec displays in which the lifetime of individual dots could be manipulated. With a 2-frame dot life, only successive independent velocity fields were presented. For observer translation, heading judgments were highly accurate, indicating that velocity field information was sufficient. However, for circular movement, observers could not determine their future curved path with a 2-frame dot life, but had an accuracy of 1.5 deg with a 3-frame dot life. 3-frame displays include accelerative components, as well as a change in element direction. An analysis showed that the change in direction of 2 elements over 3 frames was sufficient to specify circular heading if the orientation of the rotation axis was known, as it is in terrestrial locomotion. Subsequent experiments were consistent with this theory. Thus, whereas the instantaneous velocity field is sufficient for accurate judgments of translational heading, temporally extended information is necessary for judgments of circular heading.

Finally, there are other sorts of information in optical flow that are not apparent from a velocity field representation. For example, in a cluttered environment the relative motion between elements at different depths goes to zero in the direction of heading, yielding what might be called a "relative motion field". Similarly, the change in orientation of surface contours goes to zero in the direction of heading, yielding a "shear field." Experiments to test these hypotheses are in progress. While the instantaneous velocity field has had a useful life, it should not limit our understanding of optical flow.

Acoustic information for speech perception

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We do not yet understand how listeners to speech recover the talker's intended message. Our concern here is with recovery of the talker's phonetic message–that is, the sequence of consonants and vowels that compose the words of the utterance. Arguably, perceiving a phonetic message is analogous to seeing objects and events in the environment. In visual perception, observers use patterning in reflected light to recover certain causes of the light's structure in the world; that is, the patterned stimulation at the eye does not itself serve as an object of perception, but as the means by which an observer can come to know objects and events in the environment in which he or she participates as an actor. If speech perception is analogous to visual perception, then listeners should not hear the acoustic speech signal, but rather its causal source in the environment. The causal source of an acoustic speech signal is a set of linguistically-significant actions of the vocal tract that constitute the consonants and vowels of the message.

There are some barriers to the idea that listeners use acoustic signals to recover consonants and vowels as produced. One is that the literature includes claims that mappings from acoustic signals to vocal tract shapes are one-to-many. A second is that, because talkers coarticulate—that is, because they produce successive consonants and vowels in overlapping time frames—even if the mapping were determinate, it would not be possible to recover the serially-ordered string of consonants and vowels that listeners believe they hear.

We are attempting to address these problems in new ways. We think that the first barrier may be considerably weakened by attending to the dynamics of talking. Even if the acoustic signal at any given point in time is compatible with several vocal-tract shapes, contextual constraints—in particular, that the trajectory of shapes over time be physically possible—may reduce the possibilities to just one. The second barrier may be weakened by attending to the kinds of linguistically-significant actions that overlap temporally in speech. Major coarticulatory influences are between consonants and vowels, which tend to be different kinds of vocal-tract actions. Canonically, consonants create new sound sources in the vocal tract, while vowels are filters for sound sources. Accordingly, perceptual sensitivity to creations of new sound-sources allows identification of consonants while recovery of changes in the filter function allows identification of a vowel.

Our presentation at the ISEP meeting constituted a progress report of our efforts to date to mine the acoustic speech signal for information about the nature of the vocal tract itself and about the sequence of vowels and consonants in disyllabic utterances, using only the acoustic signal and an understanding of physical acoustics. We disallow "top down" information, such as knowledge of the words of the language, that mature listeners might be supposed to use, but that infant learners cannot use.

Perceptual learning and language development: The infant's discovery of phonological categories

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To acquire language, infants must learn about the properties of speech as the medium of a particular language. As they become language - users, infants must move beyond detecting only pre - linguistic information in speech to discovering various aspects of linguistic structure (e.g., words, phonemes) in the signal. According to the "psychoacoustic model" of speech perception, the object of perception, and hence of the infant's perceptual learning, is the proximal stimulus — the acoustic surface of the signal as it impinges on the ear. By contrast, the "phonetic model"

model" presumes that the object of perception and learning consists of the abstract linguistic properties of segments / features conveyed in the signal. Finally, the "ecological model" argues that the object is the distal event that shaped the signal — the articulatory movements of the vocal tract. I favor the ecological approach because language learning involves the ability not only to hear but to produce the sound patterns of the language, which the ecological model can handle without recourse to specialized mechanisms for translating proximal acoustic patterns to abstract linguistic categories. Studies on developmental changes in infants' perception of native and nonnative speech sounds indicate that the universal sensitivities of young infants have begun to become restricted by the sound patterns of their native language by 10 - 12 months, before the onset of word production. My recent work suggests the following developmental progression in perceptual learning about speech: 1) Infants under 8 months perceive simple articulatory - gestural information in speech sound contrasts, and this ability is not yet influenced by their language environment. 2) By 10 - 12 months, infants have begun to discover certain intra- and intergestural coordinations in the phonemes used by their native language, but their recognition of phoneme categories is still broad, under - specified, and may not be related to contrastive meaning. 3) At least by adulthood (probably earlier), perception of speech sounds takes place primarily at the level of phonological contrast, and unfamiliar sounds are "assimilated" to native phoneme categories on the basis of their articulatory - gestural similarities (or lack thereof). Thus perceptual learning about speech involves the discovery of articulatory - gestural relationships that recur in the spoken language of the environment.

ESSAYS

Multiple Sources of Information: For What?

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Pittenger (1989) raises pithy and pertinent questions with his essay "Multiple sources of information: threat or menace". He offers as "gut level beliefs" the notions 1) that many everyday events are multiply specified, and 2) that multiple specification is consistent with a theory of direct perception. I take issue with both of these claims.

What is Multiple?

Gibson (1966) claimed that fire is multiply specified in volatile, optic, acoustic, and thermal arrays. What does this mean? Are these four sources of information equivalent? Can each substitute for the others? Does each in isolation convey the same information as any combination of them? Are the various specifications independent of one another? More succinctly, are they redundant? Gibson (1966, p. 54) states that they are. Pittenger agrees: "to perceive people's age you can attend to their head shape, the shape of the parts of their face, *or* the height of their head relative to that of the rest of the body" (1989, p. 4, emphasis added). I have appealed to "cross - modal redundancy" myself (Stoffregen & Becklen, 1989).

The Centrality of Intermodal Invariants

I think that the central issue here turns on our understanding of what exactly is specified. Take looming. There is a unique lawful relation between time - to - contact and parameters of optical and acoustic stimulation (Schiff & Oldak, 1990). These parameters of stimulation have been shown to have robust effects on the phenomenal experience of impending collision (Schiff & Oldak, 1990), and, for optics, on behavioral responses to it (Lee & Young, 1986). We are familiar with the mathematical formula relating time - to - contact to the rate of expansion of the image of an object or surface. Discussions of impending collision treat this invariant in isolation. But organisms do not pick up individual sources of stimulation in isolation. I'm willing to wager that they could not, no matter how hard they tried. It is easy for us as scientists to ignore it, but the fact is that each of our perceptual systems is always operating; none of them ever shut down (closing your eyes is a trivial exception). Organisms pick up information through multiple perceptual systems during every waking moment, at a bare minimum for the perception and control of posture and orientation (Stoffregen & Riccio, 1988). It is sometimes assumed – when it is thought about at all – that this consists of the multiple pickup of redundant information. However, the *pattern* of stimulation *across* systems is informative, as Gibson (1966, p. 62-63) pointed out, and as Gary Riccio and I have argued extensively (Riccio & Stoffregen, 1988; Stoffregen & Riccio, 1988). Moreover, we have argued that much information is available *solely* in patterns of stimulation across perceptual systems (also known as intermodal invariants; Gibson, 1966; Stoffregen & Riccio, 1988).

What has this to do with events like fire, or impending collision? Several things. First, it is an error to assume that organisms attend to individual perceptual systems, or to individual sources of information. Gibson was at pains to point out that organisms perceive events, not the activity of perceptual systems. Hence an organism will not perceive "the visual specification of impending collision". Instead, it will perceive "the event of impending collision", however that may be specified.

This is where things get interesting. It is argued or implied that impending collision, fire, and so on are multiply (redundantly) specified in stimulation of different perceptual systems. But what is specified in the total pattern of stimulation across systems? If you see fire, hear fire, smell fire, and feel fire you will perceive fire. But not just any fire; you will perceive fire that can be seen, heard, smelt, and felt; in short, fire right in front of you. What is perceived if you smell fire but do not hear, see, or feel it? Fire, yes, but this percept and the previous one are not *equivalent*. With only smell you perceive fire - out - of - sight - at - a- distance, or fire - out - of - sight - upwind. Other combinations of the four kinds of stimulation would be caused by other combustion events. Would these events be perceived as such? If so, are the different "sources of information" really equivalent? Consider the case of impending collision: imagine yourself tied to a railroad track. Engine 99 approaches. Ordinarily you would see, hear, and feel the approach (through the ground and air). It is likely that time-to-contact is available in each of these forms of stimulation. When all are present and "redundant" you doom is specified. But what is specified, what event, if you see and feel the train but cannot hear anything? What event is specified if you can hear and see the train but there is no rumble in the tracks, no vibration in the air? With these intermodal patterns of stimulation what would you perceive? You might still perceive time - to - contact per se, but that is certainly not all that you would perceive, and your interest in time - to - contact might be substantially altered. In each of these cases the perception of the actual event (rather than some isolated property of the event) is dependent on the pattern of stimulation across perceptual systems. Different patterns of stimulation across perceptual systems are specific – uniquely related – to different events.

It will be objected that there are events that do not stimulate multiple perceptual systems but which seem nevertheless to be perceived veridically. Impending collision remains a good example. A fly ball structures light but it does not structure sound, and it does not structure mechanical stimulation of my body (before it hits me). Unimodal perception? I think not. A fly ball does not structure stimulation of the auditory system, but that system is functioning. If the ball structured the acoustic array the structure, specifying time - to - contact, would be available to the auditory system. The absence of such acoustic structure *combined* with the presence of optical structure (that is, the pattern across systems) is informative about the event. We correctly perceive the approach of a silent ball. If the acoustic array specified a different time - to - contact than the optic array we would perceive (correctly) a different event. Only the relationship between optic and acoustic stimulation is informative about the true event, not either alone. Many intermodal patterns are not redundant, but all intermodal patterns are informative about events in ways that unimodal stimulation cannot be. In sum, there is always an overall pattern of stimulation across perceptual systems. Events that stimulate one system and not another nevertheless influence the overall pattern. In the context of the overall pattern, non-stimulation of a perceptual system is as informative as stimulation.

We tend to forget this in the laboratory, where we often present stimulation to only a single modality. But the systems that *we* are not stimulating are nevertheless *being stimulated*, and the total pattern of stimulation across all systems is specific to the totality of the situation. Do we suppose that participants confuse our displays for the real thing? This question cannot be answered by appealing to the participants' introspections. We must consider behavior. Warren & Hannon's (1988) participants perceived the direction of "self-motion" in optical displays. But did they *behave* as if they were moving? Did they emit postural adjustments to compensate for the change in the magnitude and direction of the gravitoinertial force vector that must accompany an actual physical displacement? We don't know. I think they didn't, or at least not for long. Was self - motion actually specified in Warren & Hannon's experiments? The total pattern of stimulation across perceptual systems in these studies was uniquely related to a stationary person viewing a display that depicted motion through a simulated environment. (These comments do not undermine the importance of Warren & Hannon's work in demonstrating sensitivity to directional properties of optic flow.)

Intramodal Multiplicity

I have been stressing intermodal stimulation, but it has been suggested that there can be multiple sources of information within as well as across modalities. Pittenger's (1989) three ways of seeing age are a good example (head shape, intraface shape, and head/body ratio). Are these three parameters multiple in the sense of being equivalent or redundant? What happens if separate parameters are specific to different events, in this case to different ages? What then would be perceived? Most importantly, what physical reality might give rise to such non - redundant stimulation? A dwarf, perhaps? Dwarfs have large heads and small bodies (like young non - dwarfs) but can be any age. Accordingly, the three sources are not multiple or redundant: the relation between them is informative. Redundancy is only one of many possible relations, and may not be the most common. Redundancy among "sources" of information is information for one thing, while non-redundancy among these same sources is information for something else, whether the sources be intramodal or intermodal.

The Specification of Affordances

The potential power of these arguments is revealed when we consider the perception of affordances rather than the pickup of information. The perception of affordances, of opportunities for and consequences of behavior, is what really matters. Imagine that a boulder is coming in your direction. Certainly you would like to know when it will arrive, but that is not all that you want to know. In fact, time - to - contact information, considered in isolation, is useless. Knowing when the boulder will arrive is useful only if you can do something about it. The available behaviors depend on more than the boulder's motion relative to you; they are a function of properties of the situation other than the boulder, properties of the ambient environment and of the self. If you are standing on a flat, level, extended surface of high friction you may be able simply to step out of the way, assuming that you are not excessively fatigued, do not have broken leg, and so on. If the surface of support has other properties, for instance if it is very slippery, the affordance for stepping may be absent, and some other behavior required. Perhaps there is no surface of support. If you are in water you may be able to escape by pushing against the medium o f support, by swimming. If there is no support at all (if you are weightless) there may be nothing that you can do to avoid or mitigate collision. These properties of the situation, and their influence on your affordances for action, will not be specified solely in stimulation of individual perceptual systems, and they will not be specified redundantly across systems (cf. Riccio & Stoffregen, 1988). In order to detect the totality of the event (boulder W approaching you with time - to - contact X in environment Y which affords behaviors Z1, Z2, Z3) you must detect the pattern of stimulation across visual, vestibular, auditory , and somatosensory systems. Only this intermodal pattern specifies the affordances of the situation.

I guess that, in some senses, multiple sources of information exist. It is possible to detect time - to - contact from an optical transformation and/or from an acoustic transformation, and maybe from others as well. But these sources are not redundant, and so do not fit Gibson's or Pittenger's definition of multiple. Moreover, the 'sources' are not detected in isolation: I'm sure it could easily be demonstrated that intermodal invariants influence the perception of affordances in *any* situation. Even if we could detect individual sources of information in isolation, it wouldn't do us much good. Time - to - contact is only one small piece of what the organism needs to detect in order to behave adaptively in the face of impending collision. Time - to - contact is not an affordance, and it does not specify an affordance. Likewise with other information that has been "isolated" within a single modality. We can perceive direction of motion from an optic display (Warren & Hannon, 1988), but direction of motion is not an affordance and does not – by itself – specify any affordance.

Our dependence on intermodal invariants can be inferred from Warren's (1984) work with stair climbing. Warren's participants could perceive the affordance of climb - ability "just by looking at" the stairs. Visually perceived affordances? Not necessarily. Warren showed that affordances for climbing were governed by the relationship between leg length and riser height of the stairs. Did his participants detect leg length solely by *looking at their legs*? Eye height is available optically, but anyone who has flown knows that eye height need not correspond to any property of the body. Leg length is specified in invariant relationships between stimulation of the somatosensory, vestibular, and visual systems (cf. Riccio & Stoffregen, 1988). Warren did not vary the dynamics of the ambient environment, or of the participants' bodies. In fact he went out of his way to eliminate possible effects of fatigue (Warren, 1984, p. 696), which surely cannot be perceived solely on the basis of optical stimulation. Would the affordance (perceived and actual) of climb-ability have varied if the photographed stairs had been covered with glistening oil, or if oil had been poured on the floor on which the participants stood? Would the perceived affordances have varied if the participants were wearing heavy backpacks? The fact that the experimental displays were visual does not mean that the perception of affordances was solely visual. Warren implies as much in his discussion of biomechanical efficiency and the perception of optimal riser height. I do not question the validity of Warren's analysis or of his data. But I do suggest that the perceived affordances in these and many other studies may have been profoundly influenced by properties of the overall pattern of stimulation across all perceptual systems.

I have not yet addressed our chemoreceptive abilities. The tongue and nose are always operating as well as the eyes, ears, etc. Is stimulation of these organs part of the overall pattern? Sure. Gibson (1966) stressed the fundamentally intermodal nature of gustatory perception. But what about non-gustatory events? As in other systems, the absence of tastes or smells, taken in context of stimulation of other systems, is informative. We have already seen that smell is part of the intermodal pattern of stimulation that specifies combustion. Very few non-gustatory events stimulate the tastebuds. Spatiotemporally homogeneous oral solutes combined with heterogeneity in other forms of stimulation is information for unflavored (or untasted) events, objects or situations.

Conclusion

Are there multiple sources of information? Sometimes, for isolated properties of things. But organisms do not perceive isolated properties. Neither do they perceive sources of information. They perceive affordances. Is there multiple specification of affordances? I believe that there is not, and that there cannot be. To perceive an affordance is to perceive opportunities for and consequences of behavior. We sometimes say that an approaching object "affords collision", as if collision were a property of the object's motion. It is not. The object affords collision *if and only if* we do nothing about it (or nothing adaptive). Passivity is a form of behavior. I have argued that affordances (opportunities for and consequences of behavior) are uniquely (not multiply) specified in the total pattern of stimulation across all perceptual systems. A theory of direct perception, I think, demands the unique (not multiple) specification of affordances: there must be a lawful one-to-one relationship between the pattern of stimulation of (all) perceptual systems and the affordances of a given object, event, or situation for a given organism. If such a relationship exists ambiguity does not exist. I believe that such relationships exist and that they are detected and used by organisms for the adaptive control of behavior. Which aspects of the total pattern are detected, that is, which affordances are perceived in any given situation, will depend on the behavioral goals and perceptual skills of the organism (cf. Riccio & Stoffregen, 1988). It follows (I think) that any and all affordances are specified solely in the intermodal pattern of stimulation across all perceptual systems. This is probably a controversial conclusion, but it may be inevitable.

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The Demise of the Good Old Days: Consequences of Stoffregen's Concept of Information

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Stoffregen's essay on multiple specification is just the sort of response I had hoped my prior note would elicit. His arguments seem to me to be consistent with the key ideas of the ecological approach and are presented in a compelling fashion.

His central point is that information lies not in the rather local patterns to which we ecological psychologists usually refer (e.g. visual tau and body proportions). Rather, the pattern which specifies an event or affordance consists of a whole complex of co-ordinated patterns across the arrays of all relevant perceptual modalities. Stoffregen's discussions of perception of age and collision are compelling. He shows that the absence of what I took to be a redundant source of information and what I suppose to be a conflict between sources of information are, at the higher level of abstraction on which he insists, actually cases in which there is unitary information for some *different* event.

In a way Stoffregen's arguments are not really new: The pieces have been discussed for years. However they have not, to my knowledge, been pulled together before so as to make so clear that relatively low level invariants just won't do as information. Many of us, including yours truly, have discussed our research results in terms of redundant information. These comments are clearly inconsistent with Stoffregen's formulation of the concept of information.

If we take his analysis of the concept very strictly it has extremely strong consequences for the meaning of our research to date and for the future conduct of ecological studies. Below I sketch out some (surely not all) of these implications.

The Good Old Days

Ecological research has, in a way, been rather easy to do so far. Using physics and mathematics we first document the availability of information by showing that there is *an* invariant in *an* array which corresponds to a perceivable aspect of the environment. We then demonstrate pickup of that information by showing that measures of perception and/or action follow the values of that information, that distortions of the invariant result in distorted perception, etc. If we take Stoffregen's argument seriously the good old days are over. Research in going to become much different and much more difficult.

Implications for Documenting Availability of Information

Researchers will now face a formidable task in the analysis of the information for the particular events in which they are interested. For example, in the case of human growth, merely showing that cardioidal strain captures the pattern of growth would not have been sufficient. Rather we would have needed a) to find the patterns of change of the head, of body proportions, skin texture, etc. and b) specify how all those "components" are temporally co-ordinated. Thus the first consequence of Stoffregen's position is one of practicality. The task of documenting the real information for an event may be so difficult that researchers won't often be willing to complete it.

A second problem arises. In an analysis of the information for a particular event how could the researcher ever know that the complete intermodal invariant had been discovered? This problem does not seem to me to be one of those objections which, while logically possible, are unimportant in actual practice. (For example, recall that bizarre control condition some journal referee wanted you to include.) I expect that obscure and unexpected invariants abound in everyday events. Consider growth again. Most parents will have noticed that there is an olfactory consequence of growth: Babies smell different from adults and preschoolers smell different from both. Metabolism and diet changes are as inevitable during growth as are changes in body proportions. However, how many researchers interested in perception of growth would have thought to include an analysis of the chemicals on people's skin? Together, these two problems suggest that we may be doomed to producing analyses of information which are incomplete to some unknown degree. Moreover, the informational analyses we have done to date (time - to - collision, growth, etc.) are clearly incomplete according to Stoffregen's formulation.

Implications for Demonstration of Pickup of Information

Let us assume that information lies in the multimodal complexes postulated by Stoffregen. Surely ecological psychologists must suppose that perceivers detect this information. Our research must therefore involve tests of perception with the information available in its entirety. Several issues arise from this position.

First, what shall we now make of the studies we have already completed? It all involves studies of incomplete information. I certainly do not claim that our old work now must be relegated to the status of peephole and tachistoscope studies. However, we have, by artifice, made information unavailable and then assessed the resulting perceptual performance.

Second, we must test whether or not people do, in fact, use the rich intermodal information. This is very important to our theory. However, we no longer can say we have demonstrated that observers actually detect it.

Third, will we really be able to do such tests? Even if we can get around the problems in the analysis of information discussed earlier, it's going to be very difficult to produce controlled displays incorporating the auditory, visual, olfactory, etc. aspects of the information for an event.

Finally, suppose that observers fairly often fail to use the sort of information which Stoffregen postulates as the only information there actually is. By "fairly often" I mean sufficiently frequently and in a wide enough variety of events that we cannot dismiss them as unimportant to theory. I personally suspect that such failures are quite common. Should they occur, we have several puzzles to solve. First, must we then revise ecological theory to encompass failures to use available information? Second, don't the concerns I raised in my first essay come back again, though in a different form? We couldn't talk about multiple or redundant sorts of information: Auditory and visual tau, etc. aren't any longer themselves information. However, if they are used, we'd need to be concerned with questions of their redundancy, how they can be used in combination, etc.

Conclusion

Stoffregen provides a compelling argument for uniqueness of information by appealing to intermodal invariants. While this avoids the problems raised by the possibility of multiple invariants for a given event, a variety of new problems arise. To summarize the source of the problems in a somewhat inflammatory nutshell: Stoffregen's analysis makes the local invariants which we have so far studied rather like cues. That is, they are not really unique to a given event and cannot, in isolation, serve as information for perception of the environment. If Stoffregen is correct, we need to reinterpret the meaning of our old research and deeply rethink our plans for future studies.

On the other hand, I am still convinced that local invariants will have an important place in the ecological approach to perception and action. Stoffregen's analysis will, however, force us to clarify our understanding of the concepts of invariance, specification, and information. This task is urgent for two reasons. First, we are already performing studies of multiple local invariants (eg. auditory and visual information for control of the bounce pass) and of patterns which do not precisely correspond to the relevant property of the environment (eg. visual tau for accelerating objects). Second, our critics have raised questions about uniqueness for years. Their points need to be addressed more effectively. Have we any volunteers?

PEDAGOGY

From Finland:

Dear Colleagues,

I am presently working at the Dept. of Education, University of Jyväskylä, Finland, and am interested in the applications of Ecological Psychology in the field of education and schooling, but I have not found any materials yet. I am especially interested in the following topics:

1) Is it possible to practice "ecological pedagogy" in a western school system with western classroom teaching methods or not? Can the ideas of Ecological Psychology offer conceptual tools for psychologically understanding the critiques of western schools that sociologists (e.g. Bourdieu, Broady, Willis, Ziehe) have presented?

2) According to Ecological Psychology learning is not a process of constructing schema or knowledge structures, but rather of learning to perceive and to use affordances and affordance structures. So, the purpose of teaching is not to support processes of construction! But what pedagogical practices would support perceiving and using affordances? What could be the fundamental idea behind "ecological didactics?"

3) In "ecological didactics" what would be the teacher's role in supporting the perception and use of affordances?

4) Is it possible to analyze the existing standard educational materials (school books, for instance) and equipment as affordances? What do they really afford, what kind of learning do they afford etc.?

If you could please contact me about these subjects and others close to them, I would greatly appreciate it.

Pekka Ihanainen
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Foraging with Tweezers: An Affordance Exercise

Bill Warren
Brown University

This is an exercise that I've used with great success in my Ecological Psychology class to demonstrate the principles of affordances, effectivities, and body-scaling. It's adapted from a foraging exercise my brother did in Michael Zimmerman's ecology class at Oberlin College. Not only does it work, but you get to eat the raw data.

The idea is to alter the effectivity of grasping by giving students a new "forelimb" (tweezers, chopsticks, kitchen tongs) and have them collect as many pre-deposited items (lentils through limes) from a food patch as possible in a 3 min period. The class then counts the number of items in each food group collected by each forelimb. When relative frequency is plotted as a function of food diameter (D), each forelimb has a different preferred food size; but when plotted as a function of the ratio of food diameter to maximum grip span (D/G) – SHAZZAM, the curves are (more or less) congruent! Body scaling made manifest.

Moreover,the students with tongs don't even SEE the lentils, and those with tweezers often don't notice the limes. Thus, effectivities influence the information attended to – we perceive the environment in relation to our action capabilities. The standard ethological interpretation of such findings is in terms of a "search image" in the mind of the forager, but in this case there is no foreknowledge of the items being searched for and thus no specific "image." What defines the items is their graspability.

As perfected over several semesters, the best distribution of food sources is as follows: lentils (D=2mm), popcorn seeds (5mm), raisins (6mm), M&Ms (8mm), peanuts (10mm), jelly beans (12mm), pistachio nuts (13mm), malted milk balls (20mm), pecans in shells (24mm), walnuts in shells (34mm), hard boiled eggs (40mm), limes (50mm). The best "grabber- things" (Turvey, Shaw, Reed, & Mace, 1981) are tweezers (G=7mm, zircon encrusted optional), chopsticks (35mm), and kitchen tongs (80mm – the ones with the loops at the business end). Once you have made it past the cashier at the grocery with your dignity intact, the major problem is surreptitously scattering the stuff in a relatively untrafficked grassy patch of campus before class.

The analysis is a bit tricky, because you need to normalize frequency across the food groups (people collect a lot more peanuts than hard boiled eggs). First, each effectivity group pools their goodies and makes a frequency count on prepared score sheets. Similar-sized items are grouped into five or so food groups (lentils + raisins, peanuts + jelly beans + pistachios, etc.) and the frequency determined for each. Second, the class gets back together and sums the total number of items in each food group. Third, for each food group, compute the proportion of items collected by each effectivity (effectivity prop = effectivity f/food group total). Finally, for each effectivity, compute the proportion of all items collected in each food group (prop collected = effectivity prop/total number of items). Then plot on the board proportion collected as a function of D for each effectivity, and a second plot as a function of D/G – the resulting curves should be roughly congruent.

Thus, you have memorably made your points about body scaling and the perception of affordances, which the class may now digest.

MEETINGS

European Workshop on Ecological Psychology

IBHOP, Traverse Charles Susini,
13388 Marseille Cedex 13,
FRANCE.
JUNE 7 & 8, 1990

The first European Workshop on Ecological Psychology is aimed at building closer relations between European scientists sensitive to the Ecological Approach to Perceiving and Acting. It is organized by Cognition & Mouvement, University Aix-Marseille II & CNRS and will include symposia on:

* PROBLEMS IN DIRECT PERCEPTION
(organized by Onno G. Meijer,Free University of Amsterdam and Cees J. Overbeeke, Delft University of Technology, The Netherlands).

* VISION, MOTION and ACTION
(organized by Michelangelo Flückiger, University of Geneva, Switzerland and Daniel Mestre, University of Aix-Marseille & CNRS, France).

* THE ECOLOGICAL INTERFACE
(Organized by Jens Rasmussen and John Paulin Hansen, Risø National Laboratory, Denmark, and John Flach, University of Illinois at Urbana-Champaign, USA).

* CONTROL IN REACHING AND GRASPING
(organized by Reinoud J. Bootsma and Geert J.P. Savelsbergh, Free University, Amsterdam, The Netherlands).

* ECOLOGICAL ACOUSTICS
(organized by Jean Claude Risset, CNRS, Marseille, France).

For more information, contact Daniel MESTRE, Cognition et Mouvement, IBHOP, Traverse Charles Susini, 13388 Marseille Cedex 13, France. Fax: (33) 91 61 14 20. E-Mail: Patre at FRMOP11.

1990 Spring Meeting

Society Meeting XVII
Monday-Tuesday, May 21 - 22
Beckman Institute
University of Illinois

Speakers and Presentation Titles

Alex Kirlik (Georgia Tech) *Describing the environment for complex skills: Dynamic affordance distributions*

Kim Vicente (University of Illinois) *A case of reconstructive remembering in the scientific literature*

Larry Hettinger (Logicon, Inc.) *Vection and simulator sickness*

Lawrence Goldfarb (Mind in Motion) *Perceptual differentiation in movement learning*

Stavros Valenti (Hofstra University) *Perception of social affordances*

Syndy Slowikowski (University of Illinois) *Understanding ancient Greek motifs in contemporary physical culture*

Anatole Fel'dman (Institute for Information Transmission Problems, USSR) *The organization of central control signals for goal - directed movements* (with David J. Ostry and Randell Flannagan)

Robert E. Shaw (University of Connecticut) *Directionality as a problem in ecological physics*

Peter Beek (Free University, Amsterdam) *Phase transitions in coordinated rhythmic movements: A confirmation of the informational threshold nonlinearity hypothesis*

Beatrix Vereijken (Free University, Amsterdam) *A dynamical approach to skill acquisition*

Knud Kielgast (University of Aarhus, Denmark) *Gait perception*

Eric Gutjahr (University of Indiana) *Perceptions versus conceptions of events: Naive physics and the C-shaped tube problem*

Mark Strauss (University of Illinois) *A navigation aid for the blind*

Open Discussion: Multimodal Specification

ANNOUNCEMENT

Selected Essays of H.T.A. Whiting

John Whiting has, much to our regret, taken an early retirement from his position as professor and chairman of the Department of Psychology at the Faculty of Human Movement Sciences, Free University, Amsterdam, The Netherlands. He is now back in England and holds an honorary professorship at the University of York. Although Science in the Netherlands has since come to a grinding stop, not all is lost because a book is available with selected publications, spanning the period 1968 - 1989. The different papers have been clustered into three sections: (i) catching, (ii) learning and (iii) theory of human movement science.

Interested members can obtain (at production cost!) a paperback copy of this book, as well as any of the others listed below by sending a check for 25, - Dutch Guilders to Dr. R. J. Bootsma, Department of Psychology, Faculty of Human Movement Sciences, Free University, Van der Boechorststraat 9, 1081 BT Amsterdam, The Netherlands.

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