MONASH UNIVERSITY

THESIS ACCEPTED IN SATISFACTION OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

ON.................. 21 September 2004................

....[redacted]..

Sec. Research Graduate School Committee

FORMULATING WHAT PSYCHOLOGISTS SEE: AN ITERATIVE PROCEDURE

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May, 2004

The aim of this book may be summed up in very simple form. We want to see what we are talking about, and we want to talk about what we see in words which are definite with respect to what we see and with respect to each other. We want to do this in a way in which others can do it too. If we can do that we will at least have the start of agreement, which means the start of developing science.

A. F. Bentley
Unpublished notes
1921-1931

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ABSTRACT

This thesis implements an iterative procedure for formulating what psychologists see. The thesis is presented in three parts. Parts 1 and 2 develop postulations, in the sense of theoretical formulations. Part 3 lets these postulations guide and be guided by observations. The procedure is iterative in the sense of iterating between postulation (theoretical work), and observation (empirical work).

Part 1 (Chapters 1, 2, & 3) applies a method for clarifying and refining psychology's units of analysis. Chapter 1 introduces the need to clarify psychology's units, offering Dewey and Bentley's (1949) account of designation as a way of doing so. Chapter 2 applies the Dewey-Bentley account to a review and integration of three unit proposals: Kantor's *behaviour segment*, Skinner's *operant*, and Lee's *deed*. Chapter 3 extends the integration to Powers' *control system*. The resulting unit postulation is *regulative circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes.*

Part 2 (Chapters 4, 5, & 6) examines the concept *organism* in relation to designating psychological units. Chapter 4 critiques the traditional, skin-based conception of organism, and shows how this conception informs the theorising of Kantor, Skinner, Lee, and Powers. Chapter 5 attempts a sharper formulation of organism and environment by integrating Angyal's *biosphere*, Dewey's *life-activity*, and Ashby's *total system*. The resulting postulation entails a *transdermal (across-skin) bioprocess (biological total process) within which organism and environment are functionally defined complements.* Chapter 6 uses this postulation to reformulate the subject matter of psychology (i.e., what psychologists see). Integrating Bentley's *superfice*, Dewey's *coordination*, Järvilehto's *result*, Lee's *deed*, Bateson's *circuit*, and Powers' *control system*, Chapter 6 postulates part of what psychologists see as *negative feedback patternings of changes within bioprocesses.*

Part 3 (Chapters 7 & 8) lets the postulations of Parts 1 and 2 guide and be guided by observations. Chapter 7 explains how iteration between observation and postulation can be used to reach a clearer conception of what psychologists

observe. Chapter 7 overcomes the problem of a suitable data collection method with a modified version of an experimental paradigm called *Serial Visual Presentation of Text*. Chapter 8 uses the postulations of Part 1 and Part 2 to guide observation and interpretation of the resulting data. Using tabular representations, graphical transformations, and computer simulations, the postulations of Part 1 and 2 are shown to predict much of what was observed. It is also shown that the postulations guide observations suggesting refinement to the postulations. Chapter 8 exemplifies how iteration between observation and postulation can be used to achieve an increasingly clear formulation of what psychologists observe.

DECLARATION

I declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other institution, and affirm that to the best of my knowledge, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

[redacted]

DANIEL K. PALMER

ACKNOWLEDGEMENTS

My primary acknowledgement is to Vicki L. Lee. I have been extremely fortunate to have Vicki as my mentor, supervisor, colleague, and friend. Vicki, thank you – it has been a wonderful collaboration.

Each of the following made a much-appreciated contribution to the completion of this project: Dino Cevolatti, James McEwen, the ib-l discussion group (including the late Bill Verplanck and Paul Mountjoy), Rick Marken, Frank Ryan, Sholto Maud, Tom Joyce, David Widdess, John Staddon, Steve Kemp, Bill Powers, Jocelyn Dunphy-Blomfield, Elias Khalil, Jim Garrison, and Phil Runkel.

I am grateful for personal support from Susan and Keith Palmer, Floria Maschek, Henna Tse, Laurette Gautherot, Marjie Brown, Lue and Tim Ashton, and Brendan Whittingham.

Finally, I am indebted to the work of John Dewey and Arthur F. Bentley. I hope these two great thinkers would have approved of what I have done with their ideas.

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NOTE TO THE READER

Overall Format

Monash University Ph.D. thesis regulations allow two formats: (1) the conventional chapter based format; (2) a "series of published papers researched and prepared during candidature." This thesis is somewhere between the two. Though it has been prepared as a coherent, logically sequenced inquiry into a particular issue, most chapters were written as papers, and several have been published. For this reason, some chapters reiterate material from previous chapters, given that they were originally styled as stand-alone papers.

Behaviour or *Behavior*: When and Why

The Australian spelling of *behaviour* has been used except when appearing in a quotation adopting the American spelling (*behavior*).

Use of *Italics* to Indicate Talking about the Word and not the Thing

Italics have been used not only for emphasis but to indicate the word itself. An example is "The words *organism* and *environment* presuppose a conception of where the organism ends and the environment begins."

Glossary

This thesis includes a glossary of important words (see p. 190). Reference to this glossary might help the reader, especially when words are new, unfamiliar, or unconventionally used.

Page-Referenced Schematic Diagram of Whole Thesis

Appendix A (p. 151) offers a page-referenced diagram illustrating how the parts of the thesis hang together as a whole.

PART 1: A METHOD AND A UNIT

PRÉCIS OF PART 1

Part 1 outlines and applies a method for clarifying and refining psychology's units of analysis. It is organized into three chapters. Chapter 1 introduces the problem of clarifying psychology's units. It offers Dewey and Bentley's (1949) analysis of designation as a way of working toward a solution. Chapter 2 applies the Dewey-Bentley method to a review and integration of three proposals about psychology's unit of analysis.[1] These three are Kantor's *behaviour segment*, Skinner's *operant* and Lee's *deed*. Chapter 3 extends the integration to W. T. Powers' *control system*.[2] Part 1 has two aims:

(1) to establish a method for working toward increasingly accurate designations of psychology's units, and
(2) to exemplify this method by combining the most accurately designated aspects of four existing unit proposals into one unit proposal.

The second aim is a *postulation*, in Dewey and Bentley's (1949, p. 80) sense of "a condition required for further operations."[3] Parts 1 and 2 develop postulations (by bringing together the postulations of others). Part 3 uses these postulations to guide observations. As explained later, observations are the relevant "further operations." It might help the reader to keep in mind that

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[1] An earlier version of Chapters 1 and 2 were published as a single article in Palmer (2003a).

[2] Powers' *control system* unit was originally included in Chapter 2, along with Kantor's *behaviour segment*, Skinner's *operant*, and Lee's *deed*. On the advice of an anonymous reviewer (of the published version of Chapters 1 and 2), the analysis of Powers has been allocated a separate chapter.

[3] Dewey and Bentley differentiated a *postulation* from a *postulate*, which was something "taken for granted as the true basis for reasoning or belief" (p. 80).

whereas Part 1 was written as a self-contained conceptual whole, it was also written as a platform for later empirical work.

CHAPTER 1: ON CLARIFYING PSYCHOLOGY'S OBSERVABLE UNITS

Existing Discussions

Psychologists sometimes discuss the need to refine clear designations[4] of the particulars they observe, in the sense of the units,[5] items, or single cases into which their subject matter is analysed for the purposes of a scientific account (e.g., Barker, 1963; Kantor, 1938/1971; Kolb, Jacobs, & Petrie, 1987; Lee, 1995; Midgley & Morris, 1988; Miller, Galanter, & Pibram, 1960; Murray, 1951; Newtson, Engquist, & Bois, 1977; Reed et al., 1995; Rogoff, 1992; Skinner, 1938; Staddon, 1967; Thompson & Zeiler, 1986; Zinchenko, 1985). Miller et al (1960) expressed this need as follows:

> Most psychologists take it for granted that a scientific account of the behavior of organisms must begin with the definition of fixed, recognizable, elementary units of behavior – something a psychologist can use as a biologist uses cells, or an astronomer uses stars, or a physicist uses atoms, and so on. Given a simple unit, complicated phenomena are then describable as lawful compounds. That is the essence of the highly successful strategy called "scientific analysis." (p. 21)

Such discussions usually acknowledge that scientific analysis *begins* with observable units (e.g., Dewey, 1930, p. 415; Kolb et al., 1987, p. 220; Lee,

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[4] I use *designation* in the Oxford English Dictionary's (OED's) leading sense of "the action of marking or pointing out; indication of a particular ... thing by gesture, words, or recognizable signs."

[5] In this thesis the term *unit* is not to be confounded with the phrase *unit of measurement* (e.g., millimetres or joules). I use *unit* in the specific sense of a thing (object or event) distinguishable from a background, or, in the OED's phrasing, "a single individual or thing ...; one of the separate parts ... of which a complex whole ... is composed or into which it may be analysed."

1988, p. 28; Zinchenko, 1985, p. 97). That is, psychologists, like all scientists, *must* analyse their subject matter into manageable units (observable items) before they have any-thing to count, measure, manipulate, classify, or theorize about. This is not to say that scientists need define their starting units *explicitly*, but that they cannot get started without them. As explained by Dewey (1930), "what [the physicist or chemist] starts with are things [e.g., oil and water, iron and tin] having *qualities*, things qualitatively discriminated from one another and recurrently identifiable in virtue of their qualitative distinctions" (p. 415).. For this reason, such units should be designated clearly and communicably. As Skinner (1938) stressed in his seminal discussion about behavioural units, "we always analyze. It is only good sense to make the act explicit – to analyze as overtly and as rigorously as possible" (p. 9). In other words, analysis, and thus designation of units, is inevitable, and deserves explicit discussion.

Despite recognition of (a) the need to designate units and (b) the importance of making that designation explicit, relevant discussions are dispersed throughout psychology's guilds. They remain un-integrated, and seem to be on the decline. Miller et al. (1960) lamented "for the most part, serious students of behavior have had to ignore the question of units entirely" (p. 23). Zinchenko (1985) observed that "in contemporary psychology ... the problem of ... units ... is rarely brought up at all, and only then in historical context" (p. 99). Sidman (1986) discussed the historical context in which "the problem of behavioral units ... was swept under the rug" (p. 213). Such meagre attention has unquestionably contributed to psychology's much discussed lack of consensus about units of analysis (e.g., Kantor, 1963, p. 4; Lee, 1988, pp. 2-3; Rose, 1996, p. 104; Walker, 1942, p. 569).

In the interests of reviving discussions about psychological units, in the following chapter I attempt a critical integration of three different proposals of *a* (as opposed to *the*) suitable unit for psychological analysis. In what remains of this chapter, I outline some conceptual tools to be used in the integration.

Specification

In their book *Knowing and the Known*, Dewey and Bentley (1949) developed a taxonomy for assessing the relative accuracy of unit designations (which they called event or existence designations). Designating was equated with naming, where, among other things, "naming selects, discriminates, identifies, [and] locates ..." (p. 147). Dewey (1944, in Ratner & Altman, 1964, p. 266) had earlier explained that to name "is to identify-by-distinguishing; to elect or select; that is, to pick out something from other things and identify it by its difference from them" (p. 266). In other words, to name is to make a foreground different from a background. Dewey and Bentley (1949) distinguished three gradations of name,[6] ranging from evolutionarily primitive *cues* through everyday commonsense *characterizations* to the most accurate, efficient, or firm *specifications*.[7] An example of cue is a warning cry alerting companions to an immediately present predator. An example of characterization, which makes up the bulk of everyday conversation, is *dolphin*,[8] where dolphin is considered a fish because it lives in water like other fish.

The relatively accurate names underlying modern science emerge only at the next level of *specification*. An example of specification is *dolphin* when dolphin is considered a mammal (and no longer a fish) as an outcome of controlled inquiry. Dewey and Bentley (1949) described specification as follows:

> Specification is the type of naming that develops when inquiry gets down to close hard work, concentrates experimentally on its own subjectmatters

[6] Naming was located between behaviourally basic *signalling* and behaviourally advanced mathematical *symbolling*, these latter two ranges not being discussed here.

[7] The OED (which Dewey informally referred to as his 'bible') defines *specify* as "to mention, speak of, or name (something) definitely or explicitly."

[8] To reiterate, when not used for emphasis, I use italics to indicate that I mean the word as opposed to what the word names. Here *dolphin* means "the word dolphin," for example.

> [sic], and acquires the combination of firmness and flexibility in naming that consolidates the advances of the past and opens the way to the advances of the future. (p. 162)

As this statement implies, specifications were always grounded in consensible[9] observations of spatiotemporal events. Further, given that names identify-by-distinguishing, specifications (as relatively firm names) do so with minimal ambiguity or vagueness (where the less vagueness, the more accuracy). Regarding its usage in contemporary psychology, for example, the specification *neuron* is less vague than the characterization *intelligence*. Finally, specifications were never fixed or complete; "the regions of vagueness remain in specification, but they decrease" (p. 166).

In sum, Dewey and Bentley described simple *cues* and vernacular *characterizations* as relatively vague or inaccurate unit designations. They reserved the name *specification* for the most accurate (and yet ever-improvable) designations of observable units obtained by a community of scientific observers. In what follows, I use the names *designation*, *characterization*, and *specification* as Dewey and Bentley did. Accurately designated units are my goal, and accuracy of designation is the criterion against which I evaluate existing unit descriptions.

Particulars, Classes, and Beyond

Focusing on the specification of observable units does not deny the more abstract, logically secondary, and often mathematical phases characteristic of mature sciences. Despite a necessary grounding in unique particulars, science soon proceeds to abstractions (e.g., classifications, laws, and mathematical

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[9] After Ziman (1978, p. 42), I use the word *consensible* to designate observations available to all trained observers. According to Ziman, "the fundamental principle of scientific observation is that all human beings are interchangeable as observers" (p. 42), which is consistent with Dewey and Bentley's (1949) emphasis that "the names [we seek] are to be based on such observations as are accessible and attainable by everybody" (p. 48).

symbolizations). The components of Quine's (1957) tentative scientific ontology were physical objects (i.e., spatio-temporal particulars), classes of physical objects, classes of classes, and so on up. Feibleman (1944) likewise suggested actual objects, abstractions from actual objects, abstractions from abstractions, and so on. As discussed by Bunge (1959/1979, p. 270), it is only in such abstract domains that scientific laws have their purview (in the sense of holding only for classes, such as the class of physical objects). Whitehead (1911) combined the above points as follows:

> To see what is general in what is particular and what is permanent in what is transitory is the aim of scientific thought. In the eye of science, the fall of an apple, the motion of a planet around a sum, and the clinging of the atmosphere to the earth are all seen as examples of the law of gravity. (p. 11)

In developing increasingly abstract and broadly applicable accounts, however, it is a mistake for scientists, especially in fledgling sciences, to neglect the logically prior designation of particular, observable units. Murray (1951) acknowledged this in discussing psychology's inclination to "leap over all the tedious stages of observation, description, and classification through which chemistry and all the biological and medical sciences have passed, and find shortcuts to eminence via logical positivism and mathematical models" (p. 436, see also Thompson & Lubinski, 1986, p. 220). A focus on designating observable units is an attempt to begin at the beginning.

CHAPTER 2: INTEGRATING THREE PROPOSALS

With a focus on accuracy of unit designation, and with an eye toward critical integration, I now review (and where necessary, clarify), evaluate, and compare the psychological units proposed by J. R. Kantor, B. F. Skinner, and V. L. Lee.

J. R. Kantor (1888-1984): The Behaviour Segment

For Kantor, psychological events consisted of "interactions between organisms and objects" (in Kantor & Smith, 1975, p. 32). More specifically, the unit Kantor proposed and theorized about was the *behaviour segment.* Kantor (1938/1971) argued that "the psychologist is obliged to construct a descriptive unit simple and stable enough to enable him [or her] to understand what is essentially continuous and integrated. Such a descriptive tool he [or she] constructs in the form of a behavior segment" (p. 34). As Kantor went on to explain, "essentially the behavior segment is an abstraction designed to fixate a definite spatio-temporal event. This event can be analyzed into a series of factors operating in a specific framework which may be designated as a field or setting" (p. 34). In understanding the behaviour segment, two of the just-mentioned factors, which Kantor named *response function* and *stimulus function*, are central. I will discuss what Kantor designated with these two names in detail before examining other factors.

Response Function and Stimulus Function

Kantor (1959) wrote:

> The behavior segment, that is the unit psychological event, centers around a response function (rf) and a stimulus function (sf); the first is identified with an action of the organism, the second with an action of the stimulus object. The acts of referring to a building as a *house*, *casa*, or *maison* represent different modes of response functions. The building's act of stimulating one or another of these actional patterns is the stimulus function. (pp. 15-16)

For Kantor, response function (what the organism does – but see below) and stimulus function (what the stimulus object does) exist only together. In this respect, the relation between response function and stimulus function as equally-critical, co-defining aspects[10] of a single behaviour segment is analogous to the relation between husband and wife as equally-critical, co-defining aspects of a single marriage. For Kantor, a response function without a stimulus function (or vice versa) makes as much sense as a husband without a wife (or vice versa). This differs from other conceptions, in which stimulus and response exist separately, and a stimulus can precede and elicit or occasion a response. To distinguish his conception of response (as rf) and stimulus (as sf) from other conceptions (e.g., R = f(S) or S→R→S), Kantor used a bi-directional arrow (R↔S).

The names *stimulus* and *response* are notoriously ambiguous (e.g., Gibson, 1960; Kantor, 1933/1971, pp. 82-86; Schoenfeld, 1976). It was in trying to reduce this ambiguity that Kantor came to emphasize the contrast between *stimulus and response functions*, and the *stimulus objects and actions of organisms* in which they respectively inhered (Kantor, 1942/1971, p. 78). This change in emphasis partly explains a lingering ambiguity in Kantor's discussions of the response function – an ambiguity I will clear up before continuing.

In his more detailed analyses, Kantor spoke of an action of the organism as "harboring," "carrying," "constituting the vehicle of," or "being the locus of" the response function, where the response function was said to "inhere" or "be localized" in the organism's action (e.g., 1938/1971; 1942/1971; 1959, pp. 93-94). In such discussions, Kantor emphasized that response function and organism's action "must be differentiated" (1959, p. 93). Occasionally, however, Kantor wrote in ways concealing this differentiation. In his

[10] I use the noun *aspect* in Dewey and Bentley's (1949, p. 290) sense of a component of a full situation or system knowable only as a component of that system. As Bentley (1954, p. 315) noted, *aspect* is also a verb, where *to aspect* means *to observe in system* (cf. *inspect*).

prominent 1959 definition of the behaviour segment, for example, the response function "is *identified with* [italics added] an action of an organism" (p. 15).[11] It is important to appreciate that while Kantor sometimes equated the organism's acts and response functions, he more often emphasized their differentiation. I now consider Kantor's basis for the differentiation (along with the corresponding differentiation between stimulus object and stimulus function) to further clarify response and stimulus functions and their relation to the rest of the behaviour segment.

Kantor's motivation for the differentiation was the lack of any one-to-one relation between stimulus and response functions and the stimulus objects and the actions of the organism in which they inhered. Examples offered by Kantor (e.g., 1938/1971, p. 47; 1942/1971, pp. 78-79; 1959, pp. 93-94) on this point were that (a) different objects, such as a hammer or a pair of pliers, can serve the same (stimulus) function of driving a small tack into a picture frame; (b) the same object, such as a sheet of paper, can serve different (stimulus) functions such as writing notes or wrapping a gift; (c) different actions, such as nodding the head or saying "yes," can serve the same (response) function of indicating assent; and (d), the same action, such as throwing a stone, can serve the different (response) functions of moving the stone or doing something about a threatening dog.

These examples are important. They show that Kantor's stimulus and response functions are inseparable, "mutual and reciprocal" aspects of single behaviour segments. They also show that stimulus and response functions are single events viewed from different perspectives or what Kantor called "symmetrical poles." Whether "driving in a tack" is called a stimulus function, a response function, or a unitary functional relation between the two functions

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[11] Probably a contributor to these misleading presentations in Kantor's writing is the linguistically attractive tendency to describe the acts of organisms and the acts of stimulus objects as symmetrical complements within the behaviour segment. Properly speaking, however, the lines of symmetry run organism–object, act of organism–stimulus object, and response function–stimulus function (where stimulus function *is* the act of the stimulus object) (see Kantor, 1946/1971, p. 17).

depends on the aspects of the situation to be emphasized (or "aspected" in the previously mentioned sense of Bentley – see p. 10). Kantor focused above on "driving in a tack" as a stimulus function common to different objects. If, however, he focused on the fact that a tack can be driven in through a tapping or pushing action, he would be coming from the response perspective to the unitary function (i.e., driving in a tack) achievable through two different actions. For this emphasis, "driving in a tack" would be called a response function. I will return to this important point in the coming discussion (see p. 17).

Behaviour Segment as Field

Having clarified (and with the intention to shortly clarify further) the two central aspects of a behaviour segment, I now look at other factors. Besides being "bipolar acts" (1924, p. 36) or "symmetrical and reciprocal functions" (1959, p. 93), behaviour segments were viewed as "integrated systems of factors" (1921, p. 15) or "concrete field structures of confrontable elements" (1969, p. 382). As such statements suggest, Kantor emphasized that every behaviour segment involved the coming together or assemblage of many different participants or contributors in what he called an interbehavioural field or setting. In more detail, a behaviour segment, like any other event, "is regarded as a field of factors all of which are equally necessary, or more properly speaking, equal participants in the event" (1959, p. 90).

Factors participating in or contributing to[12] a behaviour segment (e.g., changing gear while driving) included the action of an organism (hand movements), a stimulus object (the gear stick), contact media (the tactile

[12] Although Kantor more often referred to factor *participation* than *contribution*, he used both terms, and I rely more on the latter because of its central usage by another of the theorists to be reviewed later in the paper (Lee), thus easing the upcoming integration. Also, while including the connotations of *participate*, the verb *contribute* carries the useful added connotation of *active* participation. Compare "participate: to take or have a part or share of or in" with "contribute: to do a part in bringing (it) about; to have a part or share in" (OED).

surfaces by which the stick is felt and the light by which it is seen), an interactional history[13] (a history of gear-changing experiences), and setting factors (e.g., the rev limit of the engine, an upcoming slope). When drawing attention to these factors, Kantor expanded R↔S to PE = c(k, rf, sf, hi, st, md), where PE stands for *psychological event*, "*c* indicates the inclusion of all necessary factors, *k* the specificity of the factors for particular situations, *rf* the response functions, *sf* the stimulus functions, *hi* the behavioural history of the organism, *st* the setting factors, and *md* the media of stimulation contacts ..." (1970, p. 106). This expanded formula should be read as a heuristic device rather than a mathematical formula. If interpreted as a mathematical formula it would be uncertain what to make of k and c. For k, or the specificity of the other factors, is placed inside the parentheses as if it were another factor, which it is not. Likewise, c could misleadingly suggest that the "inclusion of all necessary factors" was itself an additional function of these factors, which it is not. The formula is a compacted version of the statement "any psychological event entails the necessary inclusion of the following specific factors: rf, sf, etc."

On the relation among the different components of each behaviour segment or interbehavioural field, Kantor wrote "it is an essential rule that the primary interbehaving factors – for example, stimulus objects and [the actions of] organisms – must be interrelated to other factors, even though the latter are regarded as peripheral" (1959, p. 19). Further, the particular (response-stimulus) functions arising in any behaviour segment "are conditioned by the interbehavioral setting, which constitutes the framework of any particular behavior segment" (1959, p. 94).

Figure 1 portrays the behaviour segment in a diagrammatic fashion intended to help clarify its own internal relations and its relations to yet-to-be-reviewed units. Each C symbolizes one of the different factors contributing to any psychological event. Each arrow is a synonym for "contributes to." I will

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[13] Which resolved to *reactional biography* on the side of organism's action and *stimulus evolution* on the side of stimulus object.

shortly clarify the figure, which draws less on Kantor's own figures than his writings and specific examples of behaviour segments.

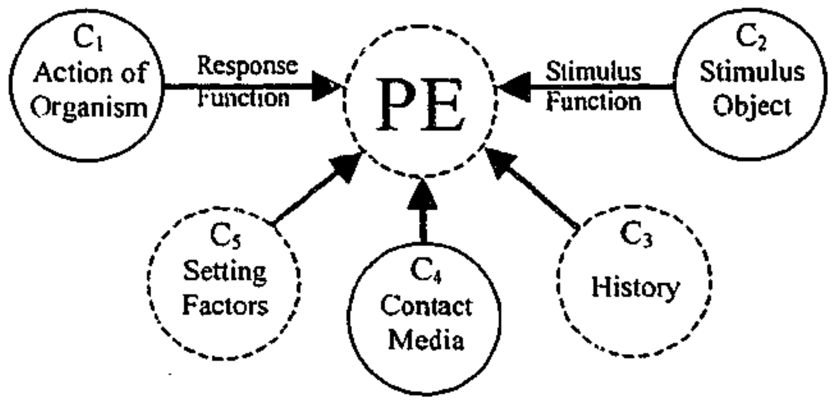

Figure 1: Kantor's behaviour segment unit, consisting of a psychological event (PE) and its many contributors ($C_{1\text{-}5}$), which for Kantor included the action of an organism (C_1), a stimulus object (C_2), interbehavioural history (C_3), contact media (C_4), and setting factors (C_5). Arrows mean *contributes to*, where the phrase "C_x contributes to PE" is synonymous with the phrase "PE is dependent on C_x" or "PE would not have happened without C_x." Note that *response function* designates the contribution of an organism's act to PE, and *stimulus function* designates the contribution of the stimulus object to PE. Continuous circles indicate accuracy of designation and dashed circles indicate ambiguity or vagueness of designation.

Is *Behaviour Segment* a Specification?

Having outlined Kantor's proposed unit for psychological analysis, I now explore the accuracy with which he designates that unit (where the name *specification* applies only to relatively accurate designation). Recalling that to designate is to point out or indicate, the first question is whether one can unambiguously indicate instances of behaviour segments by pointing them out. It will help to imagine oneself observing a psychological activity (e.g., a child writing a letter) while trying to indicate a behaviour segment to a co-observer naive to Kantor's writings.

At least some factors contributing to behaviour segments can be accurately and unambiguously designated. In Figure 1, such factors are indicated with continuous circles. We need not quibble over whether they are all accurately or unambiguously designated for present purposes, and I grant the sceptical reader some leeway with the dashed circles surrounding two of the factors leading into PE (the dashed circle surrounding PE being a separate matter to be dealt with shortly). In the example of co-observing a child writing a letter, the stimulus object (e.g., the notepad), certain actions of the organism (e.g., movements of the pen), and the media of contact (e.g., light from the window) are readily distinguished and agreed on. The same might be said of certain setting factors, such as the time being between that associated with coming home from school and going to bed, or the television being temporarily broken.

Then our co-observer says "you have indicated an action of the organism, the stimulus object, the contact media, and setting factors. But what about the behaviour segment you mentioned earlier?" To this, the interbehaviourist (a name inclusive of Kantor and other psychologists aligned with his system) replies "the behaviour segment is simply the way in which these things come together – their total interaction in the field." Believing that the groundwork is laid to designate the stimulus-response function at the heart of the behaviour segment, the interbehaviourist continues: "The stimulus function is how the notepad affects the child's interaction with it (the notepad), and is defined by its relationship to the interbehavioural field, especially to the response function, and not on the basis of the notepad alone. Conversely, the response function is how movements of the pen affect the child's interaction with the notepad, and is defined by its relationship to the interbehavioural field, especially to the stimulus function, and not on the basis of the pen movements alone."[14]

At this point the interbehaviourist receives a bewildered gaze from his or her originally keen-eyed co-observer. Something has gone wrong. Such definitions of behaviour segments and stimulus-response functions are obscure.

[14] These wordings adapted from Morris' (1982) definition of stimulus function as "how a stimulus affects an organism's interaction with it" where "stimulus functions are defined by their relationship to the interbehavioral field, especially to the response functions, and not on the basis of their stimulus forms alone" (p. 203). The reason I omit the helpful and arguably indispensable real-life example by which Morris clarified these definitions will become clear shortly.

This obscurity (and consequent bewilderment) is unnecessary, in that a more precise designation is present, though often implicit, in Kantor's writing. Let me substantiate this claim.

Though one can point out at least some of the (conceptually) separable contributors to a behaviour segment, there does not appear, at first glance, to be any thing to point out on top of these contributors (apart from making relatively vague references to their "total interaction" or similar). To review, the behaviour segment is a configuration of confrontable elements centering on a bi-directional relation between an action of an organism (in which inheres the response function) and a stimulus object (in which inheres the stimulus function). The resulting stimulus–response functional relation is defined with emphasis on the two central participants (stimulus objects and the actions of organisms) and then their various peripheral (but no less integral) accompaniments, which together make up a behaviour segment or interbehavioural field. In trying to point out a behaviour segment from its formal definitions, one's finger is drawn from the field of contributors to the functional relation at their center, then from the functional relation back to the field of contributors.

Consider something Kantor wrote in critiquing the traditional deterministic notion of *cause*: "The flame of a match in no wise determines or creates an explosion but only completes the syncrasy [i.e., the configuration] of the individual factors necessary for a certain event to occur, including the presence and flammability of the exploding materials" (1984, p. 29). Here Kantor points out that one thing, an explosion, cannot occur without an assemblage of other things, such as a lit match and a cask of dry gunpowder. These things are among the contributors to the explosion, just as stimulus objects and the acts of organisms are among the contributors to psychological events. For the explosion, however, there is a specifiable something (the explosion) that can be conceptualised *without explicit recourse* to that something's contributors (though their presence is implied). One can point out, count, and classify explosions without pointing out, counting, or classifying the contributors to explosions. Behaviour segments are different. In a behaviour segment, the closest equivalent to *explosion* is *stimulus-*

response functional relation or, more generally, *organism-object interaction*.[15] Yet Kantor, as outlined above, defines both of these with explicit reference only to their participants (and vice versa). Behaviour segments are "integrated systems of factors" or "complex interactions." *Interaction* points to *actions* and *actions* points to *actors*.

The path to firmer designation lies in the following observation. Whenever Kantor offers an example of a behaviour segment, organism-object interaction, or stimulus-response functional relation, he uses an everyday verb like *referring, driving, writing, wrapping, indicating, saying, moving*, or *pressing*. The role of such verbs in Kantor's writing is not trivial. Like explosions, one can consider the events designated by the verbs of everyday action language in conceptual isolation from their contributors. One can count and classify instances of writing a word, sentence, or letter, for example, without counting or classifying pen movements and notepads (which are co-present nonetheless).

This observation clarifies the designation of stimulus and response functions. Having designated a verb-occurrence (Labelled PE in Figure 1),[16] the response function is accurately designated as *the contribution an organism's action makes to that occurrence*, and the stimulus function as *the contribution a stimulus object makes to that same occurrence*. The two are inseparable because they designate the contribution of different factors to a single occurrence. To take away the stimulus object, for example, is to

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[15] Kantor listed criteria for distinguishing psychological behaviours, activities, reactions, or interactions from biological and physical interactions (e.g., 19[illegible], p. 5, Kantor & Smith, 1975, pp. 4-11). Note, however, that such criteria, as attributes of some interactions, are secondary to the problem of specifying the criteria for distinguishing an interaction in the first place.

[16] On this interpretation, separate names should be secured for the verb-designated action-occurrence (PE in Figure 1) to which the other factors contribute, and the sum total of all the factors inclusive of that to which they contribute (i.e., the entire figure). Where I have somewhat contentiously used *psychological event* for the first, *interbehavioural field* or *behaviour segment* appropriately encompasses the second and is consistent with Kantor's usage.

preclude the occurrence, and therefore to simultaneously preclude realization of both stimulus and response function. If no notepad, then no writing-a-letter. If no writing-a-letter, no notepad-contributing-to-writing-a-letter (stimulus function) and no movements-of-pen-contributing-to-writing-a-letter (response function). The increase in accuracy of designation speaks for itself.

Although the above differs in emphasis from Kantor's explicit formulation, it is consistent with his examples of stimulus and response functions (see especially 1938/1971, p. 47; 1942/1971, pp. 78-79; 1959, pp. 93-94). That is, the foregoing interpretation is not so much reading something new into Kantor as giving more emphasis to something ever-present but ordinarily implicit. In the following two paragraphs I review some relatively explicit statements of these points in Kantor's writing.

Consider some statements from a paper entitled *The Nature of Psychology as a Natural Science* (first published 1938). First, Kantor viewed the terms *stimulus* and *response* as referring to symmetrical poles or functions of unitary events: "...both stimulus and response are mutual and reciprocal phases of a single event which occurs under specific conditions" (p. 47). Second, Kantor used the stimulus function construct to illustrate the contribution of an (stimulus) object to these unitary events, just as he used the response function construct to illustrate the contribution of an organism's act: "the isolation of the stimulus-function phenomenon ... shows us the contribution of the stimulus object to a behavior event ..." (p. 45).[17] Third, these unitary events can be characterized (without explicit reference to contributors) as instances of the actions indicated by everyday verbs. Kantor's "in a chair there inhere numerous stimulus functions corresponding to the response functions of sitting in it, standing on it to reach something, etc" (p. 47) can be paraphrased as "a chair can contribute to *sitting down* or *reaching for something* among many other actions (e.g., throwing, hitting, lifting, etc)."

Consider next a statement from Kantor and Smith (1975) combining two of the above points. Kantor and Smith asked the reader to "reflect on how

[17] Cf. Lichtenstein's (1983) definition of *stimulus function* as "the specific role played by the stimulus object in the psychological event..." (p. 11).

much the outcropping rock *contributes*, through its various properties, to the *perceiving* and *judging* behavior of the geologist" (p. 33, all italics added). Here again is unambiguous support for a reading of Kantor such that his stimulus function (and reciprocally, his response function) most accurately designates the *contribution* of a stimulus object (or reciprocally, an organism's act) to a psychological event. Also in this statement, we find, again, that when Kantor designates a psychological event without explicit reference to its contributors, he relies on verbs from everyday action language (i.e., *perceive* and *judge*).

The foregoing suggests that bringing a verb-designated occurrence into the foreground increases the accuracy with which behaviour segments can be designated. This increase in accuracy of designation, however, remains at the level of characterization, falling short of specification. Although the verbs of everyday action language point out events, the verbs have relatively vague application criteria, and the events have relatively fuzzy boundaries. Whereas most English-speaking people can readily indicate an instance of "sitting on a chair," for example, discrepancies arise if they are asked when the sitting act starts and ends, and whether borderline examples (e.g., kneeling on a chair) qualify. For these reasons, Jacobs et al. (1988) repeatedly found their students unable to make consistent descriptions and classifications using what they called the "intuitive and informal classes of behavior" (p. 3) designated by everyday verbs. As I will stress later (and as argued by Dewey, 1930), everyday action language is an appropriate *starting point* for psychological analysis, as opposed to an appropriate *result* or *conclusion*.

Summary

Kantor's behaviour segment unit explicitly acknowledges the different factors contributing to any psychological event (many of these factors remaining neglected in contemporary psychology). Kantor accurately designates at least some of these contributors. Kantor's designation of the core event to which the factors contribute, however, is obscured with an over-reliance on relatively vague names like *organism-object interaction*.[18] This obscurity is ameliorated when we look at Kantor's examples of behaviour segments. These examples revert to the action verbs (as opposed to auxiliary verbs) of plain English. Accuracy of designation is advanced if the ingredients of behaviour segments are defined as contributions to events designated by names like *write* or *perceive*. Kantor's *stimulus function* designates the contribution of a stimulus object to such an event, and his *response function* designates the contribution of an organism's action to that same event. Because in its clearest designation the behaviour segment relies on the verbs of everyday action language, and because such verbs fall short of specification, Kantor's behaviour segment likewise falls short.

B. F. Skinner (1904-1990): The Operant

Skinner proposed the *operant* as a unit of analysis for psychology. The operant is best understood in the historical context of its development, which I now sketch.

Early in his career, Skinner (e.g., 1935; 1938) examined the *reflex*, traditionally understood as a response elicited by a stimulus, such as a knee-jerk elicited by a tap on the patellar tendon. Using such an example, Skinner (1935) reached a conclusion basic to his later work:

> [I]f we are to continue to regard the flexion reflex as a single entity, both the stimulus and the response must be taken (tentatively, at least) as class terms, each of which embraces an indefinitely large number of particular stimuli or responses but is sufficiently well defined by the specification of one or two properties. (p. 42)

In other words, after distinguishing instances of, say, "knee-jerk reflexes," two classes of different instances (i.e., one class of responses and one class of

[18] Dewey and Bentley (1949, e.g., p. 295-296) discussed the problematic ambiguity of the name *interaction* and the prefix *inter* as used in philosophy, psychology, and logic (though see Kantor's 1984, pp. 303-304 response).

stimuli) can be distinguished. These different instances differ in many ways (e.g., direction, amplitude, and latency, for responses), but have been classified on the basis of something they have in common. To define a knee-jerk reflex, one must clarify the basis for classification, that is, one must specify a criterion or commonality that unites otherwise unique instances. In Skinner's words, "...we assign a name to it [a recurring aspect of behaviour] which specifies (perhaps not explicitly) a defining property" (1935, p. 56) and "here again we merely specify what is to be counted as a response and refuse to accept instances not coming up to that specification" (1938, p. 37).

These quotations suggest Skinner was trying to specify units from the outset. He was soon to extend his approach to what is sometimes called non-elicited, purposive, or voluntary behaviour:

> The unit of a predictive science is ... not a response but a class of responses. The word "operant" will be used to describe this class. The term emphasizes the fact that behavior *operates* upon the environment to generate consequences. The consequences define the properties with respect to which responses are called similar.
>
> ... an operant is defined by an effect which may be specified in physical terms ... (1953, p. 65)

Thus, in the domain of voluntary behaviour, Skinner distinguished movements (e.g., instances of lever pressing), forming classes (e.g., "lever pressing"), and specifying a common effect (e.g., microswitch closure) by which the instances were designated instances of the same (operant) class. Most experimental work in Skinner's tradition uses proximal consequences like microswitch closure to define operants (as reported, for example, in the *Journal of the Experimental Analysis of Behavior*).

Skinner's operant is often described as a two-term contingency between behavioural particulars, called responses, and environmental particulars, called consequences (e.g., Schoenfeld, 1976; Sidman, 1986). An occurrence of the consequence is said to be contingent on an occurrence of the response. Operant contingency diagrams (and theoretical discussions) usually include a third term in the form of a preceding, *discriminative* (non-eliciting) stimulus (which in practice is never absent), but this term does not influence the present argument and will be omitted. The two-term contingency is illustrated in Figure 2 by the arrow leading from behaviour (B) to consequence (Cons) in the centre left of Figure 2. The other aspects of Figure 2 will be clarified shortly.

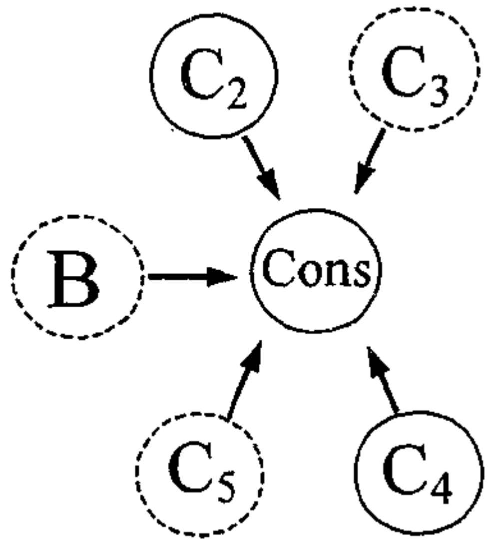

Figure 2: An illustration of a two-term contingency between a behavioural response (B) and its consequence (Cons). Also shown are further contributors the consequence depends on ($C_{2\text{-}5}$). Arrows mean *contributes to*. Continuous circles indicate accurately designated contributors and dashed circles indicate ambiguously or vaguely designated contributors.

Is *Operant* a Specification?

As we have seen, an operant is a class of responses, and not a spatially and temporally particular (i.e., observable) event. In other words, *this operant* is synonymous with *this class of responses*. A class is a logical entity that includes past, present, future, and non-actual possibilities. A class of responses is not an observable particular just as a class of trees is not an observable particular. You cannot point out a class of trees but only a particular tree or collection of trees (Lee, 1988, p. 31).

Here we must avoid a potential confusion. All particulars are instances (i.e., single cases) *and* members of classes. In Van Melson's (1961) words, "what we mean, then, by the species-individual structure of matter is the peculiar fact that every concrete material thing alongside its concrete individuality at the same time represents a certain species"[19] (p. 95). A name such as *book* identifies certain particulars (e.g., this book, that book) as exemplars of a more general class (i.e., books). Just as the designated particular is incomprehensible without the class it is a member of, the class is incomprehensible without the particulars it unites.

Now Skinner defines his operant unit as a class, rather than an observable particular, which, as just shown, simultaneously connotes the class of which it is a member. As a result, Skinner's operant remains always at one level of abstraction from particular occurrences. Where *book* applies on the one hand to individual books and on the other to the class *books*, *operant* applies on the one hand to individual (operant) classes and on the other to *operants* as a class of (operant) classes.

Accepting that the name *operant* is not a designation of any observable particular, but of classes of observable particulars, we can ask whether those particulars, responses, qualify as accurately designated units. To take an unambiguous example of a response, consider a lever press response. When one designates a lever press response, what observable particular is distinguished? There are at least two possibilities. The first is a movement of an organism's body or body parts. The second is a consequence or effect of that movement, here a microswitch closure. Though emphasizing movements, Skinner (1938) mentioned both kinds of particulars:

> By behavior, then, I mean simply the *movement* [italics added] of an organism or of its parts in a frame of reference provided by the organism itself or by various external objects or fields of force. It is convenient to speak of this as the action of the organism on the outside world, and it is often desirable to deal with an *effect* [italics added] rather than with the movement itself, as in the case of the production of sounds. (p. 6)

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[19] Here Van Melson uses *species* as a synonym for *classes*.

Both movements and effects of movements qualify as accurately nameable observable units. They can be independently distinguished, counted, and classified. However, there is much ambiguity in Skinner's writing, and in the operant literature at large, about whether the units underpinning response classes (i.e., responses) are movements, effects, or some combination. Surveying the operant literature, one finds responses defined as movements (e.g., Skinner, 1953, p. 64), effects (e.g., Stebbins & Lanson, 1962, p. 299), temporal gaps between effects (e.g., Ferraro & Grilly, 1970, p. 206; Margulies, 1961, p. 319; Notterman, 1959, p. 342), and combinations of activities (movements) and effects (e.g., Glenn & Madden, 1995, p. 241). Further, many theorists have discussed the problem of distinguishing movements from effects (Guthrie, 1940; Hamlyn, 1953; Jacobs et al., 1988; Kitchener, 1977; Ryle, 1971; Weiss, 1924; Zuriff, 1985, p. 44) and the way in which the term *response* blurs the distinction (Lee, 1988, p. 159; 1999a; Schoenfeld, 1976; Walker, 1942).

To summarize, an operant, as a class, is not an accurately designated (specified) observable unit. Further, the observable unit on which operants are predicated, the response, *is*, in formal definition and experimental application, ambiguous between two classes of specifiable referents – movements and effects of movements. So the operant is not designated with enough accuracy to qualify as specification.[20]

How do Operants Relate to Behaviour Segments?

Figure 2 suggests a novel conceptualisation of the relationship between the behaviour segment and the operant (for previous comparisons, see Hayes & Fredericks, 1999; Midgley & Morris, 1988; Morris, 1982; Parrot, 1983). Here Kantor's emphasis on the multiple contributors to psychological events is combined with Skinner's emphasis on the effects or consequences that define behavioural responses, leaving open the question whether responses are

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[20] Cf. Bentley's (1952) conclusion in a draft of a letter to Skinner about an early version of *Science and Human Behavior* (1953): "I am not able to say with any certainty what the word 'behavior' 'names' in your treatment" (Dated 2-22-52).

movements, effects, or a combination. As in Figure 1, the arrows feeding into the consequence indicate contributors without which the consequence would not have occurred. As an example, a particular instance of a particular lever depression at a particular moment by a particular rat, in the sense of the closure of a microswitch (i.e., a change in the state of the switch from off to on), couldn't happen without the rat, movement of the rat, the lever, a supporting floor, contact media, and so on. Where Skinner was primarily concerned with one of these contributors, which he named *behaviour* or *response*, Kantor emphasized them all.

V. L. Lee (1949-): The Deed

Lee (e.g., 1995; 1999a; 2000; 2001) suggests that an appropriate unit for psychology is the *deed*, defined as "...events (i.e., changes in a state of something) to which the individual's physical efforts (and much else) contribute" (2001, p. 49), or, in everyday language, "something finished, completed, done, or brought about by someone" (2001, p. 49).[21] When Lee defines a deed as a change she uses the word *change* in the specific sense of the meeting of a stipulated criterion:

> I use the word "change" to denote the moment of a difference in the state of a particular object (or surface or medium). For example, a button depression is the change observed at the *moment of a specified difference* [italics added] at a particular button (for example, 2550 milliseconds since session commencement). It is important to accept that I am talking literally and only about the change you would see if you looked at the button at that exact moment in time. Such changes either occur or do not occur. (Lee, 2000)

[21] For similar proposals see White and Liberty's (1976) *critical effect*; Newtson, Engquist, & Bois' (1977) *break-point*; Gilbert's (1978) *accomplishment*; Reed et al's (1992) *concrete functional result within a task*; Järvilehto's (2000) *result of behaviour*, and what Kemp (2002) has independently named *deeds*.

Starting with the events designated by the verbs of everyday action language, Lee developed the deed unit in refining clearer designations of these same events (here using *thing done* as a synonym for *deed*):

> Washing the dishes is something a person gets done. We would probably agree that the person has done that thing if (a) there were dirty dishes, (b) now the dishes are clean, and (c) that change in the state of the dishes would not have occurred without the person. The dishes have been done when a particular change in the state of the kitchen has been brought about (no dirty dishes, all dishes clean). You might say the person is now *doing the dishes* when you see her having effects that contribute to getting the dishes done (e.g., getting the sink full of water, getting successive dishes out of the water and onto the dish rack). However, you would not say she has *done the dishes* until the criterion implied above is met ... The specified change *is* the thing that the person gets done (i.e., completed, achieved, accomplished). (1999a, pp. 68-69)

Reminiscent of Kantor's emphasis on the multiple contributors to behaviour segments, Lee stresses that deeds always have many contributors, including an organism (e.g., a human) and a thing changed (e.g., a gear stick). For Lee (2001), deeds "are at the same time of the organism *and* the environment: They are events that have the physical efforts of the participant's body and much else as their constituents" (pp. 64-65, see also 1996a, p. 159). Accordingly, Lee (personal communication, 21 November 2002) considers a deed a *completion* in two senses: First in the sense of meeting a criterion, and second in the sense of completing the configuration of contributors necessary and sufficient for the occurrence of a deed.

To summarize, Lee's deed is a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one organism among many other contributors. Figure 3 diagrams a deed along with its many contributors. Arrows again mean *contributes to*.

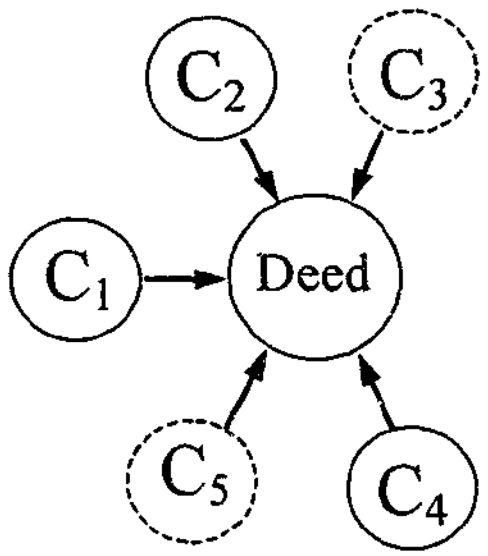

Figure 3: A diagram of Lee's deed and different contributors ($C_{1\text{-}5}$). Arrows mean *contributes to*.

Is *Deed* a Specification?

Because a deed is equivalent to the meeting of a well-stipulated criterion, *deed* is a specification. Such deeds as changes in the state of a lever from up to down, changes in the state of food from absent to present, or the completion of successive words when writing, can be designated (i.e., indicated, distinguished, pointed out) without ambiguity or vagueness. Relatively speaking, Lee's unit designation is accurate enough to qualify as specification.

How do Deeds Relate to Operants and Behaviour Segments?

A primary difference between the deed and the previously reviewed units stems from the different starting points of their developers. Kantor and Skinner started and remained with the traditional (borrowed) terminology of *stimulus* and *response* and the corresponding dichotomies of organism and object (Kantor) or behaviour and environment (Skinner). In a landmark article, Kantor (1921) wrote "what are these fundamental [psychological] data? Obviously, responses to stimuli" (p. 253). Despite recognition that "the terms [*stimulus* and *response*] are not used with precision" (1933/1971, p. 82), he stuck with them, attempting to pin their usage down in the context of his behaviour segment. Turning to Skinner, we saw earlier that he reached his conception of the operant while (a) trying to make sense of his data, and (b) interpreting the reflex as a correlation between classes of stimuli and responses. As a result, the operant is inconceivable without reference to stimuli, responses, and behaviour-environment relations.

In contrast, Lee began not only with an attempt to make better sense of operant data (more below), but with the events designated by everyday action language, and with common dictionary definitions of names like *behave*, *act*, and *do*.[22] Unlike Kantor and Skinner, Lee does not find the terms *stimulus* and *response* helpful in developing sharper designations of such events. She argues that they are ambiguous and misleading, that they "bring difficulties to psychology that cannot be answered by finding better ways to define them" and that "we must eliminate them from our technical vocabulary" (Lee, 1988, p. 159). To sum up, where behaviour segment and operant rely on the names *stimulus* and *response*, a defining feature of the deed is their explicit rejection.

A related general contrast between the deed and the other two units concerns things people get done together, or what Järvilehto (2000) named *common results*. Consider a change in the location of a large rock to which three people contribute simultaneously. For Lee, this is as much a deed as deeds to which just one organism contribute:

> If things done [i.e., deeds] ... are the single cases [i.e., units] in psychology, then it does not matter whether a thing is done by one organism acting alone or by two or more organisms acting together. What matters is that the thing is done (i.e., that the particular change occurs). (Lee, 1994, p. 17)

Operants and behaviour segments, by contrast, are defined as responses emitted by individual organisms (operants) or as stimulus-response functional relations to which the action of an individual organism and a stimulus object simultaneously contribute (behaviour segments). Any link to common results is indirect, and must be interpreted as combinations of separate operant responses or behaviour segments. Direct applicability to mutually achieved outcomes is an advantage of Lee's unit given their centrality in everyday life.

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[22] Consider the OED's leading definition of *act*: "A thing done; a deed, a performance (of an intelligent being)."

Turning to contrasts between the deed and the operant, the two differ in several important ways. This is not surprising given that the deed unit was developed, in part, from Lee's criticisms of the operant (e.g., 1996b; 1999a) and her attempts to more adequately conceptualise the data (i.e., event records) collected in operant experiments (e.g., 1996a; 1999b; 2001).

First, in accord with the earlier discussion of the operant, "...a thing done [i.e., a deed] is a single case. particular instance, or a unit whereas a functional class (or an operant) is a class" (Lee, 1994, p. 33). The time and place of a deed can be stated (e.g., this door in this building changed in state from open to closed at 11:04:45 am today), which is not true of a class of responses defined by a common effect (i.e., an operant). As Roche and Barnes (1997) put it, "the operants that comprise behavior have no boundaries in the physical world" (p. 610). Moreover, even a response member of an operant class cannot be unambiguously bounded in space and time. If a response is defined as a bodily movement effecting a microswitch closure, for example, it is possible to say when the response ended (i.e., at the moment of closure) but not when it began.

A second difference relates to the above discussion of a lever depression in which a bodily movement was contrasted with an effect or consequence of that movement. Of these two phenomena, Skinner was ambiguous (but tended toward movements). In contrast, Lee explicitly specifies what is ordinarily called the *effect*: "The changes brought about by one or more organisms comprise a subject matter that is distinguishable from the motions of the body segments and from the activities of other parts of an organism's body" (Lee, 1992, p. 19).[23] It was partly from acknowledging movement-effect ambiguity in the word *response* (also *behaviour*) and the "need to find words that denote

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[23] Cf. Guthrie (1940): "There is little use for the prediction of movements alone, and there exists almost no vocabulary for their description. To try to describe behavior by naming the muscles in use and the degrees and order of their contraction would be absurd. It is the changes brought about by movements, changes usually in the environment and not in the organism, that are of practical importance, and theories of behavior must somehow bring acts as well as movements into their predictive laws and principles" (p. 127).

our subject matter more precisely" (1994, p. 11) that Lee explored different designations, including *act* (e.g., 1988), *thing done* (e.g., 1996a), and *deed* (e.g., 2001).

As a third difference, Lee's use of the term *deed* includes more than the term *consequence* or *effect* in Skinner's sense. Consider the respective interpretations Skinner and Lee make of a cumulative record. A cumulative record is a visual representation of how at least two classes of events are distributed through time. In most of Skinner's research (e.g., Ferster & Skinner, 1957; Skinner, 1938) each increment in the slope corresponded directly to the closure of a microswitch, and each slash corresponded directly to the operation of a food dispenser. Whereas Skinner argued that an increment followed by a slash represented a *lever pressing response* followed (and potentially reinforced) by an *environmental consequence*, Lee argues that both the represented events are more accurately specified as units of the same logical type - deeds. Lee sees in the data files records of what Skinner would call effects, results or consequences, *and nothing else*. Lee's deed designation unifies what are traditionally seen as fundamentally different kinds of events (responses of the organism versus consequent environmental stimulation). For Skinner, some recorded events were of the organism (behavioural responses) and other recorded events were of the environment (antecedent and consequent stimuli). For Lee, all recorded events are deeds, which are indivisibly of organism *and* environment, in the sense of depending on contributions bodily *and* worldly. In Lee's (1994) opinion, "the units represented by psychological data are distorted by theories that partition psychological phenomena into two parts corresponding to organism and environment" (p. 32). Where Skinner advocated the elucidation of functional relations between behavioural responses of the organism and their environmental consequences (and antecedents), Lee is concerned with the internal organization of the domain of deeds (meaning an interest in classifications of deeds and in relations or patterns between the resulting subclasses of deeds) (Lee, 1992, p. 1341; 1994, p. 35). The difference in emphasis has important implications for the analysis and interpretation of experimental data (see Lee, 2001, for a recent example).

Moving to the relation between the deed and the behaviour segment, the first thing to note is that Lee's deed unit allows sharper specification of the verb-characterized occurrences on which the behaviour segment relies. This is achieved by specifying the criteria to be met before an action is said to have occurred. The characterization "washing the dishes," for example, is more accurately designated as a change in the state of the dishes from dirty to clean. If necessary, the designation can include nested deeds like a change in the state of an individual cup from dirty to clean, or a change in the state of the hot tap from open to closed. The resolution with which deeds are designated depends on the requirements of the inquiry.

Second, Lee resembles Kantor in explicitly acknowledging the many factors contributing to any instance of the deed unit. Take the earlier example of driving in a tack. From Lee's perspective, different objects (hammer, brick, etc.) and different movement patterns (pushing, tapping, etc.) are conceptualised as potential contributors to the same deed (a change in the state of the tack head from protruding from to flush with the relevant surface). That deed can be taken in conceptual isolation from the many contributors Kantor carefully categorized.

Third, where Lee is concerned with classifications of and relations between deeds, Kantor was more interested in systematizing the factors contributing to individual behaviour events (i.e., their internal organization). For Kantor (1959), "events are scientifically described by analyzing [their] participating factors and finding out how they are related" (p. 90). To sum up, Kantor clarified the contributors to events he characterized at the relatively inaccurate resolution of everyday action language. Adopting a compatible conceptualisation of contributors, Lee more accurately designates (and thus specifies) these same events.

A Preliminary Integration of the Three Units

Having outlined and contrasted the psychological units proposed by Kantor, Skinner, and Lee, I now explore possible benefits accruing from their selective integration. I have argued that the behaviour segment and the operant (or, for that matter, the response) are relatively vague (the behaviour segment), are not designations of *individual* units (the operant), or are ambiguous (the response). I have also argued that Lee's deed *is* a sharply specified individual unit.

Figure 4 suggests a preliminary integration of the behaviour segment, the operant, and the deed. The figure retains Kantor's concept of a field of contributors and Skinner's contingency as a functional (if-then) relation between two subclasses of events. Lee's deeds, however, are the event subclasses so related. In accord with the above discussion, Figure 4 shows an instance of the deed subclass on the left (e.g., microswitch closure) as among the many contributors to an instance of the deed subclass on the right (e.g., a change in the state of food from absent to present).

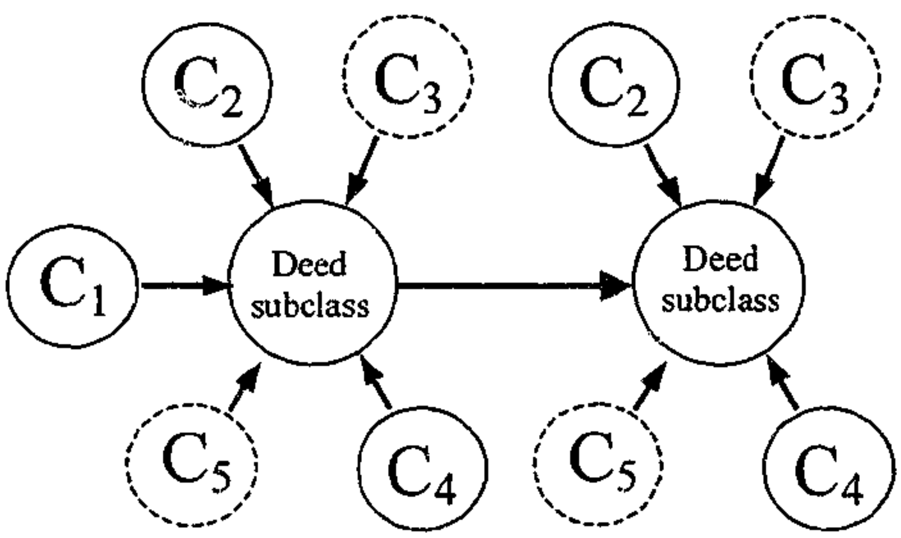

Figure 4: A dependency between two subclasses of deeds, where an instance of the subclass to the right (e.g., a change in the state of food from absent to present) depends on an instance of the subclass to the left (e.g., a change in the state of a microswitch from off to on) as one of its many contributors (i.e., as its C_1). Arrows mean *contributes to.*

The three central features of the integration are as follows. First, Figure 4 centres on deeds in Lee's sense of moments of stipulated difference (i.e., changes) in the states of objects, surfaces, or media contributed to by the physical efforts of at least one organism. Recall that a deed is binary in that it exists at and only at the moment a stipulated threshold or criterion is reached. Further, subclasses of deeds are specifiable, such as "changes in the position of the computer mouse" and "changes in the position of the cursor on the computer screen" instances of which can then be related to each other.

Second, the integration incorporates Kantor's emphasis on the many contributors to psychological events, represented with the Cs (Figure 4) leading into each deed subclass. It localizes psychological events in contributor fields including at least one organism and many other factors.

Third, the integration retains what Skinner interpreted as response-consequence contingencies as dependencies between subclasses of deeds. It is such a dependency by which a change in the orientation of a car's steering wheel contributes to a change in the angle of the front wheels (along with other contributors to that event). It is another such dependency by which that change in front wheel angle contributes to a change in the lateral displacement of the car on the road.

Causality

The integration in Figure 4 supports a systemic yet experimentally manageable conception of causality. Where interbehaviourists have found Skinner's operant compromised by its adoption of "environmental determinism" and "traditional causal philosophy" (Parrot, 1983, pp. 113-114), operant psychologists have expressed concern that Kantor's behaviour segment is too all encompassing for any causal analysis. As Marr (1984) put it, "Kantor's view may properly characterize the reality of the behavioral world, but it is difficult to see how an *experimental analysis* can be conducted in the midst of such chaos" (pp. 194-195, though see Smith, in press, for a review of behaviour segment based experimental research). The present integration neither rejects causal analyses nor accepts simple one-way linear causality, as detailed next.

A deed depends on the assemblage of its contributors in real time. To say a deed depends on one of its contributors is to say that deed would *not* have occurred *without* that contributor.[24] As Kantor wrote of the relation between a lit match and an explosion, the match merely completes the configuration of items on which occurrence of the explosion relies. If there is to be talk of *causes* in such a context, the term can only refer to what Weiss (1978) called "negative observations; a cause is a phenomenon *without* which an expected correlated change in nature would *not* take place" (p. 14, for similar perspectives, see also Ackoff & Emery, 1972, pp. 22-23; Kotarbinski, 1965, p. 15; Whitehead, 1920, pp. 143-144).

Where some inquiries examine the contributors to individual behaviour events, other inquiries examine dependencies between different behaviour events; events here named deeds. In discussing a complex set of dependencies between events qualifying as deeds, Oyama (2000) explained as follows:

> These multiple dependencies ultimately make the metaphor of the linear chain inapt, though a scientist may excise part of the process to analyze it as if it were an isolated chain running off autonomously against the background of the rest of the system. To do so, however, all of that background must be held constant (treated as *given* as well as kept from varying) ... (p. 123)

This is precisely what happens in a traditional operant experiment. Contributors such as deprivation (which Kantor would call a setting factor), lighting (Kantor's contact media), operanda (such as a lever which for Kantor is a stimulus object) and so on are held constant and thereby relegated to background. This allows a focus on relations among selected deed subclasses – for example, among changes in the state of a backlit disk from green to red, changes in the state of a lever from up to down, and changes in the state of food from absent to present.

This treatment of causality, in which the word *cause* is omitted or used cautiously as a synonym for *one of many contributors*, extends to the complex

[24] Consider here Dewey's (in Dewey & Bentley, 1949) comment that "the words 'not without' are golden words..." (p. 286), concerning the observation that the fiddler and the fiddle are equally critical partners in (i.e., contributors to) the fiddling.

networks (i.e., patterns among deed subclasses) into which everyday human lives can be analysed. As Lee (1994) put it, deeds "constitute a vast and changing domain that is spread through time and across space and manifests a remarkable density (i.e., events per unit time) and diversity" (p. 32).

Imagine an observational apparatus enabling a birds-eye view of a spatially and temporally circumscribed region of such a domain or network. An example would be the deeds occurring in a classroom between time x and y, or the deeds directly contributed to by a particular person between time x and y. Further, imagine a resolution at which the observed deeds are interesting yet comprehensible in quantity (e.g., include words spoken but not phonemes articulated, steps taken while walking but not mid-step stages). Because such visualization captures enormous quantities of deeds, imagine the apparatus displays deeds as they occur (as coloured dots on a screen, perhaps), gradually fading them out as time accrues. Train the apparatus on deeds contributed to by one person during the morning ritual of getting-up-and-going-to-work. From our birds-eye perspective, we observe a fuzzy cloud of interrelated events going from bedroom (e.g., alarm off, light switch on, body out of bed), to bathroom (e.g., hair combed, teeth brushed), to kitchen (e.g., toast cooked, newspaper read, breakfast eaten), to garage (e.g., trash out, engine started, reverse gear engaged), to road (e.g., horn sounded, pedestrian avoided), to elevator (e.g., button depressed, door opened), to office (e.g., computer switched on, email retrieved), and so on.

To sum up, the present integration accords with a systemic, non-linear conception of causality enabling complex dependencies between instances of deed subclasses to be mapped out in space-time.

Summary and Conclusion

I have applied Dewey and Bentley's (1949) account of naming to the problem of specifying psychology's observable units. In doing so, I have reviewed and preliminarily integrated Kantor's behaviour segment, Skinner's operant, and Lee's deed. Accurately designated aspects of all three units were combined in the postulation *dependencies* (Skinner, Lee) *between subclasses of* *deeds* (Lee) *with multiple contributors* (Kantor, Lee). This postulation was shown to accord with a systemic, non-linear conception of causality.

I hope these conclusions will be read in the spirit with which they were reached. I have not advocated one unit as *the* unit, or one terminology as *the* terminology. I have converged on one unit as *a* (potentially useful) unit and one terminology as *a* (potentially useful) terminology. In doing so, I have aimed at what Dewey and Bentley (1949, p. 162) described as "the combination of firmness and flexibility in naming that consolidates the advances of the past and opens the way to the advances of the future."

CHAPTER 3: EXTENDING THE INTEGRATION TO A FORTH UNIT

The previous chapter proposed an integration of Kantor's *behaviour segment*, Skinner's *operant*, and Lee's *deed.* This chapter extends the integration to Powers' *control system.*[25]

W. T. Powers (1926-): The Control System

Powers is the founder of Perceptual Control Theory (PCT). PCT begins with the observation that organisms expend effort to control variables, where *control* means *maintain against perturbation or disturbance.* When someone drives, for example, one of the variables controlled is lateral displacement of the car. Powers (e.g., 1973) argues that such control underlies all behaviour, and that it can only be understood by thinking in circles.

To continue with the same example, if a sudden crosswind should start changing the lateral position of the car to the left of lane centre, we would observe the driver (almost simultaneously) changing the orientation of the steering wheel clockwise, thereby changing the orientation of the front wheels and in turn the lateral displacement of the car, with the (correctively) changing displacement occasioning further changes in the orientation of the steering wheel, and so on.

Accordingly, the basic unit in PCT is the *control system* or *negative feedback loop.* This unit is a generic template symbolizing invariant relations inherent to the control process, consisting of an organization of numerical variables related by mathematical functions. In Powers' (1990a) words, "we have defined our system as a system of variables which depend on each other

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[25] As explained in the précis of Part 1, the control system was originally included in Chapter 2. On the advice of an anonymous reviewer (of the published version of Chapters 1 and 2), however, the analysis of Powers' unit has been allocated a separate chapter. In this reviewer's opinion, Powers' unit was different enough from the units of Kantor, Skinner, and Lee to justify a separate paper.

in particular ways. The variables come to states satisfying all relationships at once" (p. 56). Figure 5 is a block diagram of a control system (adapted from Powers, 1973, p. 61; 1990a, p. 52).

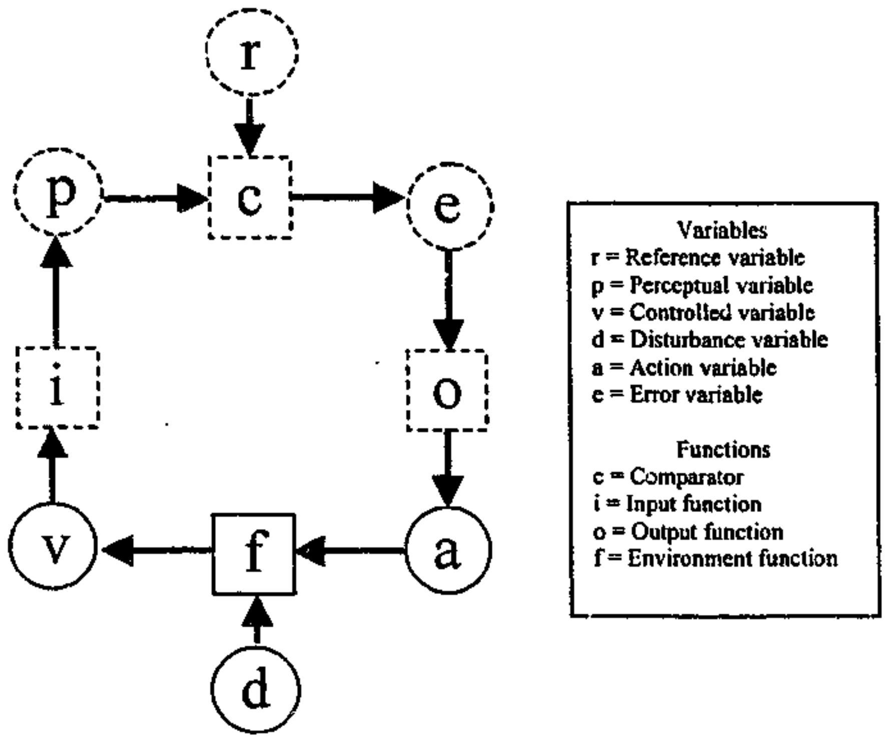

Figure 5: The control system unit of organization. Circles represent variables; boxes represent mathematical functions relating variables. The value of any variable is determined by the arrows feeding into it. Continuous outlines indicate observable system components and dashed lines indicate inferred system components. See text for details.

In working through Figure 5, keep in mind that "in a block diagram, the value of every variable is completely determined by the effects shown by arrows that reach it" (Powers, 1990a, p. 45). Figure 5 represents variables with circles and (mathematical) functional relations between variables with boxes.

We start with v, which Powers calls the *controlled variable*. In our example, the controlled variable is lateral displacement of the car on the road (assume that lane centre = zero displacement). While driving is in progress, this variable (as for all the variables) always has a value. The value of the controlled variable (v) is a mathematical function (f) of the action (a) and disturbance (d) variables. Orientation of the steering wheel is a suitable example of an action variable. The disturbance variable represents any non-system influence on the controlled variable, such as a change in the curvature of the road, a strong crosswind, or an angled rut or pothole. Next, working counter-clockwise around the loop, note that the action variable (a), is a function (o) of the error variable (e), where o and e (and for that matter, i, p, and c) are unobserved hypothetical factors in the feedback loop. Next, we turn to what determines the value of the error variable, noting that it is a combined function (c) of the reference (r) and the perceptual (p) variables. The value of the reference variable is defined empirically as "...the position of that [controlled] variable along its range of variation at which no action will be taken to change its value, magnitude, or state" (Powers, 1990b, p. 39). In our example, the reference value of lateral displacement is zero. The c function is called the comparator. The comparator subtracts the perceptual variable from the reference variable. It is this subtraction that makes the feedback negative. If the perceptual variable and the reference variable have the same value, the error variable will have a value of zero. Finally, note that the perceptual variable is a function (i) of the controlled variable, returning us to our point of departure and closing the loop. Note once again that the variables in the loop do not change one after the other in a simple linear sequence. All variables are often changing at the same time to keep all functional relations intact. Only the disturbance and reference variables are able to change independently of other variables, as on the occasion of a sudden curve, or a reference value change during a passing manoeuvre.

The control system is describable in a pair of simultaneous equations ($a = c(p-r)$ & $p = f(a + d)$ for a linear system) used in working computer simulations of real life tasks.[26] The success of control system models warrants detailed attention despite the partly hypothetical componentry that might otherwise disincline behavioural psychologists.

Is *Control System* a specification?

There are two reasons for concluding that the control system, as a circuit of functionally related variables, is not designated with enough accuracy to

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[26] See www.mindreadings.com for interactive examples

qualify as specification. First, most of its components (the input, output, and comparator functions along with the reference, perceptual, and error variables) are inferred from the remaining components, and cannot be pointed out. Here Powers' logic runs as follows: if a variable or function is (a) in the (working) control system model and (b) is not observable, then it must be internal/physiological.

As an example, PCT infers the maintained state (e.g., car in lane centre) from observable activity and then linguistically inserts it into the head as the goal or *reference variable*.[27] Powers (1990a) exemplified this logic when he asked "so how are we to get this "should-be" position into the model without pretending that there's something in the environment which we can't actually observe? We put it in the subject..." (p. 52).[28] This is reasoning many writers have explicitly rejected. Dewey (1922/1957) used the word *end* in the sense of *goal* to argue that "...ends arise and function *within action* [italics added]. They are not, as current theories too often imply, things lying beyond activity at which the latter is directed" (p. 207). Tolman (1932) argued that purpose and cognition were "defined by characters and relationships we observe out there in the behavior" (p. 19). For Ackoff and Emery (1972), "beliefs, attitudes, and traits are attributed to an individual because of what he does. These properties are derived from perceived regularities of behavior under varied but specified conditions. Such concepts do not lie behind behavior, they lie in behavior" (p. 6).

A second example lies in PCT's interpretation of the perceptual variable. Powers interprets perception as an internal representation of something external. He argues, "all control, artificial or natural, is organized around a representation of an external state of affairs" (1976/1989, p. 113). Powers

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[27] Cf. Bentley (1941c): "...behaviors should be investigated where they *are* – that is, where observation of them is made – without limitation to spots where grammatical convenience guesses them to be" (p. 11).

[28] See Chapter 4 (p. 63) for an illustration that what Powers means by "the subject" is the organism in the sense of the skin-bounded body.

equates the perceptual variable with a *perception* (a noun originating from the verb *perceive*), which he defines as follows:

> A "perception" means a neural current in a single fiber or bundle of redundant fibers which has a magnitude that is related to the magnitudes of some set of primary sensory-nerve stimulations. I suspect, though I cannot prove, that every distinct object of awareness *is* one such neural current. (1973, p. 35)

Such interpretations have been criticized elsewhere (e.g., A. F. Bentley, 1950; Gibson, 1979/1986; O'Regan & Noë, 2001; Reed, 1982), and have no basis in the consensibly observable facts of psychological situations.

As a third example, consider Powers' brain-centrism. For Powers, behaviour is an external manifestation of internal brain phenomena:

> During the past 25 years, there have been many attempts to construct models of the *brain phenomena underlying behavior* [italics added]. My model represents another attempt. (1973, p. 16)

> The only way to account for what we see happening [in a behavioural, computer-based spot-target control task]... is to turn our attention to the *real* cause of these events, the brain, and to try to guess how it does these things. (1973, p. 59)

Contrast these sentiments with those of Dewey and Bentley (1949):

> "Mind," "faculty," "I.Q.," or what not as an actor in charge of behavior is a charlatan, and "brain" as a substitute for a "mind" is worse. Such words insert a word in place of a problem, and let it go at that; they pull out no plums, and only say, "What a big boy am I!" (p. 132)

Again, we find Powers pursuing speculations removed from the observable subject matter under consideration (i.e., an instance of keeping a car on the road). Despite the impressive "plums" Powers has pulled out by way of working models and accurate predictions, his attribution of observable behavioural patterns to the brain (i.e., his brain-centrism) does not provide the consensible starting points the present project is looking for. The present project is an attempt to formulate what psychologists see, not to hypothesise about hidden inner causes of what psychologists see.

There is a second reason that the control system is not designated with enough accuracy to qualify as specification. The so-called outside (controlled, disturbance, and action) variables are not in themselves observable (and thus specifiable) occurrences. Take the action variable, which in the present example corresponds to steering wheel orientation. Steering wheel orientation is something that differs. If we like, we can measure it, quantifying different orientations on a standard numerical scale (e.g., rotational degrees from upright). The quantity resulting from measurement at any moment is what I have been referring to as the value of the action variable (likewise for the controlled and disturbance variables). As changeable quantities resulting from measurement, these variables are mathematical abstractions calculated from recorded events, as opposed to the events themselves. This status applies equally to the functions by which the variables are related.

Given that the control system and its componentry designates no observable individual occurrences, appearing more akin to a law or quantitative summary of observed invariance in relations between such occurrences, one is left anticipating a statement of what those occurrences are. In Powers' (1973, p. 288) terms, we are left anticipating what "physical phenomena" the relevant variables, as "meter-readings" are "associated with." It is a problem of formulating what we see when we look at an instance of someone controlling something.

One workable solution is directly extractable, I suggest, from something Powers wrote in 1973:

> The subject can be said to control a variable with respect to a reference condition if every disturbance tending to cause a deviation from the reference condition calls forth a behavior which results in opposition to the disturbance. (p. 47)

Here Powers is implicitly designating the distinguishable and consensible occurrences by which the control process is realized. He distinguishes three classes of events. Following Powers, I first describe these events as changes in the values of (quantitative) variables. I then describe them as the observable changes quantified by these variables and their value changes.

The first class of events is *disturbances* (changes in the value of the disturbance variable), which as shown above are non-system changes resulting in *deviations from the reference condition* (of the relevant controlled variable). These deviations are instances of a second class of events, namely *changes in the value of the controlled variable*. The class *changes in the value of the controlled variable* includes changes both approaching and deviating from the reference value of that variable. Powers wrote that during the control process, deviations from the reference condition of the controlled variable call forth instances of a third class of events, namely *behaviour*. Powers clarified what he meant by the term *behaviour* in the following statement: "Behaviors are not muscle actions, but *consequences* of muscle actions. We reproduce *outcomes*, not efforts" (1990b, p. 33). The terms *consequence* and *outcome* imply that something is different because of a muscle action, or in other words, a change has happened that would not have happened in the absence of those muscle actions. In the control system model, these changes ("behaviours") correspond to changes in the value of the action variable. So the third class of events distinguished by Powers are *changes* (i.e., *behaviours*, *consequences* or *muscle-action dependent outcomes*) that result in *opposition to the disturbance* (i.e., corrective *change* in the controlled variable). Such results are instances of the second class of events just outlined.

On this interpretation, the phenomenon of control consists of changes ("disturbances") that contribute to changes ("deviations") in a variable, which contribute to further changes ("behaviour"), which in turn contribute to corrective changes in the variable ("opposition to the disturbance"). The second two classes of changes are organized in a circuit, with the first class (disturbances) contributing to instances of change in the variable, which in turn contributes to (corrective) change in itself via an instance of the class of changes Powers calls *behaviour*. If this system of relations among changes holds, then the variable is said to be a controlled variable.

Here I have distinguished observable occurrences underlying the control system unit of organization.[29] For each quantitative value change in each of these variables (disturbance, controlled, and behavior/action) reflects an observable change that can be indicated by pointing. Further, each of these observable changes is a *change in state*, where a change in state presupposes at least two states (such as at least two road curvatures, at least two steering wheel orientations, and so on). To the extent that states can be mathematically quantified as variables with values falling on continuous dimensions (or indexes of difference),[30] changes in the values of quantitative variables represent changes in state.

I argue that the observable particulars underlying the control system are not mathematical variables or changes in their values but *state changes*, which can be dealt with quantitatively as changes in the values of relevant variables. Empirically, perceptual control theory deals not so much with the orientation of the steering wheel or the displacement of the car, as with changes in the state of these objects and invariant relations among these state changes and the other classes of changes comprising the loop. If not for state changes and systematic relations among state changes (as represented by changes in the values of variables), there would be no control process, no calculable reference value, and so forth.

This interpretation does not fall into the class of misinterpretations, often critiqued by Powers (e.g., 1979b, p. 142; 1988, p. 14), which take the control process as a circular *sequence* of discrete causes and effects or stimuli and

[29] Note the contrast in emphasis. Powers argues the control system model is physically realised in the brain and that it underlies what is seen. The argument here runs in the opposite direction: what is seen underlies the control system model as a descriptive summary of what is seen.

[30] Cf. Handy and Harwood (1973/1999) "Differences sometimes labelled 'qualitative' simply are differences noted. Differences sometimes labelled 'quantitative' are differences reported more accurately by measurements, recorded usually in number" (p. 23).

responses, each preceding the next. In the present interpretation, changes can be occurring simultaneously in all parts of the loop. At the same time, changes contribute to and are contributed to by other changes in the loop. Think about the relation between changes in the location of a computer mouse and changes in the location of the cursor on the screen. Each change in mouse position that the computer is able to detect contributes to a virtually simultaneous change in cursor position. As Shotter (1984) put it, "all the 'parts' of continuously functioning feedback loops... are (1) in operation simultaneously, yet the feedback function depends upon (2) the co-ordination of a temporal succession amongst them" (p. 202).

A second objection a perceptual control theorist might make to the present interpretation is that it ignores the perceiving organism – that it omits the *Perceptual* from *Perceptual Control Theory.* Rather than ignoring the importance of perception in the control process, however, the present interpretation emphasizes those particulars unambiguously available to a community of scientific observers. Lateral displacement could not be maintained if the driver could not see the road, and it is more directly changes in perceived lateral displacement than changes in lateral displacement per se that contribute to changes in steering wheel orientation. To discuss the control process without explicit reference to perceptual occurrences does not deny their necessary contribution.

To sum up, rather than constituting a specification of an observable unit, the control system is akin to a mathematical summary or law describing dynamic relations among observable units. Further, inspection suggests the observable units underlying Powers' control system are state changes consistent with Lee's specification of a deed.

Integrating all Four Units

I now integrate my analysis of Powers' *control system* with the earlier integration of Kantor's *behaviour segment*, Skinner's *operant*, and Lee's *deed* (See p. 31). The earlier integration was designated *dependencies between subclasses of deeds with multiple contributors* (Figure 4). How might Powers' emphasis on closed loops be combined with an emphasis on dependencies between subclasses of deeds? Figure 6 is one suggestion, portraying feedback loops generically as *circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes.*

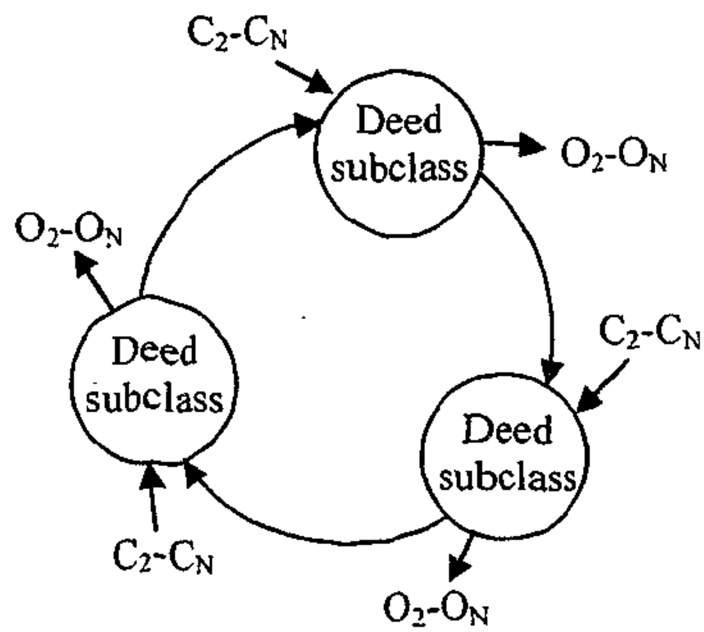

Figure 6: A circular patterning of dependencies between subclasses of deeds. Arrows mean *contributes to.* Each instance of each deed subclass has many contributors ($C_{2\text{-}5}$) and contributes to many other events or outcomes ($O_{2\text{-}5}$).

Figure 6 shows how deed subclasses can be related in trains of dependencies that are circular. In Figure 6 an instance of one deed subclass contributes, through intervening instances, to a successive instance of itself (cf. Ashby, 1960, p. 50; Bateson, 1979, p. 104). A change in the orientation of the steering wheel when driving contributes to a change in the angle of the front wheels, which contributes to a change in the lateral displacement of the car, which contributes to a further change in the orientation of the wheel, and so on. Because such feedback patternings are one of many possible configurations of interconnected deed subclasses, they remain consistent with the conception of causality discussed on p. 33 (cf. Rosenblueth, Wiener, & Bigelow, 1943).

Besides the many factors contributing to any instance of a deed subclass, Figure 6 incorporates (after Powers, Lee, and Dewey) the many non-focal outcomes contributed to by any instance of a deed subclass. Such outcomes were referred to by Dewey (1922/1957) as "the plural effects that flow from any act" (p. 212) and by Powers' (1990b) in statements such as "any act has many visible consequences ..." (p. 35). The Os leading out from each deed subclass in Figure 6 represent such outcomes. An example is a bug unknowingly squashed when a step is completed while walking.

The integration postulated here retains previously discussed features of the behaviour segment, operant,[31] and deed (See pp. 31-33). It draws on Powers' circular control system in designating a pattern of dependencies between deed subclasses that form a circuit. Figure 7 further incorporates Powers' unit in showing how this designation applies to the earlier example of maintaining lateral displacement while driving.

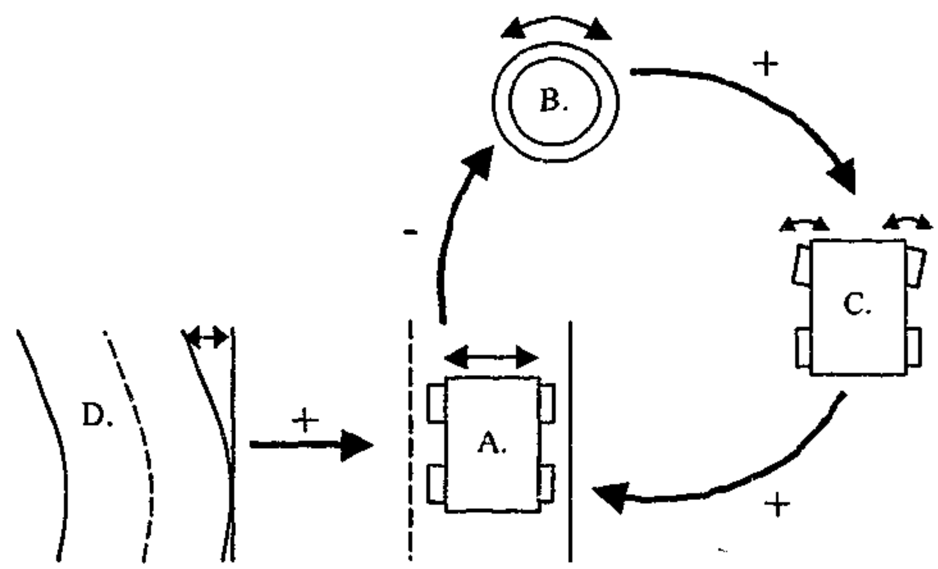

Figure 7: The proposed integrative unit designation illustrated with the example of maintaining lateral displacement of a car in the correct lane. Each letter designates the following subclass of changes (A-C of which are also subclasses of deeds): A = change in displacement of car relative to road, B = change in steering wheel orientation, C = change in rotational angle of front wheels, D = change in road curvature. Arrows between event subclasses indicate a dependency where an instance of the first subclass contributes to an instance of the second. The signs next to each arrow indicate a positive (+) or negative (-) direction of contribution, where positive means a positive change contributes to a positive change (and vice versa) and negative means a positive change contributes to a negative change (and vice versa). Arrows within each

[31] For the purposes of the present example, it is interesting to note that what Skinner called a *discriminative stimulus* can be conceptualised as a deed (i.e., a change in lateral displacement).

event subclass diagram indicate some set of differences quantifiable as a variable (e.g., steering wheel orientation).

Figure 7 comes closer to Powers' unit than Figure 6, because control system feedback is *always negative*, never positive. Where Figure 6 generalized across positive (escalating or snowballing) and negative (homeostatic or regulatory) feedback, Figure 7 applies to negative feedback only. The feedback is negative in Powers' regulative sense of protecting a controlled variable from disturbance. The important thing about a negative feedback loop among subclasses of events is that an odd number of connections must be negative, in the sense that a change in one direction contributes to a change in the opposite direction. Figure 7 demonstrates this principle. Just one of the three dependencies inside the circuit is negative: changes in lateral displacement contribute to oppositely directed changes in steering wheel orientation. If all three were positive (or two were negative), the car would be located increasingly further from the correct lane and would shortly crash.

Summary and Conclusion

I have designated a psychological unit integrating aspects of the units specified by Kantor, Skinner, Lee, and Powers. I have designated *regulative circular patternings* (Powers) *of dependencies* (Skinner, Lee) *between subclasses of deeds* (Lee) with *multiple contributors* (Kantor, Lee) *and multiple outcomes* (Powers, Lee).

This designation[32] suggests a way of bringing together a range of discussions in psychology. Some authors have emphasized deed-like units including critical effects (White & Liberty, 1976), accomplishments (Gilbert, 1978), concrete functional results within tasks (Reed et al., 1992), and results of behaviour (Järvilehto, 2000). Others have emphasized circular

[32] Note that the unit proposal under discussion is at once a *designation*, an *integration*, and a *postulation*. Which word is used depends on which aspect is being emphasised: *designation* when discussing a name of more or less firmness; *integration* when discussing a critical synthesis of past contributions; and *postulation* when discussing a guide to observation.

organizations, designated as circles of organized coordination (Dewey, 1896), functional circuits (Ashby, 1960), test-operate-test-exit feedback algorithms (Miller et al., 1960), person-mediated environment-to-environment circuits (Barker, 1963), circuits of differences making differences (Bateson, 1979), perception-action cycles (Swenson & Turvey, 1991), and balancing loops (Senge, 1994). The unit designation reached here offers a platform from which to evaluate and integrate such diverse contributions, ideally affording its own refinement.

The present unit designation also suggests new directions for experimental research. One direction entails the reanalysis of data to assess the applicability of the proposed designation. Consider the data collected in free-operant research on schedules of reinforcement. Much of this data can be construed as repetitive cycles of state changes (e.g., house light on - key down - key up - house light off/food hopper light on/food available - house light on, and so forth) that regulate food delivery profiles (For a related observation see Schoenfeld, 1976, p. 137). Another direction is to modify traditional experimental procedures to establish regulative feedback situations. Perceptual control theory already offers a rich array of such preparations (e.g., Marken, 1992).

Part 1 of this thesis is complete. In applying Dewey and Bentley's (1949) analysis of firm naming (accurate unit designation) to an integration of four proposals about a unit of analysis for psychology, the groundwork has been laid for Parts 2 and 3. Part 2 further firms the above integration, as a designation, by firming one of the unit designations on which it relies (*organism*). Part 3 uses the integration, as a postulation, to guide observations suggesting improvements to the postulation.

PART 2: A CLOSER LOOK AT THE ORGANISM

RATIONALE AND PRÉCIS OF PART 2

An important word in Part 1's unit integration was *deed* (see p. 45). Following Lee, Part 1 designated a deed as "a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one organism among many other contributors" (see p. 26).

Just as *deed* is an important word in the proposed unit designation, *organism* is an important word in the designation of a deed. The proposed unit designation, that is, depends on the word *organism*. This is not surprising, for all psychological units depend on the word *organism*, and thus some conception of what an organism is.

Traditionally, psychologists conceive of an organism as an object partitioned from an environment by a skin. Though ubiquitous in psychology, this conception is problematic, and it compromises the accuracy of the designation *organism*. This in turn compromises the accuracy of Part 1's unit designation. An unproblematic alternative conception of organism is required.

Part 2 attempts to resolve these issues by examining the organism in relation to designating psychological units. Like Part 1, Part 2 has three chapters. Chapter 4 identifies the traditional conception of organism and shows how it informs the theorising of Kantor, Skinner, Lee, and Powers. Chapter 4 also shows how the traditional conception (named *the morphological conception*) is problematic and reduces the names *organism* and *environment* to vague characterizations. Chapter 5 attempts to designate organism and environment more accurately (i.e., to move from their characterization to their specification). To do this, it examines and integrates three untraditional conceptions of organism and environment.[33] Chapter 6 develops the implications of this integration for the conceptualisation of psychology's subject matter. Chapter 6 finds these implications consistent with the unit

[33] An extended version of Chapters 4 and 5 is to appear as a single paper in Palmer (in press).

designation proposed in Part 1. In other words, by increasing the accuracy of the designation *organism*, the postulation developed in Part 2 increases the accuracy of the postulation developed in Part 1.

CHAPTER 4: THE PROBLEM

It is commonly assumed that the skin of an organism's body partitions that organism from an external environment. This chapter shows how this assumption has influenced contemporary scientific psychology (including the postulations of Kantor, Skinner, Lee, and Powers). The chapter also shows the assumption to be problematic.

Distinction, Specification, and the Morphological Conception of Organism

Distinction: Foregrounds and Backgrounds

Like Part 1, Part 2 draws on Dewey and Bentley's (1949) account of naming (see p. 6). This chapter begins by relating Dewey and Bentley's account to the concept of *a criterion of distinction.*

Dewey and Bentley (1949) discussed the process by which a foreground (what Dewey and Bentley called an *existence*) is made different from a background. They called this process *naming* or *designation*. Many later authors have discussed this process (e.g., Maturana & Varela, 1987; Oyama, 2000; Spencer-Brown, 1969; Varela, 1979; P. A. Weiss, 1978). Using the word *distinction* rather than *designation* and *unity* rather than *existence*, Maturana and Varela (1987) explained how the process always entails a *criterion of distinction*:

> The act of indicating any being, object, thing, or unity involves making an *act of distinction* which distinguishes what has been indicated as separate from its background. Each time we refer to anything explicitly or implicitly, we are specifying a *criterion of distinction*, which indicates what we are talking about and specifies its properties as being, unity, or object. This is a commonplace situation and not unique: we are necessarily and permanently immersed in it
>
> A *unity* (entity, object) is brought forth by an act of distinction. Conversely, each time we refer to a unity in our descriptions, we are

> implying the operation of distinction that defines it and makes it possible. (p. 40)

Here, Maturana and Varela repeat Dewey and Bentley's (e.g., 1949, p. 60-61) emphasis on the mutual and reciprocal relation between a designation (or an act of distinction) and an existence (or a unity).[34] What they add to Dewey and Bentley's discussion is the concept of a criterion of distinction, a concept featuring centrally in the upcoming analysis.

Specification: Accurate Distinctions Entail Firm Names

As discussed in Chapter 1 (p. 6), Dewey and Bentley (1949) suggested three grades of designation, ranging from what they called *cue* through *characterization* to *specification*. To recap, *cue* was the evolutionary most primitive form of designation, including warning cries, expletives, one-word sentences, interjections, and exclamations. From the clustering of cues develops *characterization*, which is "that type of naming which makes up almost all of our daily conversation" (p. 159). As an example from contemporary psychological discourse, the term *information* (and accompanying discussion) in cognitive psychology (e.g., Sternberg, 1999) rates as low-grade characterization. Despite being reasonably adequate for the purposes of everyday conversation (e.g., "I've got information overload"), the term makes trouble in psychological discourse because of its relative vagueness and ever-shifting usage.

It is only at the level of *specification* that the relatively accurate, efficient, or firm names underlying modern science emerge. The name *molecule* in the context of its contemporary scientific usage is an example of specification. The name *molecule* is used precisely to distinguish instances of particular existences/entities. It is not ambiguous or vague. Relative to a psychological name like *information*, the name *molecule* does not wobble (though a given molecule might). Dewey and Bentley view science as a passage from loose to

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[34] See Palmer (2003b) for discussion of this and other parallels between Dewey-Bentley and Maturana-Varela.

firm names, where "progress from stylized cue or loose characterization to careful specification [is] a compelling need" (p. 306).

Having recapped Dewey and Bentley's taxonomy for the evaluation of scientific names, and having introduced the concept of a criterion of distinction, I turn to the terminological specimen of interest in the present inquiry, namely *organism*.

"Organism": Skin as Implicit Criterion

I aim to clarify the status and role of the term *organism* in contemporary psychological science. Having recapped the way in which names designate existences (i.e., distinguish unities), I begin by inquiring about the criteria psychologists use to differentiate organisms from backgrounds or surrounding worlds.

Observe first that in psychological usage, the word *organism* is used coherently only in relation to a second word, *environment*. Each of the two words is implied by the other, and is defined in reference to the other. Each *is* what the other *is not*. As occasionally emphasized, the two make an inseparable pair (e.g., Gibson, 1979/1986, p. 8; Lewontin, 1982, p. 160).

A central argument in this chapter is that this inseparability has the following basis: The criterion by which an organism is distinguished from a background is almost universally equated with the line of demarcation between organism and environment. Organism is inside this line, and environment outside it. One begins where the other ends. Brunswick (1957) exemplified this view when, after asserting that organism and environment are "both hewn [i.e., distinguished] from ... the same block," he spoke of their "mutual boundary or surface areas" (p. 5, cf. Maturana & Varela, 1987, pp. 95-96). Here I argue that this frame of orientation, in which *organism* and *environment* are used in the way one might speak of an *object* and its *surrounds*, dominates psychological discourse (sometimes implicitly, other times explicitly). Further, this usage depends on a conception of where the boundary between organism and environment is.

A. F. Bentley (1941c) addressed this issue:

> "Inner" and "outer" are ever present distinctions, however camouflaged, in philosophical procedure as well as in conventional speech-forms and in the traditional terminology of psychology. What holds "inner" and "outer" apart? The answer must come not by way of transcendental build-up but by indications of pertinent fact. Bluntly the separator is skin; no other appears. (p. 3)

As Bentley suggested, and as I will shortly show, the line by which psychologists delineate organisms (and thus environments) is the skin of organism's bodies. Figure 8 illustrates some common binary oppositions following from an organism-environment separation hinging on the skin. In each opposition the organism is conceptualised as a container-like object with an inside and outside.

It is important to note that the skin is a *morphological* criterion of distinction: it takes the organism as a structure in space. There are two steps. The first step is to distinguish the organism, on the basis of the skin of its body, from a background. The second is to equate this background with environment. Taken together, these two steps are here designated *the morphological conception of organism*.

Organism	Environment
Person	World
Subject	Object
Inside	Outside
Mental	Physical
Ego	Non-ego
Observer	Observed
I	You
Private	Public
Knowledge	Reality
Soul/Spirit/Mind	Matter
Representation	Represented
Individual	Social
Rational	Empirical
Cognitive	Behavioural

Figure 8: Common binary oppositions following from a morphological conception of organism hinging on the skin as the critical line of separation.

Once the two-step morphological conception is applied, it constrains the resulting conceptualisation of psychology's subject matter. As Laing (1960/1965) put it, "the initial way we see a thing determines all our subsequent dealings with it" (p. 20). The morphological conception compels psychology's subject matter to be conceptualised as (a) physiological, cognitive, or behavioural events located inside or at the organism, and (b) relations (whether linear, cyclical, or mutual and reciprocal) between the organism (or (a)) and events outside the organism (in its surrounding environment).

To summarize this section; I have claimed that in practice, psychologists (a) distinguish organism from background using a morphological criterion (the skin), and (b) name the background (or, equivalently, the surrounding world) of an organism *environment*. The organism is then conceptualised as an enclosed physical space, just as a box is considered an enclosed physical space.

An Examination of *Organism* as Used in Four Psychologies

In this section I evaluate the validity of the above claims by examining how core representatives of four well-defined approaches to scientific psychology have used and conceptualised the term *organism*. In parallel with the four unit proposals integrated in Part 1, these four representatives are Skinner, Kantor, Lee, and Powers. Each examination has the primary aim of establishing the presence (or absence) of the morphological conception. It has the secondary aim of tracing the implications of this conception, if present, for the resulting conceptualisation of psychology's subject matter.

J. R. Kantor: Interbehavioural Psychology

The interbehavioural school of psychology was founded by J. R Kantor (e.g., 1924; 1959; 1984). Kantor (1959) offered a field-based alternative to what he saw as the mistaken *organism-centred* tendency psychologists have to persist in "...locating their data in or at the organism" (p. 91). Kantor's proposed unit was the *behaviour segment*, which emphasized the entire field of factors participating in any psychological event, and which always consisted of an *organism-object interaction* (see Chapter 2, p. 9). Was Kantor's unit proposal predicated on the morphological conception of organism? Early in Volume 1 of his *Principles of Psychology*, Kantor (1924) implied a morphological conceptualisation of psychology's subject matter: "...our data as natural events can only consist of an *organism's interactions with surrounding objects* [italics added]..." (p. 33). This is an instance of a theme in all Kantor's writing; a primary distinction between one thing, the organism, and another thing, its *surrounds* (for similar observations see A. F. Bentley, 1939c, p. 318; 1940, p. 242; Dewey & Bentley, 1949, p. 212). Kantor's regular reference to *contacts* (also *confrontations*) between organisms and surrounding factors was also consistent with this theme:

> Since all events consist of fields of interacting factors, we can differentiate psychological science from other sciences by specifying that it investigates the interbehavior of organisms in various stages of evolution with objects, events, and relations with which they are inevitably and constantly in *contact* [italics added]. (1963, p. 19)

In conceptualising the subject matter of psychology as *contacts* between *organisms* and *surrounds* (in the same linguistic pattern in which we might talk of a soccer-player's foot *contacting*[35] a soccer ball), Kantor (1969) equated the terms *surrounds* (or *surrounding*) and *environment* (or *environing*):

> During the evolution of organisms they have developed specialized sensitivities to their *environing conditions* [italics added]. It is the receptor mechanisms which make possible the localizing of *contacts* [italics added] between the organism and the *surrounding things and conditions* [italics added]. (pp. 49-50, see also Kantor, 1969, pp. 378-379)

To sum up: Kantor's interbehavioural psychology differs from many other psychologies in localizing its subject matter in integrated fields of participating

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[35] Consider here the OED's leading definition of the noun *contact*: "The state or condition of touching; the mutual relation of two bodies whose external surfaces touch each other. Hence to be or come in (into) contact."

factors including organisms, objects, and much else. In taking this step forward, however, Kantor maintained linguistic consistency with the morphological conception of an organism as a bounded entity surrounded by an (object-rich) external environment. He characterized the subject matter of psychology as the coming together of (surrounded) organisms and (surrounding) objects into organism-object interactions. Kantor's proposed psychological unit was therefore informed and guided by the morphological conception of organism.

B. F. Skinner: Behaviour Analysis

The definitive proponent of behaviour analysis was its founder B. F. Skinner, whose seminal text (*The Behavior of Organisms: An Experimental Analysis*) prominently featured the name under scrutiny (i.e., *organism*). Behaviour analysis is an approach to psychology taking its subject matter to be behaviour in its own right. The basic unit for a behaviour analyst is a three-term operant contingency relating behavioural responses to antecedent (discriminative) and subsequent (consequential) environmental stimuli (cf. p. 21). As implied by the three-term contingency, the most prominent distinction in behaviour analysis is not between *organism* and *environment* but between *behaviour* (or response) and *environment* (or stimulus). From early in his career, Skinner (1935) stressed "...the natural lines of fracture along which behavior and environment actually break" (p. 40) and the process of "...breaking behavior and environment into parts for the sake of description..." (p. 61).

Though Skinner primarily emphasized the distinction between behaviour and environment, to the extent he identified *behaviour* with the *organism*, his separation of *behaviour* and *environment* followed logically from a prior separation of *organism* and *environment* (i.e., the morphological conception). Skinner did identify behaviour with the organism. He conceptualised behaviour as *of* the "organism as a whole" (1938, p. 441), as a "primary characteristic of living things" we almost "identify with life itself" (1953, p.

45) and "as much a part of the organism as are its anatomical features" (1953, p. 157).

Accordingly, when Skinner (1938) wrote "...behavior is that part of the functioning of an organism which is engaged in acting upon or having commerce with the *outside* [italics added] world" (p. 6), he defined *behaviour* as (a) being a part of the functioning organism, and (b) being something different from, yet related to, the *outside world*, wher_ *outside world* was synonymous with *surrounding world*: "We are most often interested, however, in behavior that has some effect upon the *surrounding world* [italics added]" (1953, p. 59), and *surrounding world* was synonymous with *environment*: "Many theories of human behavior, nevertheless, neglect or ignore the action of the *environment* [italics added]. The *contact*[36] [italics added] between the organis.n and the *surrounding world* [italics added] is wholly disregarded or at best casually described" (1953, p. 129). These quotations indicate Skinner's adoption of the two-step morphological conception of organism.

In addition, Skinner explicitly identified the skin as a boundary in psychological theorizing. He (1974) wrote "a small part of the universe is contained within the skin of each of us" (p. 24) and went on to contrast the "...the world *around* [italics added] us..." (p. 25) with the "...the private world *within* [italics added] the skin..." (p. 34). Here Skinner stressed that "we need not suppose that events which take place within an organism's skin have special properties for that reason" (1953, p. 257). He did, however, explicitly draw and thereby validate the line in using it to organize his conceptual framework and his analysis of subtle events like thinking and imagining (as discussed by Hayes, 1994). As a final example, consider the relevance of the morphological conception, and thus the skin, to Skinner's (1974) statement that behaviourism "...is almost literally a matter of turning the explanation of behavior *inside out* [italics added]" (p. 274).

[36] See Footnote 35.

To sum up, behaviour analysis, as presented by its founder B. F. Skinner (and more recently by his intellectual descendents),[37] accepts the morphologically based usage of the term *organism*. Skinner assumes a morphological separation between organism and environment, where *environment* is synonymous with *surrounding world*. He localizes behaviour on the organism's side of the divide, advocating investigation of (functional) relations between behaviour (as response), and environment (as stimulus). Skinner's conception of psychology's subject matter was therefore informed and guided by the morphological conception of organism.

V. L. Lee: The Deed Approach

Using the phrase "the traditional view," Lee (2000) critically outlined the morphological conception of organism:

> To see where the traditional view leads psychology, imagine watching a greengrocer. He is taking oranges from a wheelbarrow and placing them on a stand. If you look at this scene informed by the traditional view, the greengrocer is in the foreground. He is the psychological unit. Everything else is background. We call it "the environment." We have individual and environment, two separate but interacting items, and therefore an elementary classification.

For Lee, this traditional view (i.e., the morphological conception) is the wrong starting point for psychology. Lee rejects interpreting psychology's subject matter through an elementary classification between the morphologically conceived organism and its surrounds. Instead, Lee starts with what she has named *deeds*. Chapter 2 brought together aspects of Lee's definitions of deeds in the designation "moments of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of

[37] Modern behavior analysts continue to adopt Skinner's morphological conception of organism and environment, if departing from his approach in other respects (for two explicit examples, see Rachlin, 1994, pp. 32-33 and Roche & Barnes, 1997, p. 602).

at least one organism among many other contributors" (p. 26). For Lee, deeds are equally of organism *and* environment (see also Chapter 2, p. 30):

> "[Deeds] are at the same time of the organism *and* the environment: They are events that have the physical efforts of the participant's body [i.e., the organism] and much else [i.e., the environment] as their constituents [i.e., contributors]" (Lee, 2001, pp. 64-65).[38]

As the foregoing suggests, Lee differs from most psychologists in putting deeds (and not morphologically conceived organisms) in the foreground, and in acknowledging the contribution of organism and environment, but keeping them both in the background.

To say Lee rejects *starting* with the morphological conception, however, does not rule out the possibility that it informs her theorising in other ways. As noted in the rationale for Part 2, Lee's designation of a deed depends on the word *organism*. In Lee's (1994) words, "things done [i.e., deeds] presuppose one or more organisms to do them" (p. 16). It is only the contribution of an organism distinguishing deeds from other (presumably non-psychological) changes. Does Lee adopt a morphological conception of organism? The following statement suggests that she does:

> By "organism," I mean an entity connected to its environment by the boundary referred to as "cell membrane" in unicellular organisms or "epidermis" in multicellular organisms. (Lee, 2000)

In this statement, Lee bounds the organism at the membrane or epidermis (i.e., the skin), and describes this surface as connecting the organism to its (surrounding) environment. This conception is morphological: it takes the organism as a structure in space (Note: from the perspective of the morphological conception, having the membrane or epidermis *separate*

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[38] Like Kantor, Lee rejects the organocentric tendency to locate psychological events at or in the organism.

organism from environment, *connect* organism to environment, or do both simultaneously amounts to the same thing).

To sum up, in her treatment of organism and environment, Lee differs from Kantor, Skinner, and, as we will see, Powers. Unlike these three, Lee rejects the morphological conception as a starting point. Lee's starting point is the deed. Lee's definition of a deed, however, is dependent on the word *organism*, and her conception of organism (and thus environment) is morphological. In short, Lee's deeds depend on a morphological conception of organism.

W. T Powers: Perceptual Control Theory

Powers founded perceptual control theory (PCT) in his seminal *Behavior: The Control of Perception* (1973). For Powers, organisms are *negative feedback control systems* which control selected variables by maintaining their perceived state against perturbation or disturbance. Powers' control system unit was introduced in Chapter 3 (p. 37).

Powers adopts an explicitly morphological conception of organism. In his variation on the common morphological theme, Power focuses on the organization of the organism's brain, emphasizing morphologically conceptualised brain-environment relations, as evident in the following three quotations:

> A brain is required in order to perceive a relationship—either a self-evident relationship *out there* [italics added] in the real environment, or a hypothetical one *inside the organism* [italics added]. (1973, p. 59)

> The brain may be *full of* [italics added] many perceptual signals, but the relationship between those signals and *external reality* [italics added] on which they depend seems utterly arbitrary... (1973, p. 37)

> ...an *external* [italics added] state of affairs is continually represented *inside* [italics added] the brain as one or more continuous neural signals. (1973, p. 39)

Further, Powers comes close to equating the boundaries of the organism with the skin:

> ...of what lies *outside* [italics added] our sensory endings we know next to nothing. (1973, p. 154)

and does equate *environment* and *surrounding*:

> From where we stand, or float, we can see the *physical environment surrounding the body* [italics added], the brain and nervous system *inside the body* [italics added], and the signals spreading through millions of channels in the brain. (Powers, 1988, p. 21)

Powers also argues that we, as *persons*, are equivalent with organisms (as skin-bounded control systems), permanently sealed off from the outside world.

> We are trapped *in here* [italics added], folks, and our very survival depends on making models that in some way reflect the regularities of the real universe that is right *out there* [italics added]... (Powers, 1988, p. 26)

Finally, Powers adopts the syntax of organism-environment *interaction*, as in his "control is a phenomenon that arises when an active system, constructed in a specific way, *interacts with its immediate environment* [italics added]" (1973, p. 11).

To sum up; Powers' perceptual control theory adopts a morphological usage and conception of *organism*. In PCT, the organism is taken as a system with a boundary partitioning system from environment, or, equivalently, the surrounding, external, or outside world. Within the confines of this framework, Powers is interested in the organization of the brain, which is seen as inside the organism, the organism being seen as inside the external world it perceives, acts on (or interacts with), and controls.

Though the morphological conception has been shown as an influence on the theorizing of Kantor, Skinner, Lee, and Powers, it is evident in most if not all approaches to scientific psychology (e.g., cognitive psychology, ecological psychology). Kantor, Skinner, Lee, and Powers were not selected because of any unique commitment to the morphological conception, but because they were the four main contributors to the unit proposed in Part 1.

Difficulties Resulting from the Morphological Conception of Organism

The psychologies discussed above assume a morphologically conceptualised line partitioning organism from environment. I next review early arguments that there is no such line; that the skin is both logically and biologically incapable of bounding the organism.

The core of the problem was stated by A. F. Bentley in an originally unpublished draft dated 1910 (later published in A. F. Bentley, 1954):[39]

> However spatially isolated the individual appears at a crude glance, the more minutely he is examined, the more are his boundary lines found to melt into those of his environment, the more frequently are functions found which work through both individual and environment so that it cannot be told where the one ceases and the other begins. (p. 5)

The harder we look for a line partitioning organism from environment, notes Bentley, the more does the possibility of any such line dissolve in front of our eyes.

Sumner (1922) offered a continuum of examples highlighting the arbitrariness of drawing that line at the skin:

> If I should ask you whether the nest of a bird constituted a part of the organism or a part of its environment, I presume that everyone present would resent the question as an insult to his intelligence. Nor would there probably be any hesitation if the question related to the patch-work dwelling of a caddis-worm, even though this dwelling is carried around by the larval insect, as if it were an integral part of its body.

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[39] Note that in this quotation Bentley is using *individual* as a synonym for *organism*. The same goes for the upcoming quotation from Angyal (1941).

> The situation becomes somewhat less clear, perhaps, when we consider the calcareous tube of a marine annelid. Here is something which is definitely secreted by the epidermal cells of the organism, and which forms a sort of permanent integument. It does not, however, in this case retain any organic connection with the body of the worm. But when we pass to the shell of the mollusk we find that there is such an organic connection with the body, so that the animal cannot be dislodged without extensive injury to its living tissues. Moreover, the purely mineral ingredients of the shell are sandwiched in between layers of a substance we commonly speak of as "organic," though not in this case as living. Does such a shell belong to the organism or its environment? (pp. 231-232)[40]

As we pass from bird nest to mollusk shell (not to mention Sumner's next step to tortoise's carapace, which includes living cells, blood vessels, and nerves) we find ourselves having moved from what we can probably agree is environment to what we can probably agree is organism without being able to say where we crossed the line. Again, the seeming security of the morphological conception is dissolving in front of our eyes. At the least, we can sympathize with Sumner's conclusion that "...the organism and the environment interpenetrate one another through and through. The distinction between them... is only a matter of practical convenience" (p. 233).

A few years later, M. Bentley (1927) used different examples to support the same conclusion:

> ...the separation of the organism and environment at boundary lines and surfaces is, in certain cases, arbitrary and conventional. The symbiotic relationship offers an example, and so does the parasite which is lodged within the host and is not therefore really external. Neither is the nutrient material ingested into the cavities really environmental. It would be

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[40] In expounding his extended phenotype theory of genetic effects, Dawkins (1982/1999, Chapters 11-13) traversed a similar continuum in the reverse direction. He also used the caddis worm example, and critiqued the "arbitrary decision to cut off all chains [of influence from gene to phenotype] at the point where they reach the outer wall of the body" (p. 232).

> difficult to define the exact moment when food-stuffs become part of the organism and cease to be 'foreign' materials; and on the other hand, the exact passage from organism to environment of rejected glandular and digestive products and of residues expired from the lungs is equally indeterminate... Once more, in our body-coverings, hand-tools and weapons... we have 'outside' attachments which might well – save for our arbitrary delimitation at the rind – be functionally partitioned with the organism, quite as much as hair, claws, and teeth, instead of with the environment. (pp. 57-58)

Here Bentley observes that in many concrete instances a skin-based separation of organism from environment becomes arbitrary and unsure.

As such quotations suggest, difficulties with the morphological conception of organism have been under discussion for many years (see also Angyal, 1941; Ashby, 1960; Bateson, 1972; A. F. Bentley, 1941a; 1941c; Dewey & Bentley, 1949; Goodwin, 1989; Järvilehto, 1998a; Lewontin, 1982; Lindeman, 1942; Llewelyn & Kelly, 1980; Lotka, 1925/1956; Mead, 1934/1969; Oyama, 2000, in press; Sullivan, 2001; Whitehead, 1933/1948). The consensus in such discussions is that any attempt to map the living organism onto a skin-based morphological template,[41] and to thereby execute a clean severance of organism from environment, fails.

For many of these scholars, this failure indicates the need for a different (i.e., non-morphological) conception of organism. An example is Angyal (1941), whom, referring to "the semi-jocular statement that the individual is within the skin and the environment is outside of it" (pp. 88-89), argued:

> Any attempt to make a morphological separation of organism and environment fails and necessarily leads to endless, hair-splitting dialectic. It will, however, be useful to go into this dialectic to some extent, not because one might expect positive results, but because it will demonstrate that the

[41] A template reminiscent of the frame in Wittgenstein's (1953) "one thinks that one is tracing the outline of the thing's nature over and over again, and one is merely tracing round the frame through which we look at it" (p. 48).

> consideration of organism and environment as structures in space is not a workable point of view. (p. 89)

After a comprehensive examination of this dialectic in the light of different biological phenomena, Argyal's conclusion was, again, that "the conception of organism and environment as morphological entities which are separable in space is inadequate for the description of biological phenomena" (p. 97). Further details of Angyal's treatment (including his alternative) are discussed in Chapter 5. For now I merely acknowledge the standpoint that difficulties with the morphological conception are insoluble; that another conception is required.

The above quotations indicate difficulties with the morphological conception (for more material, see especially Angyal, 1941, Chapter 4; A. F. Bentley, 1941a; Järvilehto, 1998a; Sumner, 1922). It is problematic (and for some scholars *impossible*) to draw a skin-based line between organism and environment. On examination, organism and environment are intertwined in a *transdermal*[42] process. Chapter 5 explores the possibility of starting psychological inquiry with a transdermal, process-based conception of organism and environment (as an alternative to starting with the morphological conception).

Organism as Characterization in Need of Specification

The above analysis suggests that when psychologists use the word *organism*, they use it as a loose name or characterization. The criteria for its application are in practice vague. This vagueness stems from the assumption that the skin of an organism's body is a sufficient criterion for accurate designation. As shown above, this assumption fails. For Dewey and Bentley (1949), increasingly accurate names are a pressing scientific objective, especially in a science like psychology where cue and characterization everywhere outweigh specification. Psychology has much to gain, therefore,

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[42] I use the word *transdermal* in Bentley's (1941c) sense of extending across the skin of the organism's body.

from a concerted effort to elevate *organism* from characterization to specification. This is especially so given the status of *organism* as a linguistic nucleus around which many other psychological names revolve (e.g., *environment, deed, behaviour, action, stimulus, input, response, output, perception, action, person, psychology*).

Summary and Conclusion

This chapter has made the following arguments:

(1) Most if not all psychology adopts a morphological conception of organism, where the boundary of the organism is implicitly (or explicitly) equated with the skin of the organism's body.

(2) The morphological conception channels the conceptualisation of psychology's subject matter down definite pathways.

(3) The morphological conception is problematic. On examination, the organism, as process (entailing thousands of interlinked sub-processes), cannot be delineated from the environment at the skin. Instead, organism and environment appear entangled in a *transdermal* process extending across the skin of the organism's body. This calls into question the morphological conception of organism and conceptualisations of psychology's subject matter that follow from it. It also suggests that the term *organism* is far from achieving the scientifically desirable status of specification in psychology – a status I pursue in the following chapter.

CHAPTER 5: OVERCOMING THE PROBLEM

Building on Chapter 4, this chapter (1) reviews three attempts to overcome the morphological conception of organism, taking some steps toward their integration, and (2) explores possible improvements for the way psychologists use *organism* and related terms. In doing so, the chapter furthers Part 2's attempt to free Part 1's unit integration from the traditional assumption that organism and environment lie on opposite sides of the skin.

A Review and Preliminary Integration of Some Non-Morphological Starting Points

In this section, I review three attempts to develop a non-morphological conception of organism (and thus environment). As will become apparent, a common conclusion is that the words *organism* and *environment* most coherently designate complementary phases within a single process.

Angyal: Biosphere

Angyal's (1941) *Foundations for a Science of Personality* is an important precursor to the present inquiry. Angyal observed that "*environment* is not identical with *surrounding world*" (p. 108)[43] and that "the consideration of the organism and environment in morphological terms leads to such logical entanglement that the concepts of organism and environment are made useless for scientific purposes" (p. 121). On top of critiquing the morphological conception of organism, Angyal (1941) developed a systematic re-conceptualisation of the organism, and thus the organism-environment distinction, as *dynamic process* (as opposed to *static structure*):

> We shall try and show in what follows that it is, in principle, impossible to draw any line of separation because organism and environment are not static

[43] This insight was also expressed by M. Bentley (1927) in his observation that "much of the surroundings of the living organism is not really environment" (p. 57).

> structures separable in space, but are opposing directions in the biological total process. (p. 92)

> ...the body surface is not the boundary of the organism. It has been emphasized that the organism is entirely permeated by the environment which insinuates itself into every part of it. On the other hand, the organism does not end at the body surface but penetrates into its environment. The realm of events which are influenced by the autonomy of the organism is not limited to the body but extends far beyond it. Every process which is a resultant of the interplay of the organismic autonomy and the environmental heteronomy is part of the life process, irrespective of whether it takes place within the body or outside of it. The biological process of feeding oneself does not begin with the chewing of one's food; the preparation of food, the raising of vegetables are also "biological" activities in the broader sense of the word. (pp. 97-98)

Here Angyal used the names *organism* and *environment* to differentiate the *autonomy* and *heteronomy* within any life process. For Angyal, *autonomy* designates self-governance, as illustrated by the healing of a burn, the reflex action by which a falling cat turns to land on its feet, and the homeostatic self-regulation of body temperature.[44] *Heteronomy*, in contrast, designates that which is governed from outside,[45] such as the burning action of a drop of acid, the gravitational influences on the cat's fall, and the air temperature. In each of these examples, an autonomous organism asserts itself upon a heteronomous environment.

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[44] The notion of autonomy or self-governance is related to the notion of control in Powers' Perceptual Control Theory (as discussed on pages 37 & 63). The relation will be discussed explicitly in Chapter 6.

[45] Angyal's somewhat misleading use of the word *outside* here is metaphorical and refers not to location in space but to being foreign (not belonging) to the biological life process under consideration (see Angyal, 1941, p. 42). A tapeworm in the stomach of a cow, for example, is heteronomous (i.e., environmental) from the perspective of the host despite being inside the skin.

An important precursor to this formulation was Von Uexküll (1926), who argued, "to be alive ... means ... the continuous control of a framework by an autonomous rule, in contrast to a heteronomous rule that loses its efficacy as soon as the framework is disturbed" (p. 223). Disturb the framework of an earthworm's dead body by cutting off its head, and the framework remains disturbed (without efficacy). Subject a live earthworm to the same disturbance, and a new head is grown – the earthworm's framework is autonomously re-asserted.

For Angyal, the relative presence of autonomy and heteronomy varies within and across different parts of the life process. Consider some examples. The process by which blood pressure is regulated is highly self-governed. It has a high degree of autonomy and a small, yet ever-present, degree of heteronomy. The movement of a shovel when digging a hole, on the other hand, has a smaller degree of autonomy and thus a higher degree of heteronomy (especially given poor hand-eye coordination, weak muscles, a blunt shovel, and rocky soil). Both processes are biological for Angyal. They are both occurrences within a single life process.

Angyal designated the realm in which the biological total process goes on the *biosphere*.[46] In his words, "the biosphere includes both the individual and the environment, not as interacting parts, not as constituents which have independent existence, but as aspects of a single reality which can be separated only by abstraction" (p. 100). Angyal's primary distinction is between biosphere and surrounding world. A secondary distinction is between autonomous (or organismic) and heteronomous (or environmental) trends within the biosphere. This approach differs *radically* from the traditional tendency, first, to distinguish the organism on the basis of its skin from a background and, second, to call that background "the environment (of the organism)."

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[46] Angyal, in apparent independence, coined and used the word *biosphere* in a way differing from Vernadsky's (1926/1998, p. 43) now popular sense of the living surface layer separating planet earth from the cosmic medium.

For Angyal, what makes a biospheric sub-process autonomous (organismic) or heteronomous (environmental) is not a matter of whether it happens inside or outside the skin, but a matter of relative contribution:

> In a study of biological dynamics we do not ask whether a given morphological entity is a part of the organism or of the environment. Rather, we wish to determine whether a part process occurs by virtue of autonomous (organismic) or by virtue of heteronomous (environmental) determination. Thus, for example, we do not ask whether the contents of the stomach belong to the environment or the organism, but whether the processes going on in the lumen of the stomach are system-determined (autonomous, organismic determination) or are due to factors foreign to the system (heteronomous, environmental determination). (p. 94)

Think about a surgeon performing open-heart surgery. Though the scalpel and the surgeon's hands are physically inside the patient's skin, their dynamics are more under the control of, and thus a part of, the surgeon. Similarly, consider the squirrel who stores food as (a) fat within its body and (b) acorns stacked within its nest. Although (a) and (b) are on different sides of the skin, they serve a common biological function, and are thereby both *inside* a single biosphere. An important implication is that for Angyal, physiological and psychological processes are viewed as abstractions from the biosphere and thus encompassed by the word *biological.*

Figure 9 illustrates Angyal's conceptualisation of organism and environment as a graded range of ratios between autonomy and heteronomy. Both extremes represent theoretical limits and not actual values. The one extreme of total heteronomy would be "pure environment," when in actuality there can be no environment without organism. The other extreme of pure autonomy would be something free from physical constraint (i.e., a fiction – Angyal's example being a transcendent soul).

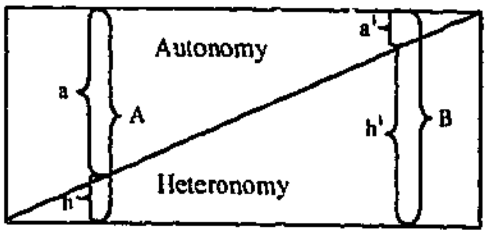

Figure 9: Range of possible ratios between autonomous and heteronomous tendencies within any living process. On the left, the ratio A (a/h) indicates a process with more autonomy than heteronomy, such as the regulation of blood pressure. On the right, the ratio B (a^1/ h^1) indicates a process with less autonomy than heteronomy, such as digging a hole. Adapted from Angyal (1941, p. 95).

Angyal (1965) acknowledged that his formulation might seem counterintuitive. Most people, he noted, experience themselves as "distinct units, with firm boundaries" (p. 8). He then explained as follows:

> Although the boundaries are, in fact, far from being firm and set, the formulation ... should be qualified by the statement that not all variations of the *a:h* ratio are gradual and continuous. There are sharp gradients between the ratios typical of different groups of functions. The high degree of control we have over the movements of our body tends to create a sharp separation between this unit and the objects and events over which our control is less immediate and certain. (p. 8)

In other words, the dexterity with which one's own body can be moved relative to other objects is consistent with Angyal's formulation. Our bodies are central to our lives in the sense of being more autonomously governed than other aspects. They are not central in virtue of being bodily alone. This is demonstrated by a paralysed leg, which might feel less a part of one than one's walking stick or wheelchair. Somatic processes are central to the biosphere not because they are inside the skin (which they are), but because they are a realm of relatively high and stable autonomy within the greater life process.

In summary, Angyal developed a non-morphological conceptualisation of organism and environment. He started by abstracting the biosphere from the surrounding world. Within the biosphere, autonomous (organismic or self-governed) and heteronomous (environmental or foreignly-governed) tendencies were then abstracted. Viewed in this way, with a shift in stress from bodily *structure* to life *process*, the organism is refashioned as the an organic-environmental life process, which extends beyond the skin.

Dewey (and Bentley): Life-Activity

In their *Knowing and the Known*, Dewey and Bentley (1949) were centrally concerned with moving from what they called an *inter-actional* to a *transactional* formulation of organism and environment. For them, "...inter-action assumes the organism and its environmental objects to be present as substantially separate existences or forms of existence, prior to their entry into joint investigation..." (p.123), whereas

> *Transaction* assumes no pre-knowledge of either organism or environment alone as adequate, not even as respects the basic nature of the current conventional distinctions between them, but requires their *primary acceptance in common system* [italics added], with full freedom reserved for their developing examination. (p. 123)

In this context, and similarly to Angyal, Dewey and Bentley critiqued the tendency to separate organisms from environments at the skin of the organism's body:

> Organisms do not live without air and water, nor without food ingestion and radiation. They live, that is, as much in processes across and "through" skins as in processes "within" skins. One might as well study an organism in complete detachment from its environment as try to study an electric clock on the wall in disregard of the wire leading to it. (p. 128)

In such statements, although Dewey and Bentley critique the notion that the skin bounds the organic life process, they leave the notion of a morphological boundary intact. Unlike Angyal, they imply it is still possible to study organisms in detachment from environments – and merely note that this strategy is unlikely to bear fruit. Later in the book, however, the morphological conception is directly rebutted:

> "Environment" is not something around and about human activities in an external sense; it is their *medium* or *milieu*, in the sense in which a *medium* is *inter*mediate in the execution or carrying *out* of human activities, as well as being the channel *through* which they move and the vehicle *by* which they go on. (p. 272)

In this statement, Dewey[47] rejects the tendency to equate *environment* with *background* or *external world* (read, *surrounding world*), instead equating it with the *medium* by means of which life-activities go on. Dewey had earlier stated that "environment ... is not equivalent merely to surrounding physical conditions" (Dewey, 1911/1978, p. 438) and "an organism does not live *in* an environment; it lives by means of an environment" (1938, p. 25, see also Dewey, 1928, p. 12). Just as fire, as process, happens not *in* but *through* or *via* a medium of wood, oxygen, and shelter, human life-activity as (a more complex, enduring, and differentiated) process happens *through* or *via* a broad medium of contributors including oxygen, food, houses, automobiles, and social institutions. From this perspective, it is more accurate to put the medium *inside* the process than the process *inside* the medium. For Dewey it makes as much sense to say "the fire is inside the wood" as it does to say "the organism is inside the environment."

Dewey's interpretation of environment as *medium* is compatible with Angyal's interpretation of environment as *heteronomy*. Consider picking, eating, and digesting an apple. Throughout this process, the apple is part of the medium by means of which the relevant organism goes on. It is environment in Dewey's sense. Simultaneously, the apple is participating in processes increasingly less heteronomous and increasingly more autonomous. The apple is becoming less environmental (and more organismic) in Angyal's sense. It is thus practicable to bring Angyal and Dewey's respective interpretations of *environment* into a common system.

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[47] Though all chapters in *Knowing and the Known* were mutually approved, several were individually signed.

In his *Logic: The Theory of Inquiry*, Dewey (1938) stressed that organism and environment were twin phases of a single life process. Further, Dewey made a distinction between that life process and the surrounding world:

> There are things in the world that are indifferent to the life-activities of the organism. But they are not parts of *its* environment, save potentially. The processes of living are enacted by the environment as truly as by the organism; for they *are* an integration. (p. 25)

> There is, of course, a natural world that exists independently of the organism, but this world is *environment* only as it enters directly into life functions. (p. 33)

Compare the last quotation with Angyal's (1941) "the surrounding world can only be called environment... when it participates in biological happenings" (p. 108) and "the objects of the external world can be called environment only in so far as they participate in the biological total process, that is, in so far as they are within the boundary of the biosphere" (p. 149). Both thinkers were expressing a common insight (An insight shared by G. H. Mead, 1934, e.g., pp. 130, 245-246). A related similarity to Angyal is evident in Dewey and Bentley's (1949, p. 65) insistence that the term *biological* should encompass physiological *and* behavioural or psychological subject matters.

To sum up, Dewey rejected prevailing tendencies to distinguish organism from surrounding world at the skin, to equate *surrounding world* with *environment*, and to focus on *interactions between* organism and environment as two separate things. Like Angyal, Dewey first distinguished a full process of life-activity from a background. He then distinguished organism and environment (read *medium*) as phases abstracted from *within* ongoing life-activity. In his words,

> ...life-activity is not anything going on *between* one thing, the organism, and another thing, the environment, but... *as* life-activity, it is simple event over and across that distinction (not to say separation). Anything that can be entitled to either of these names has first to be located and identified as it

is incorporated, engrossed, in life-activity. (in Dewey & Bentley, 1949, p. 323, see also Dewey, 1911/1978, p. 467)

Ashby: Single System

W. Ross Ashy was a pioneer of the cybernetic approach to psychology. In *Design for a Brain* (1960), he tackled the problem of how organisms lea-- and adapt. One part of Ashby's (tentatively offered) solution was what he cal. .n ultrastable state-determined system of interrelated variables and parameters. The soundness of his approach was verified with the construction of a working model (see Chapter 8: "The Homeostat") simulating aspects of homeostasis observed in organisms (see Beer, 1995, for a recent application of Ashby's approach). Here I limit my treatment to Ashby's conception of organism and environment.

In developing an account of organisms affording successful simulations, Ashby found it necessary to treat organism and environment as together constituting a single system. Thus, he argued "...the free-living organism and its environment, taken together, may be represented with sufficient accuracy by a set of variables that forms a state-determined system" (p. 36), noting "...from now on 'the system' means not the nervous system but the whole complex of the organism and its environment" (p. 41). Further, Ashby was familiar with what I have named the morphological conception of organism and the possibility of a dynamical or functional alternative: "...the anatomical criterion for dividing the system into 'animal' and 'environment' is not the only possible: a functional criterion is also possible" (p. 106). In more detail, Ashby explained as follows:

> As the organism and its environment are to be treated as a single system, the dividing line between 'organism' and 'environment' becomes partly conceptual, and to that extent arbitrary. Anatomically and physically [i.e., morphologically], of course, there is usually a unique and obvious distinction between the two parts of the system; but if we view the system functionally, ignoring purely anatomical facts as irrelevant, the division of the system into 'organism' and 'environment' becomes vague. Thus, if a mechanic with an artificial arm is trying to repair an engine, then the arm

may be regarded either as part of the organism that is struggling with the engine, or as part of the machinery with which the man is struggling. (p. 40)

Ashby comports with Angyal and Dewey in distinguishing organism from environment only within a unitary dynamical system. For all three theorists this system extended across the skin of the organism's body. The three scholars offered different criteria for distinguishing organism from environment (as aspects of one system). Angyal distinguished organism and environment by distinguishing autonomy from heteronomy. Dewey distinguished organism and environment by distinguishing life-activity from the medium by means of which life-activity goes on. Ashby argued that the distinction could be made differently for different purposes, and that "these divisions, though arbitrary, are justifiable because we shall always treat the system as a whole, dividing it into parts in this unusual [i.e., non-morphological] way merely for verbal convenience in description" (p. 41).

To sum up, in developing a systematic cybernetic account of the organism (including its brain, behaviour, learning and adaptation), Ashby argued against the morphological conception with its "anatomical criterion" for distinguishing organism and environment. He instead made the distinction functionally, dividing a unitary system into parts organismic and environmental according to the practical requirements of any given inquiry.

Dewey came from philosophy and psychology, Angyal from psychology and psychotherapy, and Ashby from cybernetics and neurology. Each ended with a compatible analysis. In their common rejection of the morphological conception, they emphasized organism and environment as (secondary) distinctions made within (primary) unitary dynamical systems. This completes my review of three attempts at non-morphologically based conceptualisations of organism. I now extend their preliminary integration and develop an analysis of the term *organism* in psychological usage. Given that Part 1's unit integration depended on the term *organism*, and given that the conventional (morphological) usage of this term is problematic, an improved usage is an important goal within the larger thesis.

Thoughts Toward More Accurate Designation

The Organism as Bioprocess

What, then, of the name *organism*? As this and the preceding chapter have shown, the way psychologists use the name *organism* is not accurate enough to qualify as specification. The word *organism* is used as a low-grade and confused characterization. The basis for the confusion is the tendency to conflate the physical body participating in a living process with organism and the physical surrounds of that physical body with environment. On inspection, however, *organism* and *environment* refer coherently (i.e., in the light of known fact) only to dynamic complements within a unitary and transdermal living system. One cannot obtain a living process by taking an organism, an environment, and putting them together. One can only obtain organism and environment (through provisional abstraction) once a unitary living process is at hand. In other words, a *physical* separation of the organismic and environmental phases of a living process is a *logical* impossibility. The phases are distinctions made within the dynamics of the whole system, and to separate these phases would be to destroy the system and thus the basis for distinguishing them in the first place.

The status of *organism* as low-grade characterization diminishes the clarity with which such points can be made. In unconsciously complying with the almost irresistible tendency to imbue synonymy to *organism* and (skin-bound) *body*, some readers will find themselves thinking that of course the organism (read *body*) and environment (read *surrounds*) can be morphologically separated (or, for that matter, connected). Terminological clarification is needed.

Dewey offers a starting-point in his informal musings on the etymology of *organism* penned in a (1948) memorandum to Bentley:

> I am inclined to think we should try to find and use a word that wouldn't be handicapped, as the *word* "organ*ism*" (like other Isms) has now been loaded down. I'll bet ninety readers out of a hundred wouldn't stop to think twice, coming across the expression "a dead organism." The damn "body" has got

> away with it. One can at least use "medium" as a synonym for "environment" when advisable. But unless one keeps saying "living being," "living creature," etc [misunderstanding is possible]; it's too bad there isn't a noun to go with biological. (in Ratner & Altman, 1964, p. 592)

Recall that Angyal's *biosphere* was offered as just such a noun for the reasons Dewey here outlines. It is a shame that *biosphere* has long had a different (though related) usage (see Vernadsky, 1926/1998). In the interests of unambiguous designation, the term *bioprocess* will be used as an alternative name. *Bioprocess* is a convenient abbreviation of Angyal's *biological total process* (i.e., a synonym for *biosphere* in his usage). Further, *bioprocess* captures the dynamic nature of the entity it is being used to designate, speaking to Dewey's concerns when he:

> ...got to mulling over the difficulty there seems to be in getting over to readers the organic-environmental activity as one "thing" and as in process. I concluded it was because the word "Organism" (especially in the *ism*) carries with it a kind of readymade hypostatization. (in Ratner & Altman, 1964, p. 592)

In the context of etymological concerns, it is illustrative to note that *organism* is a historical combination of *organize* and *ism*. Here the suffix *ism* forms a simple noun of action from a verb, as when the act of *baptizing* becomes *baptism*. *Organism* can be read as a noun denoting the process, act, or result of *organizing*. The verb *organize* combines *organ* in the sense of *tool, instrument*, or *functioning component of a greater whole* and *ize* in the sense of *to make into*. This sense is consistent with Angyal's analysis of the organism as a realm of increasingly (but never completely) autonomous organization – where the organism (as ongoing process of *organizing*) continuously assimilates (and eliminates) previously 'external' or 'chaotic' material into functioning components of the *organized* total process. It is also consistent with the emphasis other scientists place on viewing organisms as dynamic organizations (e.g., Goodwin, 1989, p. 29; Maturana & Varela, 1980, p. 48; Von Uexküll, 1926, p. 352; Wiener, 1954, pp. 95-96).

To sum up, the bioprocess conception of organism (1) offers an alternative to the problematic morphological conception of organism, (2) brings together aspects of Angyal's biosphere, Dewey's life-activity, and Ashby's single system, (3) is consistent with the etymological origin of the word *organism* in the word *organize*, and (4) fits with the emphasis many scientists place on the organism as a dynamic organization.

Contrasting the Two Alternatives: Organism as Body versus Organism as Bioprocess

Figure 10 compares the morphological and the bioprocess based conceptions of organism and environment. Plate A illustrates the traditional morphological conception of organism as a skin-bound object surrounded by an environment. Plate B illustrates a dynamical alternative in which a unified bioprocess (biological total process or organism-environment system) is designated or distinguished from the surrounding world on the basis of a continuously changing boundary. The conception illustrated in Plate B is a first step toward a sharper designation of *organism*. Further steps will be taken in Chapter 6.

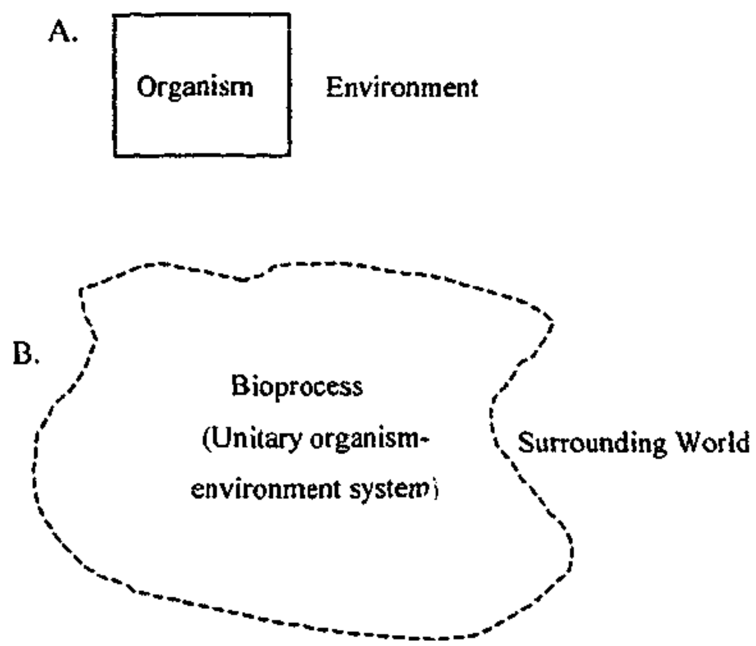

Figure 10: The morphological (A) and bioprocess (B) conceptions of organism and environment.

In the interests of sharpening the contrast, I reiterate the following similarities and differences. The two different conceptions of organism distinguish a focal unity (i.e., an event, entity, or object) from a background or surrounding world. The two conceptions differ, however, about the unity distinguished. In the morphological conception (Plate A) the focal unity is the organism's body (an object in space). In the dynamical alternative (Plate B) the focal unity is the entire bioprocess or organism-environment system (a process in space-time). The two conceptions differ about the criteria of distinction (this is necessarily true; identical criteria would yield identical unities). In the morphological conception, the criterion is skin. In the dynamical alternative the criterion is the extent of the living system's ongoing self-organization (or autonomy). The latter criterion is not clear-cut in the same sense that there is no clear-cut line between a whirlpool and the surrounding water or a fire and the surrounding air. Moreover, the boundaries of such dynamic unities are in continual flux (making the static dashed line in Figure 10 potentially misleading).

A second similarity between the two conceptions is that both retain a place for the words *organism* and *environment*. They differ, however, in the unities these words designate. In the morphological conception, the word *organism* is used to designate the initially distinguished entity (i.e., the skin-bound body) and the word *environment* is applied to the background surrounding this entity. In the non-morphological alternative exemplified by Angyal, Dewey, and Ashby, both words designate dynamical complements *within* (and secondary to distinction of) bioprocess or unitary organism-environment system. In the non-morphological conception, environment and surrounding world are distinct, whereas in the morphological conception they are equivalent.

Summary

Psychologists commonly conceptualise organisms as bodies separated from surrounding environments by skin. There are two steps. First, the body is distinguished from its background and called *organism*. Second, the

background is called *environment*. This conception is morphological. On scrutiny, it is seriously problematic.

This chapter reviewed three attempts at improved conceptions of organism. All three distinguished a unitary, dynamic, and transdermal life process from a background, *only then* distinguishing organism and environment as complementary phases *within* that life process. Such a method is consistent with the etymological relation of the word *organism* to the words *organ* and *organize*.

The word *bioprocess* was offered as an alternative to *organism*, which is ambiguous between *body* and *life process* (which *bioprocess* abbreviates). The reduction of such ambiguity is a hallmark of psychology's needed progression from loose *characterizations* to accurate *specifications* (Dewey & Bentley, 1949). As transdermal organic-environmental process, *bioprocess* encompasses physiology *and* psychology's subject matters, inviting revision of traditional perspectives on the relation of the organism to psychology. The following chapter explores a bioprocess-based conceptualisation of psychology's subject matter. In doing so, it will show an alternative to interpreting Part I's unit proposal from the perspective of the morphological conception of organism.

CHAPTER 6: THE BEHAVIOUR OF ORGANISMS

So far, Part 2 has (1) outlined the morphological conception of organism, (2) shown it to inform the theorising of psychologists including Kantor, Skinner, Lee, and Powers, (3) shown the morphological conception to be problematic, (4) integrated three non-morphological alternative conceptions, and (5) explored the implications for how psychologists think and talk about organisms.

This chapter completes Part 2's attempt to reconceptualise the traditional conception of what an organism is. As explained in the rationale for Part 2, Part 2 is a necessary part of this thesis because the traditional, skin-based conception of organism would otherwise distort interpretation of the psychological unit postulated in Part 1. The way psychologists think about organisms, that is, influences the way they think about the behaviour of organisms. This chapter sets out to examine and clarify the designation the *behaviour of organisms* (or, in everyday language, *what organisms do*). In doing so, it draws on Chapter 5's clarification of the designations *organism*, *environment*, and *bioprocess*.

The phrase *behaviour of organisms* is used inclusively of perceiving, visualizing, thinking, talking, remembering, imagining, and so on (i.e., inclusively of cognition and language). For this reason I use the phrases *behaviour of organisms* and *psychology's subject matter* interchangeably. Although the phrase *what organisms do* is conceptually less problematic than the *behaviour of organisms* (see Lee, 1999a), both are problematic in implying that psychology's subject matter is an internal or peripheral property of the organism (as opposed to an occurrence within the organism-environment system or bioprocess as will be argued here). Though I use these phrases, along with the related words *action* and *activity* (in reviewing scholars who have used them), I use them cautiously, as loose names to be refined with more accurate designations during the course of the chapter.

Non-morphological approaches to designating the behavior of organisms (i.e., psychology's subject matter) have been under development for many years. After the style of Chapter 5, this chapter begins with a review of five contributions.

A Review and Preliminary Integration of Some Non-Morphological Approaches to the Conceptualisation of Psychology's Subject Matter

Bentley: Behavioural Superfice

The previous chapter had more recourse to the Dewey part of the long-standing co-development and then collaboration of Dewey and Bentley (culminating in *Knowing and the Known*, 1949). I now explore one of Bentley's important earlier solo offerings. In his own writing, Bentley had long advocated a locus of behavioural activity that was *transdermal*[48] in the sense of occupying a region "…literally wider than any region enclosed by the skin" (1941c, p. 8, see also 1935; 1939a; 1939b; 1939c; 1940; 1941a; 1941b):

> …for many important purposes we must regard *a behavior* as a process, activity, or event that ranges through a region wider than that within a 'skin.' Matter-of-fact observation, to be maintained, must have precise, literal statement accompanying it. If the behavioral event *is* wider that the physiological skin, if it is actually so observed, then *literally* we should report the locus of the behavior to be wider, and also its *boundaries*. (1941a, p. 41)

> …we can attain no description that makes sense at all for actual human behaviors – lovings, hatings, buyings, votings, fightings, helpings, talkings, schemings – without observing and describing the behavioral activity as itself positively and directly transdermal. (1941c, p. 10)

As a tool for direct transdermal description of behaviour, Bentley (1941a; 1941c) introduced the word *behavioural superfice*, which designated "…the

[48] A word Bentley came to emphasize over his earlier *situational* which he used in the same sense and for the same purpose (and which is making a return in the situated cognition movement (e.g., Clancey, 1997)).

boundaries of any area in which organism-environment adjustments of the behavioral type are in progress" (1941c, p. 15). Bentley rejected the skin-bound (i.e., morphologically conceived) organism as a starting point. After adopting such a starting point, psychologists usually localize behaviours in tacit reference to the skin (whether internally, peripherally, externally, or some combination, as discussed on p. 57). Instead, Bentley suggested *starting* with the superfice, studying the behavioural occurrences it bounds (spatially and temporally), as directly transdermal – the skin not necessarily implicated at all. For Bentley (1939b) a behavioural superfice (or in his earlier phrasing, *situation*) encompasses organism and object "...not as isolated beings forcing themselves or being forced into contact with one another, but as phases of one common, naturalistic process or event" (p. 171).

Importantly, the behavioural superfice was offered as something *within* the greater life- or bio-process. Thus, to the question "what and where is behaviour?" Bentley (1941b) answers, "the location of behavior is literally in naturally evolving life on earth. It is literally in organism-environment" (p. 485, see also Dewey & Bentley, 1949, p. 151). The unitary processes of organism-environment, what is more, include for Bentley the subject matters of physiology: "...a situational inquiry into behaviors, we conclude, may be differentiated from other situational physiological inquiries by the greater complexity of the processes of organism-environment it studies..." (1939c, p. 322, see also 1954, p. 305). This is consistent with Dewey and Bentley's (1949, p. 65) insistence that the term *biological* "must" cover physiological *and* behavioural inquiries, despite their simultaneous conviction that "the technical differentiation, in research, of physiological procedures from behavioral is of the greatest import in the state of inquiry today..." (p. 65). What was in question was not the utility of the distinction but its misinterpretation as a factually pre-given line of separation (which we still, today, find lingering at the rind).

To sum up, Bentley's *behavioural superfice* extends his transdermal analysis to behavioural domains, effecting "...the suppression of the old pretence that the human epidermis is the most vital line of demarcation in the universe" (1939c, p. 316). Importantly, the behavioural superfice delineates a sub-realm of the greater bioprocess rather than anything external to or separate from it.

Dewey: Coordination

Having found in Bentley's behavioural superfice a tool for focusing on the regions of the bioprocess distinguished and studied as psychological, I now increase the resolution with which the content of these regions is conceptualised. Turning back to Dewey, I show that his famous[49] 1896 *Reflex Arc Concept* paper provides the tools needed to take this analysis many steps further. In critiquing the traditional reflex arc based conception of stimulus and response, Dewey (1896) laid solid foundations for a non-morphological conception of psychological process. In the following three paragraphs I review three of the paper's core contributions.

First, Dewey (1896) *starts* with an organized coordination and *only then* distinguishes stimulus and response as dynamic complements *within* this greater whole.[50] What was to be avoided was "...beginning with stimulus or response instead of with the coördination with reference to which stimulus and response are functional divisions of labor" (p. 361). It was by starting with stimulus and response as parts rather than the whole from which they had been tacitly derived, wrote Dewey, that "...the supposed problem of the adjustment of one to the other... is a purely self created problem" (p. 364). So the first theme is that for Dewey the greater coordination, as an "organic unity" or

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[49] To repeat a footnote from Bentley (1950), "at the time of the celebration of the fiftieth anniversary of the *Psychological Review*, this paper was judged by a vote of several hundred leading American psychologists to be the most important paper ever published in that journal. Even yet its values are only partially realized" (p. 780).

[50] It is illustrative to note that this mirrors his interpretation of the distinction between organism and environment. For Dewey, before anything can be assigned either name, it "...has first to be located and identified as it is incorporated, engrossed, in life-activity" (in Dewey & Bentley, 1949, p. 323). In other words, Dewey (like Angyal), *starts* with the unitary process of life-activity and *only then* distinguishes organism and environment as dynamic complements *within* this greater whole (see Chapter 5, p. 75).

"psychical organism," was always primary – the distinction of stimulus and response always secondary.

The second theme concerns the events designated *stimulus* or *response*. For Dewey, "the only events to which the terms stimulus and response can be descriptively applied are to minor acts serving by their respective positions to the maintenance of some organized coördination" (pp. 369-370). Further, each act was itself a sensory-motor coordination, such that "it is an act, a sensori-motor coördination, which stimulates the response, itself in turn sensori-motor, not a sensation which stimulates a movement" (p. 366). To clarify this point, Dewey called on William James' example of a child seeing, reaching for, being burned by, and withdrawing from a candle. Here, Dewey noted that "the real beginning is with the act of seeing; it is looking, and not a sensation of light," where "...if this act, the seeing, stimulates another act, the reaching, it is because both these acts fall within a larger coördination..." (pp. 358-359). When behaviour flowed smoothly, argued Dewey, there was one continuously reconstituted coördination, describable by the observer as a "continuously ordered sequence of acts, all adapted in themselves and in the order of their sequence, to reach a certain objective end" (p. 366).[51]

A third theme was Dewey's emphasis that the coordination was always a *circuit*. In discussing act-sequences (i.e., ongoing psychological activity) as continuous circuits of coordination, Dewey was anticipating the later advent of cybernetics. In Dewey's words, "what we have is a circuit, not an arc or broken segment of a circle. This circuit is more truly termed organic than reflex, because the motor response determines the stimulus, just as truly as the sensory stimulus determines movement" (p. 363). Using the example of someone running away from a threatening sound, Dewey noted that the hearing of the sound and the running away from it are co-influencing co-occurrences. The running changes the hearing and the hearing changes the running, where both persist simultaneously. It is not one then the other but both together in ongoing cyclical relation. For Dewey, every action is circular in this sense,

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[51] A statement that for Dewey was equally applicable to physiological subject matters such as "the series of events in the circulation of the blood" (p. 366).

where, again, "it is the circuit within which fall distinctions of stimulus and response as functional phases of its own mediation or completion" (p. 370). The complementarities between Dewey's analysis of circuits and the later developments of Weiner, Ashby, Bateson and other cyberneticists – particularly the formal description of negative feedback – will be discussed later in this chapter.

Dewey's behavioural analysis is consistent with Bentley's behavioural superfice (unsurprising given Dewey's influence on Bentley's intellectual development). Dewey's coordination is appropriately localized in such a transdermal superfice. As Bentley (1941c) put it in discussing Dewey's (1896) paper, "manifestly there is no attribution here of intradermal localization to psychological fact" (p. 7).

To sum up, Dewey (1896) viewed stimulus and response as functional divisions of labour within a greater and more primary coordination. Each coordination was describable as an ordered sequence of sensory-motor *acts* named stimuli or responses according to their role within the greater coordination. Dewey's coordinations were always *circuits*, and are coherently localized in transdermal behavioural superfices (as described by Bentley).

Järvilehto: Result

In attempt to overcome a morphological conception of psychology's subject matter, Järvilehto (e.g., 1998a; 1998b; 1999; 2000) developed his *Theory of the Organism-Environment System*, which "starts with the proposition that in any functional sense organism and environment are inseparable and form only one unitary system" (1998a, p. 321). I here review one of the theory's central features, the *result of behaviour*, tracing its relations to Dewey's analysis. As Järvilehto explains,

> The key concept in the analysis of the organism-environment system is the result of behavior. To continue its life process every organism must achieve positive results. Thus, the general architecture of any organism-environment system corresponds to the result, and its systems dynamics may be understood only by taking a historical perspective and looking at the

> development of the necessary conditions for the achievement of the certain result. The structure of the organism-environment system can only be understood in terms of the results of behavior. The result is therefore the factor to which all the organization of the system is related. (1998a, p. 330)

> The key concept of the theory is the concept of result which does not mean a simple effect or consequence of behavior, but a possibility of a new act, a transition from one act to another... (2000, p. 37)

An important point here is that Järvilehto's results are distinctions made *inside* the system, and are the means by which the system is defined – by which its architecture or dynamical organization is ascertained. Further, for Järvilehto, though "the concept of result is necessary for determining the architecture of the organism-environment system," "life is a continuous process; there are no results as such. Results are our way to divide this continuous process in meaningful parts" (personal communication 15 August 2000). Järvilehto (2000) elaborated this important point with the example of picking something up:

> ...with words we can never describe an action, but only common results. If I want to tell what happens when I take a pencil from the table, I must divide my action into smaller results of action: my hand is now here, I move it, at the next moment it is there, I take a grip on the pencil, etc. If I am further asked what I mean with "move" or "take", I must again go to the results and say, for example, that moving means the hand is now here, but at the next moment there. [...] In fact, *each verb is an abbreviation of a sequence of results* [italics added]. (p. 49)

For Järvilehto, results are abstracted from the continuous life process (and its sub-processes) to parse that process (or sub-process) into comprehensible units. Everyday verbs (the language of action) designate sub-processes within the organism-environment system that require, when pushed for detail, descriptions of sequences of results.[52] This is reminiscent of Dewey's (e.g., 1896; 1930; 1938) behavioural analyses, especially given Järvilehto's definition of a result of behaviour as a "transition from one act to another." As shown above, Dewey (1896) analysed behaviour into the ordered sequences of acts constituting coordinations. In Dewey's words, "...behavior is sequential, one act growing out of another and leading cumulatively to a further act until the consummatory fully integrated activity occurs" (1938, p. 31), where "a response is not action or behavior but marks a change in behavior. It is the new ordinal position in the series, and the series is the behavior" (1930, pp. 413-414).

To sum up, Järvilehto's result of behaviour places psychological phenomena *inside* the organism-environment system. Järvilehto stresses the observer's parsing of continuous action into transitional results of behaviour in a manner compatible with the analyses of Dewey (1896, 1930, 1938).

Lee: Deed

Chapter 4 (pp. 61-63) examined Lee's (e.g., 1988; 1994; 1996a; 1999a; 2001) deed approach for any commitment to the morphological conception of organism and environment. Lee was found to differ from most psychologists, including Kantor, Skinner, and Powers, in rejecting the morphological conception as a starting point. Nonetheless, Lee was found to adopt the morphological conception in discussing the contribution that organism and environment make to deeds. Despite drawing on the morphological conception, Lee's deed unit is designated with relative accuracy (see p. 27), and overlaps with aspects of Dewey's acts and Järvilehto's results. For these reasons, Lee's deed unit is included here as a potential contributor to a non-morphological account of psychology's subject matter.

To review, for Lee (2000), deeds are changes, where

[52] See Zuriff (1985) for a complementary argument that, ultimately, "...movement-description reduces to achievement-description" (p. 44).

> I use the word "change" to denote the moment of a difference in the state of a particular object (or surface or medium). For example, a button depression is the change observed at the *moment of a specified difference* [italics added] at a particular button...

An important aspect of this definition is that any given deed entails the meeting of a *specified criterion* (or, in the above quotation, *difference*) prescribed by the observer. Observers of psychological processes (such as an instance of bike-riding) parse that process into series of deeds by stipulating the thresholds by which the deeds are to be counted as having occurred (e.g., the pedal or wheel crossing the point of zero degrees in rotation, the handlebars crossing their mid-point, the chain having moved from one cog to another, the brake pads having made contact with the rim of the front wheel). This makes deeds dependent on the observer or observers stipulating the criteria. Here we see an overlap with Järvilehto's analysis of *results* as serving to parse continuous processes into meaningful parts (i.e., as being equally dependent on the observer). Lee (1994) directly discussed psychological processes as series of deeds or things done: "[patterns] must be inferred from the *processes (i.e., series of changes)* [italics added] that occur in large collections of things done distributed through time" (p. 39). Further, where Järvilehto suggests that verbs are always abbreviations of "sequences of results," Lee suggests that the actions designated by verbs are relatively fuzzy analytical units (e.g., washing the dishes), and that deeds enable sharper analytic treatment of the same processes and their component events (e.g., a change in the state of the sink from empty to filled, a change in the state of a dish from dirty to clean). In the terms of Dewey and Bentley (1949), the name *action* is to the name *deed* as characterization is to specification.

Lee's analysis also overlaps with that of Dewey. First, Dewey's analysis of psychological process as the act sequences comprising any given coordination is consistent with Lee's analysis of the deed series into which psychological processes can be analysed. Second, Lee and Dewey reject the viewing psychological events as *either* stimuli *or* responses. Consider, again, seeing a candle, reaching for it, and being burned. In the traditional (and still popular) view, this is a stimulus-response-stimulus sequence. For Dewey the sequence is act-act-act and for Lee it is deed-deed-deed. The three events are treated as being of the same logical type rather than being partitioned into environment (stimulus or input) and organism (response or output). Third, and in a related vein, Dewey and Lee place sensation and movement inside such events (acts or deeds). For Dewey (1896) "...both sensation and movement lie inside, not outside the act" (p. 359); for Lee (1999a) "the constituents of the things we get done [i.e., deeds] are both sensory and motor, as is evident by considering, for example, how we rub our fingers over an object to determine its texture" (p. 79).

In an attempt to make sense of psychological process, Lee has developed an analysis of deeds and their relations (or patterns) having much in common with the analyses of Järvilehto and Dewey. Because deeds are the meeting of specified criteria, they are dependent on the criterion specifying activity of observers. Such considerations suggest Lee's deeds can contribute to a non-morphological account of psychology's subject matter.

Bateson: Circuits of Differences Making Differences

Gregory Bateson (e.g., 1972; 1979) developed an alternative to the morphological conception of organism. Importantly for present purposes, Bateson placed the phenomena of concern to psychologists *inside* his enlarged and dynamical conception of organism (where in Bateson's unconventional usage, *organism* is synonymous with *mind*):

> I suggest that the delimitation of an individual mind must always depend upon what phenomena we wish to understand or explain. Obviously there are lots of message pathways outside the skin, and these and the messages which they carry must be included as part of the mental system whenever they are relevant.
>
> The elementary cybernetic system with its messages in circuit is, in fact, the simplest unit of mind; and the transform of a difference traveling in a circuit is the elementary idea ...
>
> But what about 'me'? Suppose I am a blind man, and I use a stick. I go tap, tap, tap. Where do I start? Is my mental system bounded at the handle

> of the stick? Is it bounded by my skin? Does it start halfway up the stick? Does it start at the tip of the stick? But these are nonsense questions. The stick is a pathway along which transforms of difference are being transmitted. The way to delineate the system is to draw the limiting line in such a way that you do not cut any of these pathways in ways which leave things inexplicable. If what you are trying to explain is a given piece of behavior such as the locomotion of the blind man, then, for this purpose, you will need the street, the stick, the man; the street, the stick, and so on, round and round.
>
> But when the blind man sits down to eat his lunch, his stick and its messages will no longer be relevant – if it is his eating that you want to understand. (1972, p. 434)

In these statements Bateson understands organisms or "individual minds" as continuous circular pathways of *differences making differences.* In this example, a difference in the surface of the street touching the stick makes a difference in the motion of the stick which makes a difference in the motion of the man's body which makes a difference in the surface of the street touching the stick and so on. Bateson refined such ideas into generic tools for the transdermal analysis of biological phenomena, which, like Angyal and Dewey-Bentley before him, he defined broadly (and chose to designate "the world of mental process").

There are important overlaps among the analyses of Bateson and the four scholars reviewed above. I will mention three. First, Bateson accords with Bentley in arguing that psychological process are transdermal. A process like navigating-with-stick extends beyond the skin. Enter Bentley's behavioural superfice as explicitly transdermal delineation.

Second, Bateson follows Dewey in emphasizing the continuous *circuits* comprising biological (physiological and psychological) subject matter. For Bateson, such circuits are the "simplest units of mind." This observation is extended in the next section, which discusses negative feedback.

Third, Bateson (1972) identifies the components of such circuits with differences that make differences (which he also designates *transforms* or *news of* difference): "...a circuit is a closed pathway (or network of pathways) along which *differences* (or transforms of differences) are transmitted" (p. 482). This unit resembles Dewey's transitional acts, Järvilehto's results (defined as transitions), and relations of dependency between Lee's deeds (defined as moments of difference). Again, these complementarities are extended later in the chapter.

In sum, Bateson's non-morphological approach incorporates a transdermal orientation to psychological process, an emphasis on closed circuits, and a definition of the components of those circuits as differences making differences. In these respects his writing is consistent with the previously reviewed analyses of Bentley, Dewey, Järvilehto, and Lee.

Negative Feedback

In this section, I further integrate the foregoing conceptualisations of psychology's subject matter. I show how negative feedback assists such integration. This is not the first reference to negative feedback in this thesis. Negative feedback was discussed in Chapter 3's inclusion of Powers' *control system* unit in an integration of Kantor's *behaviour segment*, Skinner's *operant*, and Lee's *deed* (see p. 37). Chapter 3 showed that negative feedback contributes to an accurate designation of a psychological unit. This chapter shows that negative feedback also contributes to a non-morphological conception of psychology's subject matter. As the remaining chapters will elaborate, the convergence on negative feedback in these two contexts is important in the overall argument of this thesis.

What is Negative Feedback?

Negative feedback designates any self-corrective organization in which, to borrow Bateson's phrase, "differences can be used to stimulate that which will make them not different." A difference between the actual and the user-specified temperature of a thermostatically controlled heater will turn the heater on or off in such a way that the difference is soon removed. The system is configured to maintain temperature within a narrow range by opposing disturbances that would otherwise lead to temperature change far greater than the slight deviations that actually occur. Similarly, a difference between the colour of a chameleon's body and its background contributes to the removal of that difference through a change in body colour.

A complementary way of thinking about negative feedback entails a circle of functional relations between at least two variables, where an odd number of connections between the variables is negative. Let one variable correspond to the concentration of carbon dioxide in the blood, and a second variable correspond to the rate of respiration (holding depth of respiration constant for this simple example). If we observe this two-variable system, we will see an *increase* in carbon dioxide concentration (i.e., a difference between optimal and actual concentration) occasioning an *increase* in rate of respiration which occasions (all else being equal) a *decrease* in carbon dioxide concentration, which occasions (again, all else being equal) a *decrease* in rate of respiration, and so on, round and round. The link from the first variable to the second is positive (the more A the more B; the less A the less B), but the link back again is negative (the more B the less A; the less B the more A). The outcome for an appropriately organized circuit is keeping carbon dioxide concentration within a non-lethal range.

Negative feedback is ubiquitous in biological phenomena. Positive feedback (i.e., runaway or snowballing) loops are occasionally present in stable (i.e., persisting) bioprocesses, such as in the clotting of blood or in the uterine contractions of childbirth. But they are rare and always subordinated to negative feedback loops, as when blood clotting contributes to the regulation of arterial pressure.

Negative feedback traverses the traditional distinction between physiology and psychology. Among the phenomena of concern to physiologists are negative feedback processes by which (see Ashby, 1960, p. 59-61, for further examples):

- The diameter of the pupil changes to maintain approximately constant the amount of light entering the eye.

- The orientations of the leaves of a plant change to remain facing the sun.

- Thirst, and thus water intake, changes to maintain the water content of the body within certain bounds.

Among the phenomena of concern to psychologists are negative feedback processes by which:

- The orientation of the steering wheel of a car changes such that the distance between the car and the verge stays almost constant.

- When reaching for an object like a pencil the position of the hand changes to continually decrease the amount by which the hand has not yet grasped the pencil (see Wiener, 1948, p. 7).

- The rate at which words are fixated when reading changes in order that their comprehension remains constant.

In both sets of examples one thing varies to keep something else relatively invariant. The pattern of negative feedback applies to physiological and psychological processes and to processes that incorporate both. When we pick up and drink a glass of water (and thus exemplify two of the above listed instances of negative feedback) there is no line at which one subject matter turns into another, but a continuous process from which the subject matters of many sciences, including physiology and psychology, can be abstracted (cf. A. F. Bentley, 1941a, p. 56). Looking closely at the physiological and the psychological, we find the one fading into the other and observe identical (negative feedback) dynamics in both.

Dewey's Anticipation of Negative Feedback

Besides anticipating aspects of Järvilehto's results, Lee's deeds, and Bateson's circuits, Dewey (1896) anticipated the later formalization of negative feedback. Consider a passage from his discussion of the example of a child reaching for, being burned by, and withdrawing from a candle:

> ...the so-called response is not *to* the stimulus; it is *into* it. The burn is the original seeing, the original optical-ocular experience enlarged and transformed in its value. It is no longer mere seeing; it is seeing-of-a-light-that-means-pain-when-contact-occurs.... *The fact is that the sole meaning of the intervening movement is to maintain, reinforce, or transform (as the case may be) the original quale* [italics added]; that we do not have the replacing of one sort of experience by another, but the development ... the mediation of an experience. (pp. 359-360)

Remember that here Dewey is critiquing the traditional view that one event (the candle as stimulus) causes another event (reaching for the candle as response), which causes a third event (the pain of being burned as a stimulus), which causes a fourth event (withdrawing the hand as response). "In its failure to see that the arc of which it talks is virtually a circuit, a continual reconstitution," wrote Dewey (1896), the traditional reflex arc idea "breaks continuity and leaves us nothing but a series of jerks" (p. 360). Contrary to postulating a linear series of separate events, Dewey's analysis starts and ends with a continuously developing coordination, which can be applied to the present example as follows.

As a starting point, as a continuous development of what she was seeing previously, the child sees the candle. This seeing is ongoing and continues throughout what follows. The reaching, which develops out of the posture or movement the child was previously making, is then made *into* the stimulus, or the seeing of the candle, in the sense that the reaching changes the seeing – it changes what is being seen or experienced – this is its "sole meaning." Upon contact with the candle, rather than the burn being an entirely new experience, it is what Dewey calls "the original seeing... enlarged and transformed in its value" (p. 359). The withdrawing of the hand, in turn, is *into* the experience of being burned (Dewey's "seeing-of-a-light-that-means-pain-when-contact-occurs") in the sense that it serves to transform that experience in a pain-reducing way.

The link between this analysis and negative feedback is direct. Experiences are maintained, reinforced, or transformed by other actions which fall into a circuit with the experiencing such that what one experiences affects what one does and what one does affects what one experiences. Later developments in cybernetics have shown that the underlying pattern by which such maintenance (e.g., of car position), reinforcement/amplification (e.g., of hand-candle proximity), or transformation (e.g., of soft clay from blob to bowl) is negative feedback. To paraphrase Dewey (1896, pp. 359-360) in the context of driving a car, "the sole meaning of turning the wheel is to maintain the seeing-of-the-car-in-the-middle-of-the-correct-lane."

Powers and Negative Feedback: Behaviour as the Control of Perception

Any discussion of how negative feedback contributes to the conceptualisation of psychology's subject matter would be incomplete without mention of Powers' Perceptual Control Theory (PCT). As discussed in Chapters 3 and 4 (see p. 37 & p. 63), the building block or analytical unit of PCT *is* a negative feedback loop, which Powers calls a *control system*. As the name suggests, the purpose of a control system is to control, where *control* means to protect or maintain against disturbance. PCT also offers an account of how many negative feedback loops can be integrated in hierarchies. I will draw on aspects of Powers' account of such hierarchies shortly.

Powers' analysis of negative feedback is consistent with several themes in Dewey's (1896) analysis. These include a rejection of linear stimulus-response-stimulus causality, the realization that all parts of the loop are present and changing at the same time, an emphasis that stimuli are never external to perceptual activity, and the argument that behaviour operates to maintain or transform aspects of experience in an ongoing circular relation. Unfortunately for present purposes, however, Powers departs from Dewey (not to mention Ashby, Bateson, Angyal, Bentley, and Järvilehto) in forcing negative feedback on to a morphological template where organism and environment are taken as two spatially separate (though adjoining) things. PCT's morphological separation of organism and environment is explicit and was reviewed in Chapter 4 (p. 63). In drawing on Powers towards a non-morphological account of psychology's subject matter, therefore, we must exercise caution.

The Bioprocess as a Network of Negative Feedback Loops

I hinted above at PCT's analysis of complex behaviour through hierarchic organizations of higher and lower order control systems. Powers (1973) gave the example of a computer operator using a joystick to keep a cursor tracking a mobile target on a computer monitor. Maintaining the truth of the descriptive proposition "the spot is on the target" entails systematic change in the descriptive proposition "the hand/mouse position is x,y," which entails systematic change in the descriptive propositions about the tensions of the relevant muscles. As Powers notes, "there is, in short, a hierarchy of negative feedback control organizations visible in the subject's behavior" (p. 52). The negative feedback loop dealing with cursor-target proximity relies, in part, on the negative feedback loop dealing with mouse position, and this mouse-position loop relies, in part, on the many negative feedback loops dealing with muscle tensions. Stability of higher-order variables is achieved through relative variability in those of lower order. As mentioned above, this broader organization (encompassing all three layers in the hierarchical spot-control process) intertwines physiological and psychological domains. At a still broader level, Powers views not only the subject's behaviour but the subject themselves as a network of negative feedback loops. In Powers' (1976/1989) own words, "I say that human beings are self-reorganizing hierarchies of negative feedback control systems" (p. 105, cf. Bateson & Bateson, 1987; Maturana & Varela, 1980). Here, as I hinted earlier, we see that aspects of PCT can contribute to a non-morphological account.

Completing the Integration

This section shows how the insights of the scholars reviewed above and the generic notion of negative feedback can be integrated into a non-morphological account of psychology's subject matter. I will use the example of seeing, reaching for, and picking up a pen to clarify each step in the account as it now stands. As I will show, envisaging psychology's subject matter as within the bioprocess results in a unit consistent with the unit proposed at the end of Part 1.

(1) We begin with Angyal and Dewey. This entails the distinction of a transdermal bioprocess from a surrounding world and the possibility of further distinctions within that bioprocess (as detailed in Chapter 5).

(2) Next comes Bentley with a behavioural superfice delineating a sub-realm of the regions of the bioprocess in which psychology's (i.e., behavioural) subject matters go on. To distinguish an instance of book-being-read, car-being-driven, math-problem-being-solved, pen-being-picked-up,[53] etc., is to distinguish and delineate such a (transdermal) superfice. It localizes a unitary phenomenon and again invites further distinctions.

(3) Looking more closely, we note that the behavioural process within a superfice entails the coordinated activity of different part processes. To understand the reaching phase of picking-up-a-pen, reference must be made to coordination between seeing-position-of-hand-relative-to-pen and moving-the-hand. Here Dewey's concept of *coordination* allows us to characterize the process as a continuous circuit.

(4) The description so far remains at the level of the verbs comprising everyday action language. As mentioned in the sections on Järvilehto and Lee, verbs are loose characterizations rather than sharp specifications. To move from characterizations toward specifications, we turn to the units designated by Dewey (acts), Lee (deeds), Järvilehto (results), and Bateson (differences making differences). These units allow us to distinguish and classify particulars and patterns of particulars within any coordination (or superfice). Further, these units converge on a *change* as the common element, as follows. Where Dewey uses the term *act* in the sense of a change (e.g., 1896, p. 366; 1930, pp. 412-414), Järvilehto's results are always transitions, Lee's deed specifically entails a change in her sense of the moment of a specified difference, and for Bateson differences either are changes (1972, p. 452) or can

[53] After Bentley (1939b) I hyphenate these phrases to emphasize that the processes they designate are unitary, with traditional distinctions into "subject" (organism), "verb" (behaviour), and "object" (environment) being secondary (and not for my purposes necessary).

only make differences by triggering "...*events*, which we call *changes*" (1979, p. 97).[54]

In the interests of accurate designation, I use *change* in the sense of an *instance of becoming different*.[55] This avoids the more general connotations of the term *change* as something happening over time, as opposed to the changes of concern here, which occur at an instant – the moment a prescribed criterion (or stipulated threshold) is met. As argued by Dewey, Järvilehto, and Lee, any durational behavioural process can be analysed into sequences of such changes (and must be if any scientific account is to be realized).

It is worth emphasizing that the ascription of changes depends on prescribed criteria – that is, on the action of an observer. Specified instances of becoming different are a way of parsing *continuous* conduct into manageable units. They are not pre-existent atoms out of which superfices and bioprocesses are constructed, but distinctions made within the already existing bioprocess/superfice/coordination. For this reason, Dewey (1930) wrote, "it is hardly possible, I think, to exaggerate the significance of this fact [temporal spread] for the concept of behavior. Behavior is serial, not mere succession. It can be resolved—it must be—into discrete acts, but no act can be understood apart from the series to which it belongs" (p. 412). Figure 11 illustrates these points with the example of picking up a pencil or moving an object from one point to another. Although an act characterization like "picking up the pencil" has fuzzy boundaries, this fuzziness evaporates once we draw the lines, criteria, or thresholds by which the act is analysed into a sequence of *instances of becoming different*.[56]

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[54] This also fits with Ashby's (1960) "...behavior is itself a sequence of changes (e.g., as the paw moves from point to point)" (p. 13).

[55] This definition comes from the Concise OED's leading definition for the word *change*.

[56] As an example from operant psychology, the characterization "lever press" becomes more precise when a completion criterion is specified (i.e., micro-switch closure).

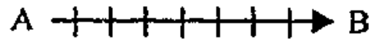

Figure 11: This simple diagram illustrates the way in which continuous conduct can be analysed into instances of meeting prescribed criteria. The continuous action of moving the hand from point A to point B (represented by the horizontal arrow) is dealt with as a sequence of changes, each change corresponding to the hand passing one of the vertical dashes (ignoring for simplicity vertical movements). The resolution of the dashes will depend on the requirements of the observer. Note that recording the time at which the hand passes each mark allows the derivation of hand velocity and acceleration.

(5) In considering the patterns made up by changes observed within coordinated activity, negative feedback is likely to describe these patterns (which is not to exclude possibility of observing different patterns). In a process like keeping-car-in-middle-of-lane, differences in the position of the car are organized into a negative feedback circuit with differences in the orientation of the steering wheel such that disturbances like lateral gusts of wind are equally and oppositely opposed. Likewise, in the process of picking-up-a-pencil, deviations of the hand from the most direct trajectory toward the pencil are fluidly corrected via negative feedback.

Further, as we have seen, negative feedback is a generic way of conceptualising the broader bioprocess and for dealing with the nested way in which the stability of the whole process (and sub-whole processes) is maintained through the relative variability of the part-processes (and so on). This gives a framework for dealing with the hierarchical organization of behaviour. Getting a word typed is of a higher order than getting a letter typed and of a lower order than getting a sentence typed. If appropriate to our inquiry, we can define the completion of each word as a single change and inquire about how these changes function in the broader process of completing successive sentences. Conversely, we might look downward to evaluate the way in which the completion of individual words arises from the coordinated completion of individual letters. To go further down, we might look at the patterned series of changes by which an individual key depression is effected. And so on.

These five steps are a preliminary means of conceptualising and investigating psychology's subject matter as transdermal process. Nowhere in the above is it necessary to postulate a skin-bound organism-agent, an external environmental object, and to then try and bring them together with terms like *behaviour*, *input*, *output*, *interaction*, and so on. By never taking them apart the above method is free to investigate the details of the focal process and in so doing to develop whatever distinctions serve its coherent description.

The integration in the above five steps is consistent with the unit designation proposed at the end of Part 1 (*Regulative circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes*). It also increases the accuracy of that designation. It does so by clarifying the designation *organism* on which the earlier definition of a *deed* was dependent. On Page 26 of Chapter 2 a deed was defined as "a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one *organism* [italics added] among many other contributors." Part 1 followed Lee in arguing that it is misleading to think of deeds (or what are here designated *instances of becoming different*) as of the organism *or* of the environment (see Chapter 2, p. 30). For Lee, this is because deeds are always of both together, in the sense of having both as contributors. As shown in Chapter 4 (p. 61-63), however, this argument can be made without departing from a morphological conception of organism (as body) and environment (as surrounding world). This chapter has developed further the argument of Part 1. Here, deeds, or instances of becoming different, are units designated only within bioprocesses. Because a bioprocess has organism and environment as dynamic and inseparable complements, deeds are of both the organism and the environment in a different (and, I have argued, conceptually more coherent) sense than described in Part 1.

Conclusion

As stated at the outset, the way psychologists conceptualise organisms has implications for the way they conceptualise the behaviour of organisms. This chapter began by distinguishing a unitary bioprocess or life process within which organism and environment are distinguishable only as complementary phases. This untraditional starting point was shown to support a postulation of behaviour as patternings, particularly circular negative feedback patternings (or coordinations) among changes (or instances of becoming different). These patternings were localized within a transdermal behavioural superfice, which was localized within the greater bioprocess. Despite its unconventional rejection of the traditional skin-based starting point, the approach was shown to comport with central themes in the writings of Angyal, Dewey, Bentley, Ashby, Bateson, Järvilehto, Lee, and Powers.

In exploring an untraditional, non-morphological conception of organism and environment (as inseparably together within bioprocess), Part 2 has postulated at a unit not inconsistent with that developed in Part 1. Reaching a similar postulation from a different starting point supports the validity of both postulates. Further, where the unit postulated in Part 1 relied on a vague and problematic characterization of organism, Part 2 has clarified the designation *organism* and relations between the organism and the unit postulated in Part 1. In doing so, it has moved the proposed unit away from characterization and toward accurately designated scientific specification.

PART 3: ITERATING BETWEEN OBSERVATION AND POSTULATION

Précis of Part 3

Part 3 uses the unit postulations reached in Parts 1 and 2 (p. 45 & pp. 101-104) to guide experimental observation. Part 3 has two chapters. After a summary of progress made, Chapter 7 explains how iteration between observation and postulation can be used to reach a clearer conception of what psychologists observe. Specifically, Chapter 7 explains how postulations can guide observations in the sense of predicting what is there to be seen if looked for in the right way. This method, which uses the data as a conceptual window on the subject matter, is contrasted with the usual method in psychology, which uses the data to test hypotheses. Chapter 7 overcomes the problem of a suitable data collection method with a modified version of an experimental paradigm called *serial visual presentation of text*.

Chapter 8 uses the unit postulations of Part 1 and Part 2 to guide observation of the resulting data. Using tabular representations, graphical transformations, and computer simulations, Part 1's unit postulation is shown to (1) predict much of what was observed, (2) suggest its own refinement, and (3) highlight several anomalies. Part 2's bioprocess-based unit postulation is then used to guide observation of the same subject matter, and to resolve the anomalies by further refining Part 1's unit postulation. Chapter 8 exemplifies the approach to experimental observation described in Chapter 7. It exemplifies how an iterative procedure between observation and postulation can help to better formulate what psychologists see.

CHAPTER 7: ON USING POSTULATION TO GUIDE OBSERVATION

Summary of Progress Made

This chapter starts with a review of what has been done so far.

Integration of Past Unit Postulations (Part 1)

This thesis began with the unit postulations of four psychologists. These postulations were the *behaviour segment* (Kantor), the *operant* (Skinner), the *deed* (Lee), and the *control system* (Powers). Each postulation was based on particular observations. Each postulation was also an attempt to accurately designate what psychologists observe in general. The four postulations, however, were ostensibly disparate. Part 1 argued that bringing together the most accurately designated aspects of the four postulations allowed a fuller statement of what psychologists observe than any one postulation by itself. The fuller statement was summarised in the postulation "regulative circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes" (p. 48), where a deed was "a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one organism among many other contributors" (p. 26).

Integration of Non-Morphological Approaches to Organism and Environment (Part 2)

Part 2 of this thesis integrated previous attempts to overcome a morphological conception of organism and environment. The integration brought together postulations that organism and environment are most accurately designated as functional complements within a single system or bioprocess (Chapter 5). Part 2 also brought together postulations that this system can be analysed into negative feedback patternings among instances of becoming different (Chapter 6). Like the postulations integrated in Part 1, these postulations were based on observation, and were an attempt to accurately designate what psychologists and other scientists observe. Further, their integration was not inconsistent with Part 1's integration.

Overall

Parts 1 and 2 contributed to the overall argument by bringing together postulations that came from attempts to accurately designate what psychologists observe. The focus so far, that is, has been postulation in the sense of theoretical integration.

The Next Step

Iteration Between Observation and Postulation

Many writers have noted that a central feature of scientific inquiry is iteration between observation and postulation (e.g., A. F. Bentley, 1950; Dewey & Bentley, 1949; Lee, 2000; Whitehead, 1929/1978). Bentley (1950) put the matter directly:

> It is science in the making if, by science, is understood a procedure of observation and postulation, with all observation recognizing that it arises out of postulation, and with all postulation recognizing that it arises out of observation... (p. 775)

Similarly, Dewey (in Dewey & Bentley, 1949) argued that ideas or postulations are *escapes*, saved from being *evasions* only if they direct further observations, which in turn suggest further postulations, and so on (p. 319, see also p. 80). Whitehead (1929/1978, p. 5) likened "the true method of discovery" to the flight of an airplane, which starts on "the ground of particular observation," takes a flight through "the thin air of imaginative generalization," and "lands again for renewed observation rendered acute by rational interpretation." Figure 12 illustrates this circular interplay, which for the above commentators is the way inquiry develops an increasingly accurate designation of what is being observed (i.e., a clearer conception of subject matter).

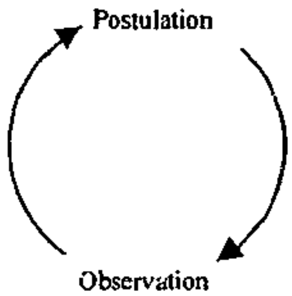

Figure 12: Iterative cycle between observation and postulation by which scientific inquiry achieves increasingly accurate designation of subject matter. Arrows mean *contributes to.*

From this perspective, theoretical integration, as a form of postulation, is not an end in itself. Theoretical integration, the importance of which was emphasized by Ziman (1971, p. 344), is useful only if it informs fresh observation, which suggests revisions to the original integration, which guides further observation, and so on. This suggests that the next step for the present inquiry is using the theoretical integrations developed in Parts 1 and 2 to guide observations.

Usual way of Doing Things: Using Data to Test Hypotheses

Psychologists typically do not seek sharper formulation of their subject matter by iterating between observation and postulation. Psychologists usually begin with a hypothesis or prediction about a specific experimental effect. Observation is then made to "test" (i.e., validate or invalidate) the hypothesis. The following representative example was published in a leading psychology journal (*Psychological Science*).

Altmann and Gray (2002) reported an experimental evaluation of what they called the "Functional Decay Theory" of memory. To paraphrase the authors, functional delay theory holds that items in memory decay or fade to lessen interference with new items. After outlining the theory, the authors derived two experimental predictions:

- Prediction One: "...performance [on some task requiring a specific item in memory] should decline gradually as time passes after an update [to that item in memory], as the current item decays and becomes harder to sample" (p. 27).
- Prediction Two: "...the cognitive system adapts to changes in the update rate by varying the decay rate [activation loss per unit time]. That is, if the number of memory updates per unit time varies, then loss of activation per unit time should also vary" (p. 27).

The authors next "...*tested* the *predictions* of functional delay theory using a task-switch [experimental] paradigm..." (p. 28, italics added). The experiment consisted of several thousand discrete trials, each of which "began with the appearance of a stimulus and ended with a key press" (p. 28). On each trial a computer presented a digit between 1 and 9 (but never 5). Each of 36 participants was required to press one of two keys to indicate (a) whether the digit was odd or even, or (b) whether the digit was high (greater than 5) or low (less than 5). Which task was required depended on the most recent instruction: "Even Odd" or "High Low." The computer systematically varied the number of trials between instruction updates and whether the instruction (and thus the appropriate task) was repeated or switched on a given update.

In their results section, Altmann and Gray presented statistical summaries of reaction time (from digit presentation to button depression) and percentage incorrect (errors). They explained, "reaction time data are [group] means of participant's [individual] medians on correct trials from blocks on which accuracy was at least 90%. Error data are means of participant's means. The data are shown in Table 1" (p. 30). Besides presenting these statistical summaries in a table, bar and line graphs were used to make trends already visible in the table more visible, and an inferential statistic (ANOVA) was used to demonstrate the statistical significance of these trends. The most important trends were (a) reaction time and percentage incorrect values increased during series of between-instruction trials, and (b) the slope of this increase was higher when there were few as opposed to many between-instruction trials. Altmann and Gray concluded that finding (a) validated Prediction 1 and finding (b) validated Prediction 2. They concluded that "these findings are strong initial support for functional delay theory" (p. 31).

This example highlights the main features of the hypothesis testing approach. For the purposes of the present discussion, it is important to emphasize Altmann and Gray's use of the word *data*. In the hypothesis testing approach, the word *data* is used loosely to include records of observations (e.g., timestamped records of individual digit presentations and button depressions), variables calculated from these observations (e.g., reaction times, percentage correct scores) statistical summaries (e.g., average reaction times, average percentage correct), graphical re-presentations of these records (e.g., line and bar graphs of these averages), and inferential statistics (F and p values in ANOVAs). The records of observations themselves are rarely presented, discussed, or even collected during an experiment (the experimental software program automatically calculating and presenting averages and percentages). The focus is instead on transformations of the recorded observations showing the presence or absence of the predicted effect (usually statistically significant differences among group averages). The focus is not on what was observed, but on whether summaries and transformations of what was observed support the hypothesis being tested.

A Different way of Doing Things: Data as Conceptual Window

The present method is not hypothesis testing in the above sense. The present method follows from the discussion about using iteration between observation and postulation to clarify what is being observed. Part 1 and 2's postulations are not predictions of effects that might or might not be observed in an experimental situation. Instead of predictions of what *might* happen, or what *might* be observed, they are predictions what *is* happening, or what is *already there* to be observed. Oppenheimer (1979) clarified this distinction:

> The theories of physics are not so much statements of what will happen in the future as they are statements of what is actually going on. *The main prediction of a theory is that some process is taking place and that one can*

discover it, provided one looks in the right way, at the right time or place, and with appropriate instruments. (p. 18, italics added)

The earlier claim that postulations *inform*, *guide* or *contribute to* observations can now be clarified: Postulations guide observations in the sense of predicting what particulars are there to be seen if looked for.

How does this inform a different approach to experimentation? In the experiment reviewed above, predictions were made about trends in statistical averages of (a) the time taken from the presentation of a stimulus to the occurrence of a button-pressing response, and (b) the percentage of occasions on which a response was incorrect (relative to the most recent instruction). Think about the words *stimulus* and *response* in this context (not to mention words like *memory*). These words were not offered as postulations in the sense of predictions of what was there to be seen if looked for. It was assumed that digit presentations were accurately designated *stimuli* and button depressions *responses*. In other words, *stimulus* and *response* were treated not as postulations but as postulates (a distinction clarified on p. 2 & p. 192). As postulates, these words did not guide observations in the interests of clarifying the subject matter represented by the data. Instead, they *imposed* an interpretation on the data in the interests of testing a hypothesis or prediction about a theory (of memory). As postulates, *stimulus* and *response* were placed outside the iterative loop of observation and postulation discussed above. They were made un-refinable. Making basic postulations un-refinable (i.e., treating them as postulates) stunts scientific progress (Dewey & Bentley, 1949; Muller, 1943). This is especially so for postulations as problematic and much criticised as *stimulus* and *response* (see p. 10, 24, 28, and 88).

Treating postulations as predictions of what is there to be observed suggests a different approach to experiment, observation, and data. First, the word *data* is not used loosely to include records of observations, tables, figures, and other transformations of these records. *Data* designates only records of observations.

Second, it is not assumed without question that the data represent stimuli (or inputs), responses (or outputs), or anything else. Such postulations are treated as provisional and revisable predictions of what is there to be seen. The inquiry is focused on their revision and refinement.

Third, *data analysis* does not mean glossing over the recorded observations (read *data*) with summaries and transformations in the interests of evaluating a specific hypothesis about something other than the data (e.g., memory or behaviour-environment relations). Such an approach hardly sees the data (Lee, 1996a, p. 158). In the alternative offered here, *data analysis* means using the recorded observations as a *conceptual window* on the subject matter, in Lee's (1996a, p. 150) sense of using the data to clarify the subject matter the data represents. Postulations are treated as predictions of what the data can help us to see (where what we see suggests revisions to our postulations).

From these considerations, the present method predicts that if we look in the right way, and through the conceptual window of an appropriate data set, we will see the following items (postulated in Part 1):

- Deeds with multiple contributors and multiple outcomes
- Dependencies between subclasses of deeds
- Regulative circular patternings of these dependencies

Further, given the postulations developed in Part 2, it is suggested that we will also see:

- Negative feedback patterns among instances of becoming different within bioprocesses.

A Problem

There is a problem in applying the present method to data from a conventional psychological experiment. The problem is that in accord with their hypothesis testing aims, most experiments are designed such that (a) one or all of the above items are precluded from happening, or (b) when those items are able to happen, they are not recorded.

Consider the postulation "regulative circular patternings" (or "negative feedback"). Many data collection methods in psychology inhibit or disallow circular patternings. In button pressing reaction time or target detection tasks, a discrete presentation (the so-called stimulus) is followed by a discrete button depression (the so-called response), at which point the trial ends (as in Altmann and Gray's procedure). Such procedures preclude the occurrence of real-time feedback circuits between presentations and button depressions.

The same problem applies to many continuous trial procedures. In the cognitive paradigm of serial visual presentation of text, for example, continuous prose is often presented word-by-word to a reader at a speed held constant by the experimenter (e.g., Masson, 1983). Here there is no opportunity to modify the rate of word presentation. Negative feedback, and thus a regulative circular patterning of changes, is not allowed (and thus not observed or recorded).[57]

When contemporary experimental psychology does not preclude the items the present method aims to observe, it often fails to record those items. Like the Altmann and Gray procedure, much so-called data collection records only computer-calculated averages. These averages obscure the momentary details of individual performance the present method hopes to observe and better formulate.

Such data collection methods are not adequate here. The present data collection method must record in detail from a situation in which loops of deeds can be patterned through time (i.e., where such units are not made unobservable by experimental constraints and data collection resolution).

One Way Forward: A Suitable Data Collection Method

The above problem was overcome with a modified version of the serial-visual-presentation-of-text (SVPT) experimental paradigm.

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[57] All such experimental paradigms follow from the (morphological) postulate that participants are input-output boxes. In this way, postulates are often self-fulfilling. They support data collection methods yielding observations consistent with themselves and precluding inconsistent observations.

What is SVTP?

In SVPT, successive text segments of one or a few words are presented to a static central viewing window on a computer monitor (see Potter, 1984, for an introductory review). SVPT is usually used to study reading. Unlike normal page reading, SVPT distributes textual segments through time, as opposed to (page) space. SVPT has been used to investigate normal skilled reading (e.g., Juola, Ward, & McNamara, 1982; Masson, 1983; Rubin & Turano, 1992), to help readers with low vision (e.g., Arditi, 1999; Fine & Peli, 1995), and to explore alternatives to entire pages when display size is limited, as on a mobile phone or web page banner (e.g., Juola, Tiritoglu, & Pleunis, 1995; Kang & Muter, 1989; Rahman & Muter, 1999). Figure 13 illustrates the experience of SVPT with snapshots of three successive screen updates.

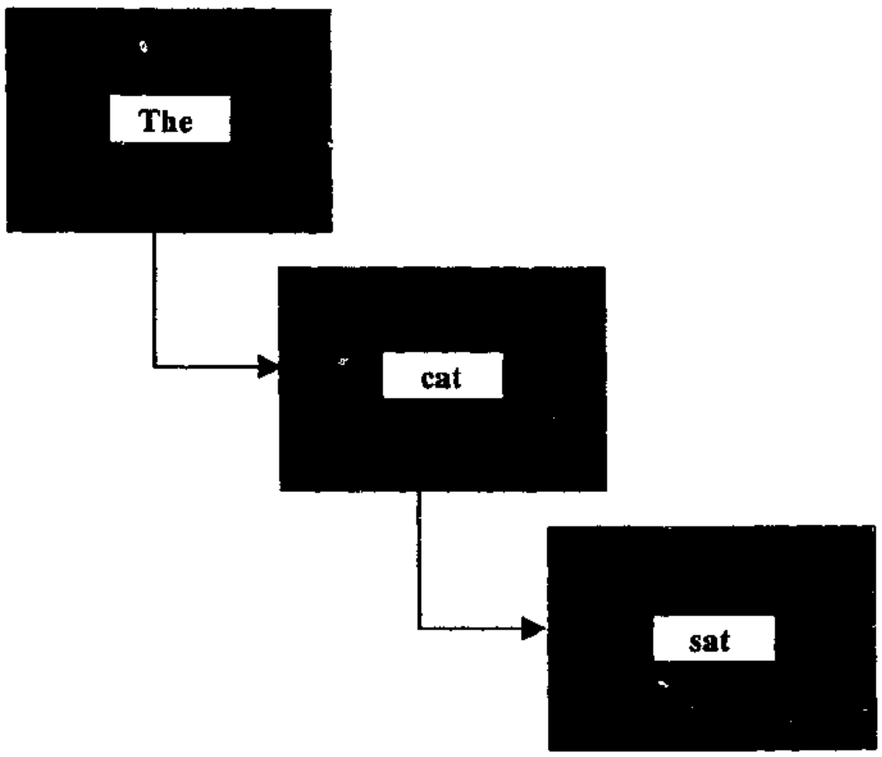

Figure 13: An illustration of what participants experience during SVPT. Each of the three boxes represents the computer monitor at a moment in time. At a presentation rate of 60 words per minute, each word would be present for one second.

Why SVPT?

There were two reasons for selecting SVPT as a data collection method. First, SVPT enables the inexpensive, computer-controlled collection of detailed, real-time records from well-defined instances of psychology's subject matter. Because words (or other textual segments) are presented individually, it is possible to record how long each word remains visible before being deleted and replaced by the next word. This affords a running record of the moment-by-moment word presentation rate (WPR). Events contributed to by the participant (such as key depressions) are also easily recorded. Computerized data collection avoids issues of inter-observer reliability and generates precise records of many more events per unit time than a human observer can manage.

Second, in SVPT, control of WPR can be assigned to the participant, the computer, or any combination of the two. In most SVTP research, WPR has been preset by the experimenter and unchangeable by the participant (e.g., Fine & Peli, 1995; Masson, 1983). In a few studies, however, the experimenter has preset the *initial* value of WPR, but then allowed the participant to change it with key depressions or mouse movements (e.g., Castelhano & Muter, 2001; Muter et al., 1988). Importantly, this enables circular iterations of influence between WPR and changes in the states of keys or other input devices. In other words, this data collection method allows the recording of loops in real time, the importance of which was discussed above.

The Version of SVPT Used Here

A modification of the standard SVPT preparation was used in a full-scale experiment (a publication-style write-up of which is included as Appendix B). During this experiment, six participants were each presented with six texts (Reader's Digest™ articles of about 1000 words in length). The conditions under which each text was presented are described in Appendix B. The present description is restricted to the conditions under which Text 6 was presented. This restricted focus is due to Text 6 being the text from which a representative sample of the data was obtained for the purposes of carrying out the present method.

During Text 6, participants were presented with an 1161-word text on a computer screen. Importantly, participants were instructed *not* to read the text, but only to maintain constant the word presentation rate (WPR). Words were presented one-at-a-time in a centrally located viewing window. Words initially appeared at 46 words per minute. Participants could influence (i.e., increase and decrease) WPR by tapping one key (the up-arrow key) to increase it and another key (the down-arrow key) to decrease it. At the same time, the computer increased and decreased WPR in a smoothly varying disturbance pattern. If the participant tapped no keys, WPR would smoothly undulate within 5 and 770 words per minute. To complete the assigned task (maintaining a constant rate), participants had to cancel out this undulation by tapping the up- and down-arrow keys.

At any time during the presentation of Text 6, participants could depress the space bar to make a completion meter visible. The completion meter was a horizontal red bar indicating the proportion of the text presented and remaining to be presented, and is illustrated in Figure 14. Text presentation was not paused or altered by the presence of the completion meter.

Figure 14: Illustration of completion meter during present modification of SVPT. The length of the grey bar (which was actually red) corresponds to the proportion of text presented, and was filled in from left to right. In this example the word "sat" might be the 333rd word of a 1000-word text (hence the bar being one third of its possible length).

The following chapter closely examines the data collected while one participant (Participant 6) maintained a constant word presentation rate (WPR) on Text 6. There were three reasons for using data from Text 6 as opposed to one of the other five texts.

First, Text 6 was one of three of the six texts in which the assigned task was maintaining a constant word presentation rate. During the other three texts, participants were instructed to read the text. Though reading the text required some control of WPR, reading comprises many other processes beyond the complexity of what was required here (detailed data from a well-defined instance of psychology's subject matter).

Second, Text 6 was one of two of the three non-reading texts on which participants were required to tap, as opposed to press and hold down, the up- and down-arrow keys to influence WPR. The data from a tap (as opposed to a press and hold) text was chosen because it gave participants more control (see p. 164 for details).

Third, of the two remaining texts, Text 6 was the second. Participants were more experienced and more likely to have reached a steady state in their dynamics of dealing with the task. Of the six participants, Participant 6 was chosen first for complying most with task instructions, and second for maintaining a lower WPR than other participants. Though the advantage of maintaining a lower WPR won't be clear until the next chapter, it enabled the full variety of recorded events to be captured in a close-up snap shot of the data (see Figure 19).

CHAPTER 8: POSTULATION – OBSERVATION – POSTULATION

This chapter implements the method developed in Chapter 7 with three aims. The first aim is to firm up (correct and clarify) Part 1 and 2's integrations of past postulations. The second aim is to lay foundations for experimental work that brings in all aspects of this integration (deeds, dependencies between subclasses of deeds, and so on). The third aim is a concrete demonstration of using iteration between observation and postulation to clarify what psychologists observe. This chapter has two main sections. The first uses the postulation developed in Part 1 to guide observation. The second uses the postulations developed in Part 2 to guide observation.

Using the Postulation of Part 1 to Guide Observation

Recorded Events

Table 1 displays the first three columns of a 21-row subsection of data recorded while Participant 6 maintained relatively constant the SVPT word presentation rate of a 1161-word text (i.e., Text 6). The 21 rows were written in 4.4 seconds of session time, which equates to an average rate of just under five rows per second. The 21 rows come from a data file 14,006 rows long.

Change Type	Object Changed	Time in Seconds Since Text Began
wu (word update)	vw (viewing	648.58
wu	vw window)	649.57
kd (key depression)	sk (slow key)	650.05
kr (key release)	sk	650.17
kd	sk	650.27
wu	vw	650.27
kr	sk	650.35
kd	sk	650.43
kr	sk	650.50
kd	sk	650.60
kr	sk	650.68
wu	vw	650.78
wu	vw	651.28
kd	fk (fast key)	651.52
kr	fk	651.62
kd	fk	651.72
kr	fk	651.82
wu	vw	651.95
wu	vw	652.60
kd	fk	652.88
kr	fk	652.98

Table 1: A 21-row subsection of the data file generated by one participant during SVPT. Data were written row-by-row. Column 1 shows a change type (an update of the visible word, a key depression, or a key release). Column 2 shows the object changed (the viewing window, the slow-down key, or the go-faster key). Column 3 is a timestamp indicating the time at which the row was written in seconds from the start of the text.

Each row in Table 1 records a change detected by the computer. As shown in Column 1, there were three classes of recorded changes:

- A change (word update) in the contents of the viewing window (e.g., "cat" replacing "The")
- A change in the state of a key from up to down (key depression)
- A change in the state of a key from down to up (key release)

Column 2 shows which of the following objects the change was detected at:

- The viewing window (vw)
- The speed-up (up-arrow) key (also called the fast-key or fk)

- The slow-down (down-arrow) key (sk)

Column 3 is a timestamp indicating the moment of the recorded change in seconds since the start of the text. As an example, Row 5 of Table 1 represents a depression of the slow-down key that occurred 650.27 seconds after text commencement (and simultaneously with the word update in Row 6).

Each row of Table 1 represents a change someone could observe if they were in the right place at the right time and they knew what to look for. If we were observing the down-arrow key (or a videorecording of the down-arrow key) 650.27 seconds after text commencement, we would have seen a change in its state from up to down.

All changes recorded in Table 1 appear consistent with the deed postulation. In other words, the deed postulation appears to predict what Table 1 helps us to see. Chapter 2 defined a deed as "a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one organism among many other contributors." Chapter 3 added the emphasis that deeds contribute to multiple outcomes. For clarity in the following discussion, the different aspects of this definition are segregated as follows. A deed is:

(1) a moment of a stipulated difference (i.e., a change)
(2) in the state of an object, surface, or medium
(3) contributed to by the physical efforts of at least one organism
(4) with many other contributors
(5) which contributes to multiple outcomes

The changes corresponding to the rows in Table 1 are consistent with Aspects 1-3. They are moments of a stipulated difference, in the state of an object, contributed to by the efforts of the participant. Key depressions and releases are changes in the state of a key, and are contributed to by the participant's coordinated finger movements. Word updates are changes in the state of the viewing window. Did the participant's efforts contribute to word updates? Though word updates occurred regardless of whether the participant depressed the speed- and slow-keys, once one of these keys had been depressed (at least once), these depressions did contribute to whether a word update occurred at any instant (The details of this contribution are explained in the next section). In this sense, the participant's physical efforts did contribute to word updates.

What about Aspects 4 and 5? Did the changes recorded in the rows of Table 1 have multiple contributors? Did they contribute to multiple outcomes? Consider key depressions and releases. Key depressions and releases had multiple contributors, including the keys, the keyboard supporting them, and movements of the participant's finger. Updates to the viewing window also had multiple contributors, including the window, the computer monitor, the electricity powering the monitor, and the computer program's instruction to change the window contents. Neither key depressions and releases nor word updates would have occurred without a configuration of many different contributors.

Key depressions and releases also had multiple outcomes. One outcome of either change was the writing of a row of data. Another was a displacement of the air surrounding the key. As discussed in the next section, depressions of the up- and down-arrow keys also contributed to the rate of updates to the viewing window. Changes in the contents of the viewing window also had multiple outcomes, including a row of data being written and an increment in the variable the program used to access the next word. Such changes would not have occurred without word updates.

The changes recorded in Table 1 meet all five criteria for constituting deeds. What does this mean for the method of iterating between observation and postulation developed in Chapter 7? It means the data are a conceptual window through which deeds can be seen. The deed postulation accurately predicts at least some of what was there to be seen during SVPT rate regulation. Further, the deed postulation suggests new observations, such as multiple contributors and outcomes. Figure 15 illustrates key depressions and releases, as one example of the deeds recorded in the rows of Table 1, with a simple graphic.

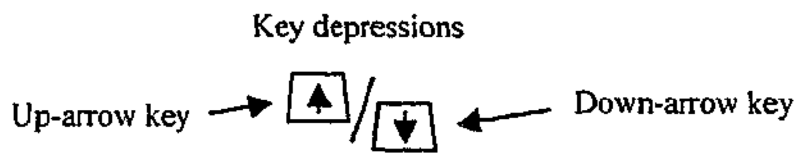

Figure 15: Graphic representing the deed subclass of key depressions (and releases).

The data in Table 1 has enabled us to see deeds, and to see that many deeds were occurring within the process of maintaining-WPR-constant. There is much, however, not yet seen, and which Table 1 does not help us to see. If we restrict ourselves to the changes recorded in Table 1, we are not seeing how the recorded events are spread through time, how they are dependent on one another, and patterns among multiple dependencies. In fact, as shown in the next section, we are not even seeing all relevant changes.

Variables and Changes in their Values

Table 2 is a fuller version of the data presented in Table 1.[58] Besides indicating a timestamped change in the state of an object, each row shows the values of three variables at the moment the row was written: Word presentation rate (WPR), the disturbance variable, and the opposition variable.

[58] For ease of presentation, Table 2 is a modified version of the actual data file as written during the experiment. See Appendix C for an unmodified version.

Change Type	Object changed	Time in Seconds	Words per minute WPR	Disturbance variable	Opposition variable
wu (word update)	vw (viewing	648.58	62.94	-27.06	90
wu	vw window)	649.57	62.05	-27.95	90
kd (key depression)	sk (slow key)	650.05	61.81	-28.19	105
kr (key release)	sk	650.17	76.77	-28.23	105
kd	sk	650.27	76.75	-28.25	120
wu	vw	650.27	91.75	-28.25	120
kr	sk	650.35	91.73	-28.27	120
kd	sk	650.43	91.72	-28.28	135
kr	sk	650.50	106.71	-28.29	135
kd	sk	650.60	106.71	-28.29	150
kr	sk	650.68	121.71	-28.29	150
wu	vw	650.78	121.71	-28.29	150
wu	vw	651.28	121.83	-28.17	150
kd	fk (fast key)	651.52	121.93	-28.07	135
kr	fk	651.62	106.99	-28.01	135
kd	fk	651.72	107.05	-27.95	120
kr	fk	651.82	92.11	-27.89	120
wu	vw	651.95	92.2	-27.80	120
wu	vw	652.60	92.83	-27.17	120
kd	fk	652.88	93.18	-26.82	105
kr	fk	652.98	78.31	-26.69	105

Table 2: A fuller version of the 21-row subsection of the data file presented in Table 1. Columns 4, 5, and 6 respectively display the value of word presentation rate, the disturbance variable, and the opposition variable at the moment the row was written. These three columns are expressed in words per minute.

What is a Variable?

Here, the word *variable* designates a changeable quantity with a definite value at every instant (after Ashby, 1960, p. 14). The three variables whose values are shown in Table 2 were the following.

Word Presentation Rate. The first variable is the rate at which words were updated in the viewing window, called *word presentation rate* (WPR) or simply rate. WPR is expressed in words per minute (wpm). At a WPR of 120 words per minute, the three-word sequence [The – cat – sat] would take 1.5 seconds to be presented (each word being visible for half a second before being replaced). WPR will be discussed further after the remaining two variables are introduced.

Disturbance. The second variable is called the *disturbance*. The disturbance is also expressed in words per minute. The computer was pre-set to vary the disturbance independently of what the participant did. The disturbance was given an initial value of 46 by the computer program and then continuously undulated in a time-based sine-wave pattern. The amplitude of this pattern ranged randomly from 150 to 450 around an axis of 320 (i.e., with a minimum possible value of -130 and a maximum possible value of 770. The period of this pattern ranged randomly from 0.5 to 1.5 (peak-to-peak or trough-to-trough) cycles per 2 minutes. During the text from which the data in Table 2 were collected, the disturbance variable initially increased from 46 to a value of 764 after 62 seconds of session time, gradually decreasing to a value of 141 after 121 seconds of session time, and so on.

Opposition. The third variable is called the *opposition*, also expressed in words per minute. The opposition variable was given an initial value of zero by the computer program, and changed only when the participant depressed one of two keys. When the participant depressed the speed-up (up-arrow) key, the opposition variable increased by a value of 15. When the participant depressed the slow-down (down-arrow) key, the opposition variable decreased by a value of 15. In this way, the opposition variable indicated the cumulative result of all previous speed-up and slow-down key depressions. If the participant had pressed the up-arrow key ten times and the down-arrow key once, the opposition variable would have a value of 135.

I now return to WPR. WPR was always equal to the sum of the disturbance and opposition variables. If the disturbance value was 100 and the opposition value was –50, WPR was 50 wpm. If the disturbance then increased to 110 and the opposition remained unchanged, WPR was 60 wpm, and so on.

Figure 16 represents these three variables with simple graphics that will be used again later in the chapter.

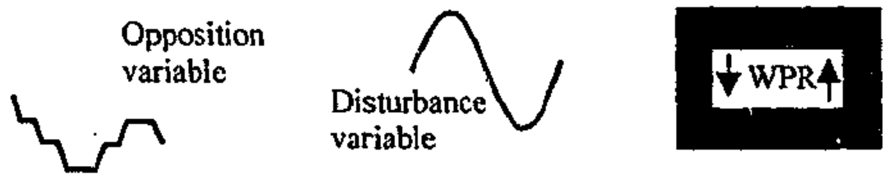

Figure 16: Simple graphics representing changes in the value of three many-valued variables: opposition, disturbance, and rate (WPR).

Calculating Variables

The computer program frequently calculated and updated the values of WPR, disturbance, and opposition. On every iteration, the program loop updated the current value of the disturbance value (approximately 30 times per second) by entering the current time since the start of the session into a time-based sine function.[59] The opposition variable was updated (increased or decreased) whenever the up- or down-arrow key was depressed. WPR was updated on every program iteration by adding the current values of disturbance and opposition.

It is important to explain what might appear to be an anomaly in Table 2. Upon an up- or down-arrow key depression, the opposition variable was increased or decreased, and a row of data was written immediately. Only then did the computer execute further tasks, such as updating the value of disturbance and WPR. This meant that a change in WPR corresponding to a change in the opposition variable affected the data file on the next row. On row three of Table 2, for example, the change in opposition from 90 to 105 recorded by that row does not affect the value of WPR until the next row (where it changes from 61.81 to 76.77, the difference between these two being slightly less than 15 because of a slight decrease in the disturbance variable). This is partly misleading, in that the change in WPR was usually closer in time

[59] Details of this sine function are explained on p. 163.

to the contributing change in opposition than to further changes (and corresponding rows of data). It is a reminder, however, that there was a delay between the two changes, even if the computer immediately calculated the new value of WPR after writing to file. Opposition had to change before that change could contribute to a change in WPR.

All three variables can be worked out from the information given in Table 1 and nothing else, at least approximately. Consider WPR. The computer program calculated WPR by adding opposition and disturbance. It then used WPR to calculate the delay between successive word updates (delay in seconds = 60/WPR). We can go in the opposite direction and get WPR by dividing 60 by the time in seconds between successive word updates (WPR = 60/delay in seconds). We can get the exact value of the opposition variable just as the computer did: by starting at 0 then adding 15 for every up-key depression and subtracting 15 for every down-key depression. We can then get the approximate disturbance value by subtracting opposition from WPR.

So these three variables do not tell us anything we can not estimate from the changes recorded in Table 1. As we see next, however, the variables enable graphical representations making visible new aspects of the experiment.

Graphical Representation of Variables

Figures 17, 18, and 19 graphically represent the values of the WPR, disturbance, and opposition variables through time. Figure 17 represents these variables throughout the 19 minutes Participant 6 spent maintaining the WPR of Text 6 constant. Using asterisks, Figure 17 also represents moments at which the space bar was depressed (and the completion meter was visible). Figure 18 enlarges (i.e., zooms in on) a 2 minute 17 second subsection of Figure 17. Figure 19 enlarges a 4.4 second subsection of Figure 18, a 4.4 second subsection corresponding to the 21 rows of Table 2 (p. 126).

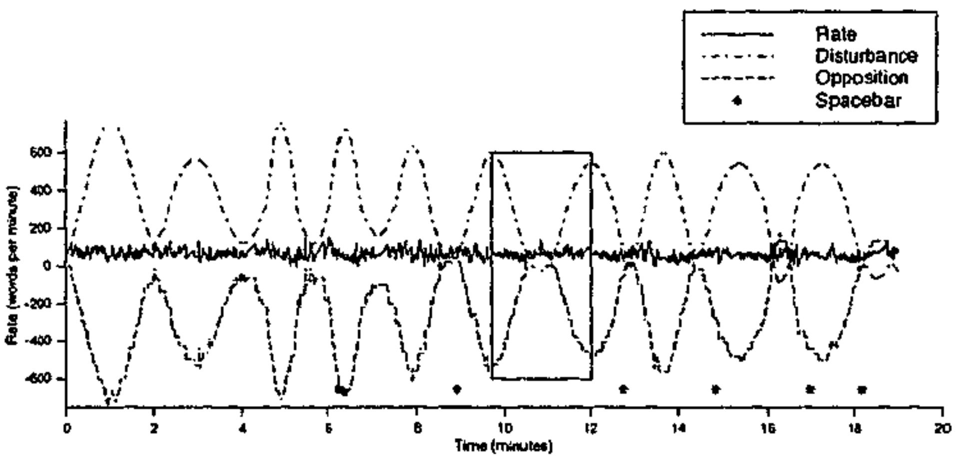

Figure 17: Values of word presentation rate (Rate), disturbance, and opposition variables during a word presentation rate regulation task. Variables are plotted over time in words per minute. Asterisks indicate completion meter visibility (i.e., when the space bar was depressed). The upright rectangle encloses the section of the graph enlarged in Figure 18.

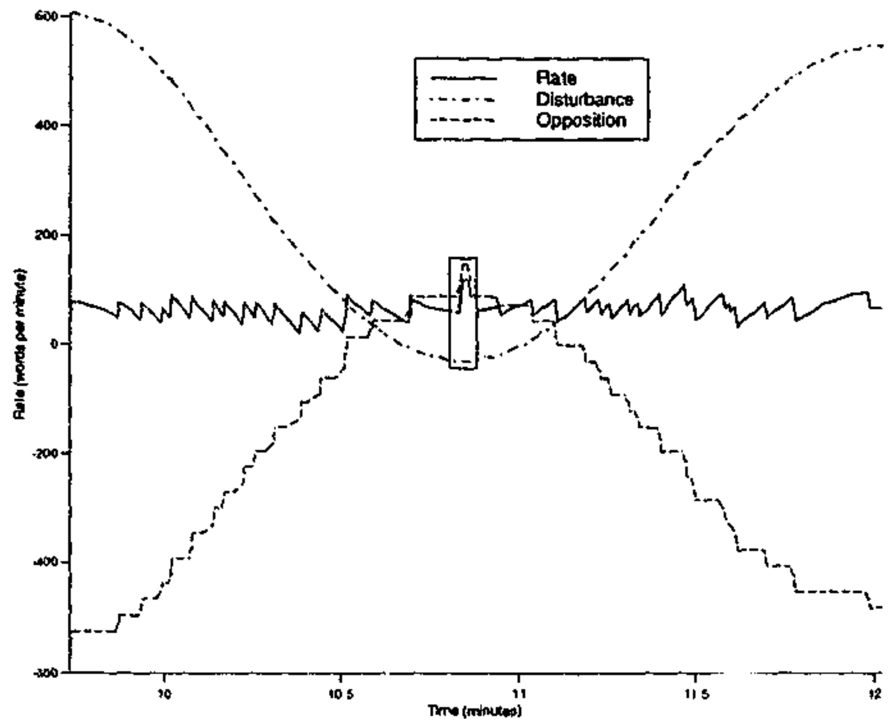

Figure 18: An enlargement of the enclosed section of Figure 17. Other details the same. The upright rectangle indicates the section of the graph enlarged in Figure 19.

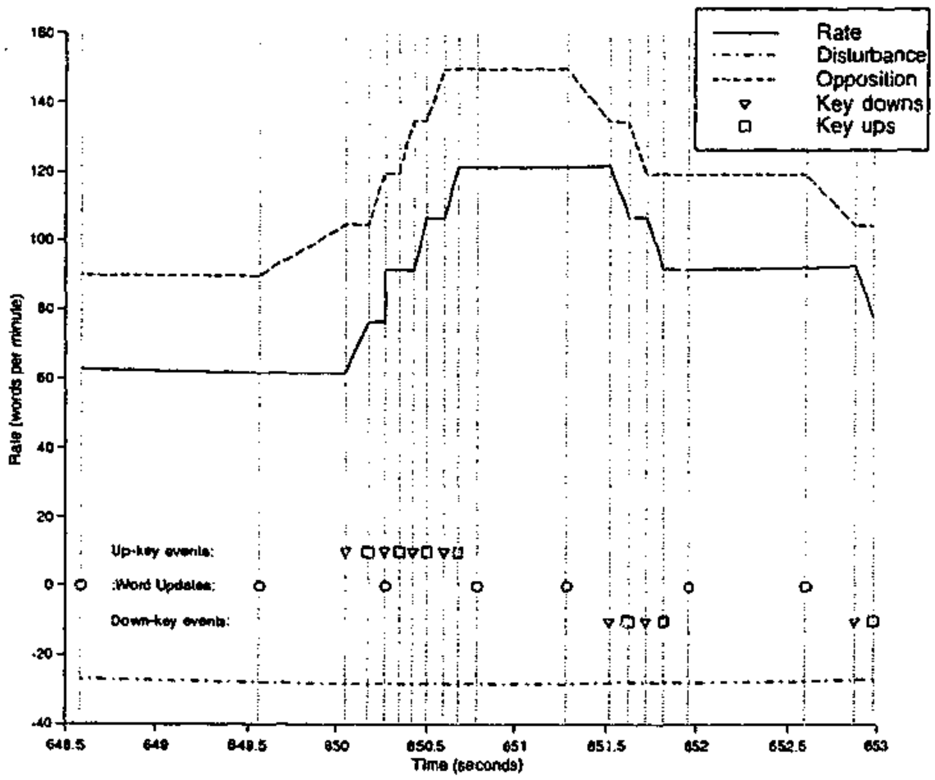

Figure 19: An enlargement of the enclosed section of Figure 18. Other details the same, except as follows. Time is in seconds, not minutes. Dashed vertical lines indicate the moment at which rows of data were written by the computer program and correspond to the rows of Table 2. Each dashed vertical line is labelled as corresponding to a word-update (circle), an up-arrow key depression (upper inverted triangles), an up-arrow key release (upper squares), a down-arrow key depression (lower inverted triangles), or a down-arrow key release (lower squares). Note that the second up-arrow key depression occurred simultaneously with a word update (see Rows 5 and 6 of Table 2).

Scientific Visualization. Figures 17, 18, and 19 are scientific visualisations. As explained by McCormick, DeFanti, and Brown (1987, p. 3) scientific visualisations transform huge data sets into visual images. Such images make seen previously unseen aspects of the subject matter. In Figure 17, the opposition variable undulates equally and oppositely to the disturbance variable. This geometrical pattern makes visible aspects of the experiment present but invisible in the data files (e.g., Table 2). Figure 17 helps us see more of what was going on during the experiment. Figures 18 and 19 show how the lines in Figure 17 relate to the individual rows of the data file. Figure 17 presses together (compresses) many points, where each point corresponds to the value of a variable in a row of the data file (cf. Lee, 1999b, p. 98). Besides making visible more of the subject matter, Figure 17 allows us to see the row-by-row changes of Table 1 and Table 2 in the context of the larger process they were part of.

Changes in Variables as Deeds?

As shown in Figures 17, 18, and 19, two important aspects of the experiment were (1) changes in the three variables over time, and (2) relations between these changes. Using Part 1's deed postulation to guide observations suggests the following question: do these changes qualify as deeds? Segregating the designation of a deed as above, we can ask whether each change in the value of one of these variables is:

(1) A Moment of a Stipulated Difference? Changes in the value of all three variables qualify as moments of stipulated difference. These differences can be stipulated as the moment of any detected difference in the value of a variable.

Nonetheless, changes in the values of variables differ from the changes discussed above. Instead of changes in the state of what was effectively a two-state system (key up/down, this word present/next word present), these changes are from one state to another state of a many-state variable. Despite more states, however, for the purposes of measurement the number of states is still finite. For a range of 0-600 words per minute at a resolution of 3 decimal places, for example, the number of detectable values of that variable is 600,000 (cf. Rucker, 1988, p. 118). Data collection requires that what might appear to be continuous change is parsed into discrete units, however tiny (cf. Ashby, 1960, p. 87, see also Chapter 6, p. 103).

(2) In the State of an Object, Surface, or Medium? Changes in the values of the WPR, opposition, and disturbance variables are not changes in the state of an object, surface, or medium. If the deed designation was a postulate (taken as fixed and unchangeable), this would prevent such changes from ever being counted as deeds. Recall, however, that the deed designation is here a postulation, open to revision in the light of the observation it guides. If extending the designation can capture more of what was observed, then such extension deserves consideration. An extension of this aspect of the deed designation will be explored below.

(3) Contributed to by the Physical Efforts of at least One Organism? The participant[60] contributed effort to changes in the value of the opposition variable by depressing the up- and down-arrow keys. Because the value of WPR was dependent on the value of opposition (in addition to disturbance), changes in opposition also contributed to changes in WPR. These changes in WPR were therefore contributed to by the physical efforts of the participant, if indirectly.

The participant did not contribute effort to changes in the value of the disturbance variable. The computer program made these changes independently of what the participant did. As in the discussion of Aspect 2, this suggests that changes in the value of the disturbance variable do not qualify as deeds. Further, given that changes in the disturbance variable contributed to some of the changes in the value of WPR (i.e., those changes not contributed to by changes in opposition), those changes in WPR also appear not to qualify as deeds. This apparent anomaly is examined further in the

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[60] As noted at the beginning of the section, Part 2's postulations are not used to guide observation until later in the chapter. Until then the words *organism* and *participant* are used uncritically.

section using Part 2's postulation to guide observation. As above, the anomaly will be treated as an opportunity for refining the deed postulation.

(4) With Many other Contributors? Changes in the values of the WPR, opposition, and disturbance variables had as contributors (would not have happened without) the variables themselves, the computer hardware, and the software program. Further, changes in opposition were contributed to by key depressions; changes in disturbance by the sine-function; and changes in WPR by changes in both opposition and disturbance. Changes in the value of these three variables are therefore consistent with this aspect of the deed designation.

(5) Contribute to Multiple Outcomes? As detailed in the next subsection, changes in the value of WPR, opposition, and disturbance contributed to a change in at least one of the other variables. Changes in the value of these variables also contributed to changes in the next row of the data file. Changes in the value of these three variables are therefore consistent with this aspect of the deed designation.

Refining Part 1's Deed Postulation

I now show how the above observations suggest refinements to the deed postulation. Consider first the following two subclasses of changes (1) changes in the value of the opposition variable and (2) changes in the value of the WPR variable resulting from (1). Both are instances of becoming different contributed to by the efforts of the participant, with multiple contributors, and with multiple outcomes. The only aspect of Part 1's deed designation inconsistent with these changes is that the changes be in the state of an object, surface, or medium.

As mentioned in the discussion of Aspect 2, the deed designation is open to revision. In the present method, just as postulation guides observation, observation guides postulation in the sense of changing it to capture more of what is observed. As an example of this process, the postulation that deeds are changes in the states of physical objects, surfaces, and mediums is revised. The revised deed postulation includes virtual objects such as computer indexes and rates of changes (e.g., the rate of updates to the viewing window) as the thing that changes. What matters is that there is a change to which the participant contributes, a change which can in turn contribute to further events. The revised postulation designates deeds as "moments of stipulated difference (i.e., changes) contributed to by the physical efforts of at least one organism among many other contributors."

Whereas the deed designation has been refined to incorporate changes in opposition and some changes in WPR (those contributed to by changes in the opposition), the designation still excludes changes in the value of the disturbance variable and resulting changes in the value of WPR. This is because these changes are not contributed to by the efforts of the participant. They are inconsistent wih Aspect 3 of the deed designation. This prompts the question of how such changes, as part of the observed subject matter, are to be conceptualised. If not deeds, what are they? Part 2's postulations will later be used to suggest a revision resolving this anomaly. First, however, I look at dependencies and patterns of dependencies between the subclasses of changes discussed so far (keeping in mind that not all of the changes are consistent with the current deed designation).

Dependencies

Reliable Dependencies

During the process of maintaining-WPR-constant, the data files recorded many reliable dependencies. These dependencies were reliable in the sense of one change contributing to another change with a probability of 1.0. A depression of the up-arrow key, for example, always contributed to an increment of 15 in the opposition variable. That change in the value of the opposition variable in turn always contributed to an increment of 15 in the value of WPR. Similarly, changes in the value of the disturbance value always contributed to changes in the value of WPR. Figure 20 illustrates these three reliable dependencies.

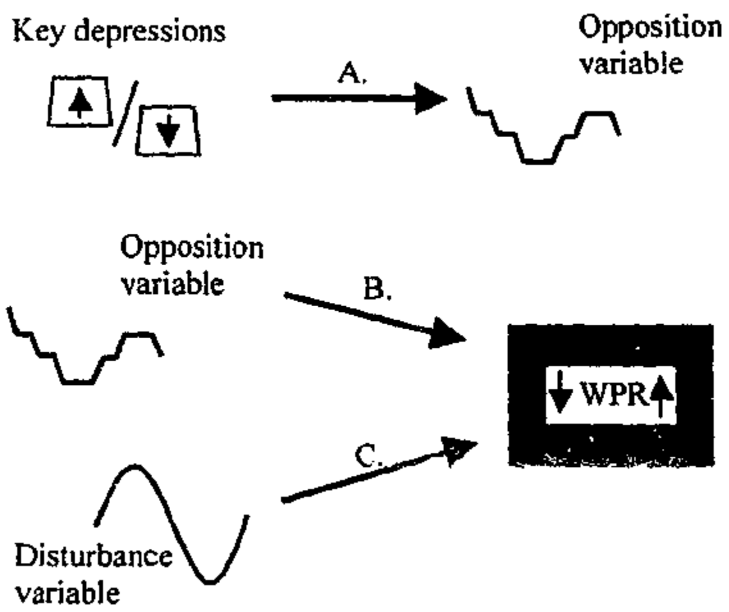

Figure 20: Reliable dependencies between (A) a key depression and a change in the value of the opposition variable; (B) a change in the value of the opposition variable and a change in the value of WPR; and (C) a change in the value of the disturbance variable and a change in the value of WPR.

A forth example of a reliable dependency was that between a depression of the space bar and the appearance of the completion meter (and conversely a release of the space bar and a disappearance of the completion meter). The asterisks in Figure 17 indicate occurrences of this dependency.

The dependencies mentioned so far are consistent with the discussion of dependencies in Part 1's unit integration (see p. 33). In each dependency, one change contributes to another change, here with a probability of 1.0. The dependencies postulated in Part 1, that is, predict some of what was observed.

Probabilistic Dependencies

The dependency to be described next was probabilistic in the sense of lacking a one-to-one relation between a change and the change it contributed to. This was the dependency between a change in the value of WPR and a depression of the up- or down-arrow key. This dependency is illustrated by the graphic in Figure 21.

Figure 21: Dependency between changes in the value of WPR and changes in the states of the up- and down-arrow keys. The dependency is probabilistic in the sense of lacking any invariable relation between instances of the first and second subclass of changes.

An individual change in the value of WPR did not necessarily contribute to an individual depression of the up- or down-arrow key. As shown in Figures 17 and 18, however, changes in the opposition variable cancelled out (or opposed) the influence of disturbances (i.e., changes in the value of the disturbance variable) on WPR. Changes in the value of the opposition variable were dependent on up- and down-arrow key depressions. Changes in disturbance could not directly contribute to key depressions, but only to changes in WPR. This means that changes in WPR had to contribute to key depressions, or in other words, that the observed pattern of key depressions would not have happened without the observed pattern of changes in WPR.

The dependency between changes in WPR and key depressions is thus consistent with Part 1's postulation of dependencies between subclasses of deeds (along with the reliable dependencies discussed above). Because the reasons for the probabilistic nature of this dependency are best understood in the context of the maintaining-WPR-constant process as a whole, they are discussed in the next section.

Circular Patternings of Dependencies

Chapter 3's unit designation entailed circularity – specifically *regulative circular patternings* of dependencies between subclasses of deeds. This section poses the following question: does this postulation predict what was there to be seen during the experiment? Answering affirmatively, Figure 22 applies Figure 7 (p. 47) to the WPR regulation process.

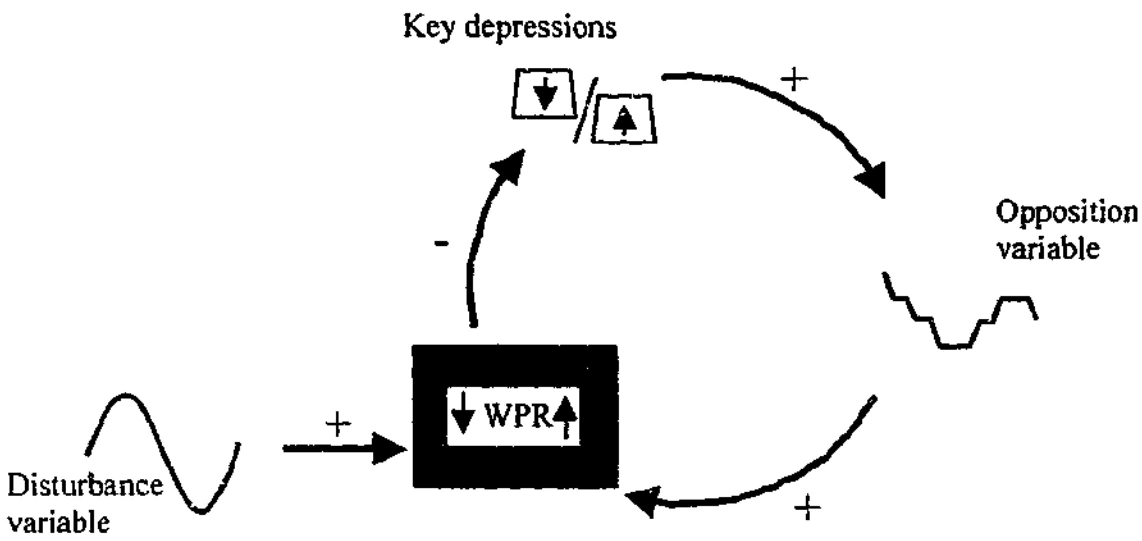

Figure 22: Part 1's unit integration illustrated with the example of maintaining-WPR-constant during SVPT. Arrows, which mean *contributes to*, connect the following four subclasses of changes: changes in the speed and slow keys from up to down, changes in the value of the opposition variable, changes in the value of the WPR variable, and changes in the value of the disturbance variable. The signs next to each arrow indicate a positive (+) or negative (-) direction of contribution, where a plus means a positive change contributes to a positive change (and vice versa) and a minus means a positive change contributes to a negative change (and vice versa).

Figure 22 is consistent with the horizontal mirror pattern of Figures 17 and 18. As mentioned above, to keep WPR relatively constant, it was necessary to pattern key depressions such that the opposition variable equally and oppositely mirrored the disturbance variable over time. In general, that is, increases in WPR had to contribute to depressions of the down-arrow key, and decreases in WPR had to contribute to depressions of the up-arrow key.

Graphical representations of the data thus help us to observe circular patternings of dependencies in the process of maintaining-WPR-constant. Further, it is correct to designate those circular patternings *regulative*. WPR was regulated in the sense of having its value maintained within a small proportion of its possible range. "Regulative circular patternings of dependencies," as an aspect of Part 1's unit postulation, thus predicts part of what was there to be seen if looked for.

Using Computer Simulation to Elucidate the Dependency Between Changes to WPR and Key Taps

Appendix B's experimental report went beyond representations of the data to build a computer simulation (see p. 175). Figure 30 (p. 181) compares a representation of data recorded from the participant (identical with Figure 17) with a representation of data recorded from the simulation. The simulation closely modelled the participant's molar pattern of key depressions in opposing disturbances to (and thus maintaining constant) WPR. It did this by regularly calculating the difference between the goal WPR (defined empirically as the average rate in the data being simulated) and the actual WPR. Following Powers (1973), the result of this calculation was designated the *error*. The error was translated into a key-tapping rate that would eliminate the error (i.e., remove the difference between goal and actual WPR) in a short time.

Comparing the actual and simulated data helps explain the probabilistic dependency between changes in the value of WPR and changes in the states of the up- and down-arrow keys (and thus the opposition variable). As outlined above, this was not a reliable, one-to-one dependency. Comparing what the participant did and what the simulation did suggests the following three clarifications of what was happening when changes in WPR contributed to key depressions and releases:

(1) The simulation continuously varied the rate of individual key depressions (and thus the rate of change in the opposition variable). This suggests that the dependency is best designated as not between changes in the value of WPR and individual key depressions, but between changes in the value of WPR and changes in the *rate* of individual taps (i.e., depressions and releases). In this way, the simulation suggests a new perspective on what was being observed. Detailed examination of the data from this perspective showed that, unlike the simulation, the participant didn't so much vary the rate of individual taps, but the rate and length of *bursts* of individual taps. A change in the value of WPR, that is, contributed not to just one key tap but to a change in the rate and length of bursts of key taps. As

Figure 19 indicates, during such bursts, keys were tapped (i.e., depressed and released) at a rate of between 3 and 6 taps per second, and with a burst length of between 2 and 6 taps. This clarification of the changes contributed to by changes in WPR makes the patterns of key taps more orderly and comprehensible.

(2) A second clarification of the dependency between changes in WPR and key taps concerned not what was being contributed to (i.e., changes in the rate and length of bursts of taps), but what was contribut*ing*. The simulation worked by varying the rate of key taps (and which key was tapped) not due to *any* change in WPR, but due to changes in WPR *away from* the goal WPR.[61] This suggested that the same condition obtained for the participant, a suggestion consistent with the data and its representations. The dependency between changes to WPR and key taps, that is, is designated more accurately as a dependency between changes in WPR away from the goal WPR and changes in the rate and length of bursts of taps.

The above clarification follows from a similarity between what the simulation did and what the participant did. A related clarification follows from a difference between what the simulation did and what the participant did. The moment the simulation calculated a non-zero error (i.e., a positive or negative difference between goal WPR and actual WPR), the rate of key taps was adjusted to oppose this difference, however tiny. This was not so for the participant. Presumably there was a perceptual threshold below which the participant was incapable of detecting a difference. The data show that the participant was maintaining WPR near to 60 wpm. It is unlikely, however, that the participant could detect a change in WPR from 60 to 61 wpm: There was a functional dead band within which change was imperceptible and thus unable to contribute to what the participant was doing. So not every change in WPR away from the goal WPR could contribute to a change in the rate or length of bursts of taps on the up- or down-arrow keys. The first part of the focal dependency, that is, is best designated not as a change in the value of WPR, or a change in the value of WPR away from the goal value of WPR, but a *perceived*[62] change of WPR away from the goal WPR.

(3) There is a third reason the focal dependency was not as simple as every change in the value of WPR contributing to an individual tap of the up- or down-arrow key. This reason has to do with the dynamics of the circuit as a whole. In order for the simulation to work, it was necessary to include what Powers (1978) named a *dynamic constraint*. This means that an error, or difference between goal and actual WPR, could not contribute to a change in opposition (via bursts of key taps) that would immediately cancel out that error. Instead, only a proportion of the needed change in opposition could occur. Otherwise the simulation could not maintain WPR constant: it would instead drive the value of WPR into uncontrollable oscillation. As Powers (1978) explained, "treating behavior as a succession of instantaneous events propagating around a closed loop will not yield a correct analysis, no matter how tiny the steps are made, unless this dynamic constraint is properly introduced" (p. 428). This suggests that to maintain WPR as constant as he did, the participant changed the rate and length of bursts of key taps in response to perceived changes of WPR away from the goal WPR, and that he did so in accordance with a dynamic constraint. The dynamic constraint meant that only a

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[61] Following Powers (1990b), the goal or "reference value of a variable is the position of that variable along its range of variation at which *no action* will be taken to change its value, magnitude, or state" (p. 39).

[62] The word *perceive* is a provisional characterization. Further development of the present beginnings would attempt to increase its accuracy (much like Part 2's treatment of the word *organism*).

proportion of the change in the rate and length of bursts of key taps removing the difference between goal and actual WPR occurred. In this way, changes in the dynamics of key tapping were constrained to ensure the smooth operation of the whole circuit (see Figure 22) over time.

These three clarifications suggest the dependency between changes in WPR and key taps was not so much unreliable (relative to other dependencies), as its initial designation was simplistic or inaccurate. Comparing the actual and simulation data suggested that (1) key tapping was organized as bursts or changes in the rate and length of bursts rather than individual taps, (2) WPR had to perceivably change away from the goal WPR before being able to contribute to key tapping, and (3) keys had to be tapped according to a dynamic constraint, such that only a proportion of the key taps (or change in the rate and length of bursts of key taps) required to eliminate the error actually occurred. These three considerations sharpen the designation of this dependency. They also reiterate that not only can postulation guide observation, but observation can suggest improvements to the original postulation. This section has shown how computer simulation can assist in iterating between observation and postulation toward a sharper formulation of the subject matter.

Using the Postulation of Part 2 to Guide Observation

So far, this chapter has used the postulation developed in Part 1 to guide observation. That postulation, an integration of four past postulations, was "regulative circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes." I have used the aspects of this postulation to guide observation in the sense of predicting what was there to be seen during a recorded instance of someone completing a well-defined task (maintaining-WPR-constant). The records (data) were used as a conceptual window on the moment-by-moment details of this instance of psychology's subject matter. The postulation was shown to predict much of what was recorded. It was also shown to guide observations that suggested refinements (such as including changes in the value of variables and changes in the rate and length of bursts of key taps as deeds) and that highlighted aspects and anomalies requiring clarification (such as whether disturbance occasioned changes in the value of WPR count as deeds).

This section uses the postulations developed in Part 2 to guide observation of the same subject matter Part 2 was concerned with how psychologists conceptualise organisms, and how this conceptualisation influences the way they conceptualise their subject matter. Chapters 4 and 5 described, critiqued and offered an alternative to the traditional (morphological) view of an organism as something within a skin, and an environment as something outside that skin. The alternative used the notion of a transdermal bioprocess (biological total process) containing organism and environment as functionally defined complements.

Chapter 6 used Chapter 5's alternative conception of organism and environment to guide an alternative conception of psychology's subject matter (see pp. 101-104).

This alternative is the postulation "negative feedback patterns among instances of becoming different within bioprocesses." To get to this postulation step by step, we start with a verb-designated behavioural process, here "maintaining-WPR-constant." This process is an example of what Bentley named a behavioural superfice (see p. 86). Next, following Dewey, we note that the process consists of a circular coordination among part-processes such as tapping the keys and speeding up or slowing down WPR. Improving on the relatively vague language of everyday action language (verbs), the coordination is then analysed into subclasses of instances of becoming different, or changes, defined as the moment that a prescribed criterion is met. In the present context, the relevant subclasses of changes were changes in the state of a viewing window, changes in the rate and length of bursts of key taps, changes in the opposition and disturbance variables, and perceived changes in the value of WPR away from goal WPR. The coordination is then described as negative feedback patternings among these change subclasses. Figure 22 shows how the above subclasses of changes were organized in a negative feedback circuit during the process of maintaining-WPR-constant. That Figure 22 portrays both Part 1 and Part 2's postulations supports the earlier (e.g., p. 105) claim that they are consistent with one another.

Conceptualising maintaining-WPR-constant as involving negative feedback circuits within a bioprocess contrasts with the traditional approach. In the traditional approach, Participant 6 is an organism. As an organism, he is contained within the skin of his body. Outside his skin is the environment. The computer is part of the environment. As an instance of the organism interacting with its environment, the participant interacts with the computer. The participant-computer interaction consists of stimuli and responses (which some psychologists call *sensory inputs* and *motor outputs*). In the present example, key depressions would be interpreted as organismic responses. Changes on the screen such as updates to the viewing window would be interpreted as environmental stimuli. And so on. The whole treatment is dictated by the initial adoption of the morphological conception of organism. The morphological conception, that is, supports a particular way of seeing the recorded events, in the sense of interpreting these events as *either* organism *or* environment. The morphological conception is a postulation, and it guides particular observations.

As shown in Part 2, however, the traditional approach is problematic. First, the skin cannot coherently enclose an organism when an organism is seen as a dynamic living process (see pp. 65-68). Second, if organism and environment cannot be separated at the skin, neither can stimulus and response, as shown over 100 years ago by Dewey (see p. 88). As Dewey pointed out, the traditional and morphologically based stimulus-response framework treats stimulus and response as initially separate, creating the non-problem of bringing them together.

The present approach dissolves this non-problem by rejecting the morphological conception from which it follows. Here, we begin with a single system and then explore the changes and relations within this system. This does not preclude the organism-environment distinction. All it precludes is equating this *distinction* with a skin-based *separation*. Recognising the distinction *as* a distinction (and not a separation) frees it up and allows it to be made more satisfactorily.

In some situations, it might be useful to distinguish organism from environment in Dewey's sense of life-activity from the medium through and by which that activity goes on (see pp. 75-78). Applying this basis for the distinction to the present experiment, environment-as-medium included:

- The hardware of the computer, including its monitor and keyboard.
- The software of the computer, including the SVPT program and contingencies within this program.
- The light by which the monitor and keyboard were seen.
- The participant's body.
- The floor, chair, and table supporting the computer and the participant's body.

These items were part of the medium through which the process of maintaining-WPR-constant occurred, just as an apple is part of the medium through which the process of eating-an-apple moves occurs. The medium of such a process is inseparable from the process in that without the medium, there could be no process. In his analysis of organism as activity and environment as medium, Dewey offers one non-morphological way of seeing the process.

Angyal (1941) offered another non-morphological basis for the organism-environment distinction. Angyal equated organism with autonomy and environment with heteronomy. *Autonomy* designates *self-governance* and *heteronomy* designates *foreign-governance* (as discussed on pp. 70-75). Angyal's analysis is particularly appropriate to the present data. During the experiment, autonomy was exercised when changes in opposition reduced the heteronomous influence of the disturbance on WPR. Any perceived influence of the disturbance on the rate at which WPR was being maintained, that is, was opposed. The disturbance was a heteronomous influence within the process, and without which the process would not exist. The opposition was an autonomous influence within the process, and without which the process would not exist. Organismic autonomy and environmental heteronomy, that is, were codefining complements within the broader activity (as already implicit in the words *opposition* and *disturbance*). Figure 23 adapts Figure 9 (p. 74) to the present experiment. Figure 23 suggests that Angyal's qualitative description of a ratio between autonomy and heteronomy can be quantified with an index of control (or the extent to which WPR is maintained constant). This index would indicate the extent to which (heteronomous) disturbances are (autonomously) opposed. One such measure was used in the report written up in Appendix B – Powers' *S* statistic (see p. 166).

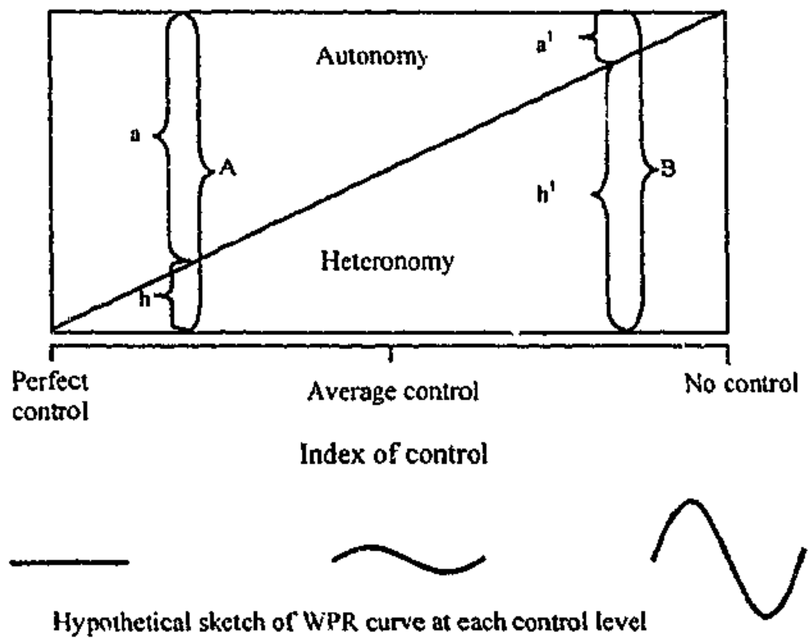

Figure 23: Possible range of ratios between autonomy and heteronomy in the process of maintaining-WPR-constant. During the process, the level of control (extent to which WPR is maintained constant) varies somewhere between the two extremes of perfect control and no control. During the process from which the current data were recorded, the level of control varied between something like the ratios A (a/h) and B (a^1/h^1).

Like Dewey, Angyal offers a non-morphological way of seeing the observed events. Both Dewey's and Angyal's ways see organism and environment functionally and transdermally. The postulations developed in Part 2 guide new observations. In seeing a key tap, we see not a behavioural response emitted by an organism's body, but a change within an organism-environment system, a change by which the autonomy of the system is exerted. Such observations suggest refinements to the postulation, such as bringing together Angyal's autonomy/heteronomy ratio with Powers' quantitative index of control. Such refinements to postulation are able to guide fresh observation, and so on, in an ongoing iteration toward a sharper formulation of the subject matter.

Using the Postulation of Part 2 to Improve the Postulation of Part 1

Besides offering an alternative to the traditional approach, Part 2's postulation suggests refinements to Part 1's deed postulation (which has so far been refined to read "a moment of a stipulated difference (i.e., a change) contributed to by the physical efforts of at least one organism among many other contributors").

One aspect of this postulation remains problematic. This aspect concerns a deed being "contributed to by the physical efforts of at least one organism." There are two problems with this aspect of the deed designation. First, most readers will read the word organism morphologically. The phrase "physical efforts of... [an] organism," that is, will be read as "physical efforts of the body." Part 2 showed this substitution to be problematic. Second, as shown earlier, this qualification raises the anomaly of how to conceptualise changes in the value of the disturbance variable, and changes in the value of WPR contributed to by changes in the value of the disturbance variable. The participant did not contribute effort to these changes. Yet these changes were an important part of the process of maintaining-WPR-constant. If these changes (in the value of the disturbance variable) are not deeds, what are they?

Part 2's postulation resolves both of the above problems. In that postulation, we do not begin with separate changes, including as relevant only those to which the participant's body contributed effort. Instead, we begin with the whole process. Within this process we define relevant subclasses of changes and look at their relations. Some of these changes might show organismic or autonomous trends within the process (e.g., changes in the value of the opposition variable) and others environmental or heteronomous trends (e.g., changes in the value of the disturbance variable). Because organism and environment are viewed as complementary functions within a greater process, changes in both are equally important. Changes in the value of the disturbance variable might not meet the original definition of a deed, but they are moments of difference within the observed process, and without which the observed process could not be properly understood. They are just as relevant and important as other changes within the process.

The postulation resulting from this chapter's refinements to the unit integration of Part 1 now stands as follows: "regulative circular patternings of dependencies between subclasses of deeds with multiple contributors and multiple outcomes," where deeds are "moments of difference (or instances of becoming different) distinguished within bioprocesses."

Summary and Conclusion

Parts 1 and 2 of this thesis integrated some accurately designated aspects of past postulations about the units psychologists observe. These past postulations were guided by past observations. The integration guided new observations, in the sense of predicting what was there to be seen if looked for. This chapter used the postulations of Part 1 and 2 to guide observation of maintaining-WPR-constant during a modified version of SVPT. Everything was seen as predicted, and what was seen suggested how to improve several aspects of the guiding postulation. This chapter road-tested the argument presented in Chapter 7 about using iteration between observation and postulation to more sharply formulate the phenomena psychologists observe.

This chapter's demonstration of the iterative procedure developed in the previous chapters has implications for how psychologists theorise and conduct their empirical research. One implication is the suggestion that postulation should draw on and bring together the most accurately designated aspects of past postulations. The aim should not be to prove that a particular postulation is either true or false,[63] but to capitalise and extend on the well-formulated aspects of what psychologists have previously said about what they see. A

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[63] Cf. Dewey and Bentley (1949): "In seeking firm names [i.e., accurate unit designations], we do not assume that any name may be wholly right, nor any wholly wrong. We introduce into language no melodrama of villains all black, nor of heroes all white" (p. xxi).

central feature of this approach is that *all* postulation is treated as a refinable prediction of what is there to be seen. "All postulation" includes specific postulations, such as *stimulus* and *response* and the classification of psychology's subject matter implied by these terms. Psychologists typically exclude such postulations from critical examination and ongoing refinement. Specific, literal designations of the items psychologists observe deserve as much, perhaps more, examination and refinement as the more general or abstract postulations relying on those items (e.g., memory, cognition).

Another implication concerns experiments that do not allow observation of the events postulated and observed here, by having an experimental design and apparatus that rules out such events, by failing to make detailed records, or both. Most experiments in psychology fall into one of these categories. Such experiments make it impossible for psychologists to see an important part of what they could see with appropriate modifications to their experimental procedures. What is not seen cannot guide an iterative cycle in which observation and postulation guide and correct each other. By limiting the observational phase of this cycle, psychologists can only perpetuate present conceptualisations of what it is they are observing. If psychologists could bring more thorough observations into such a cycle, they might achieve an increasingly clear formulation of those observations. In particular, they might:

1. See in detail a vast domain of events
2. See in detail the dynamic organization of this domain
3. Develop postulations incorporating what is seen in this domain
4. Use those postulations to guide deeper observation within this domain, and so on, round and round.

APPENDIX A: SCHEMATIC DIAGRAM OF WHOLE THESIS

Figure 24 illustrates how Parts 1, 2, and 3, contribute to this thesis as a whole.

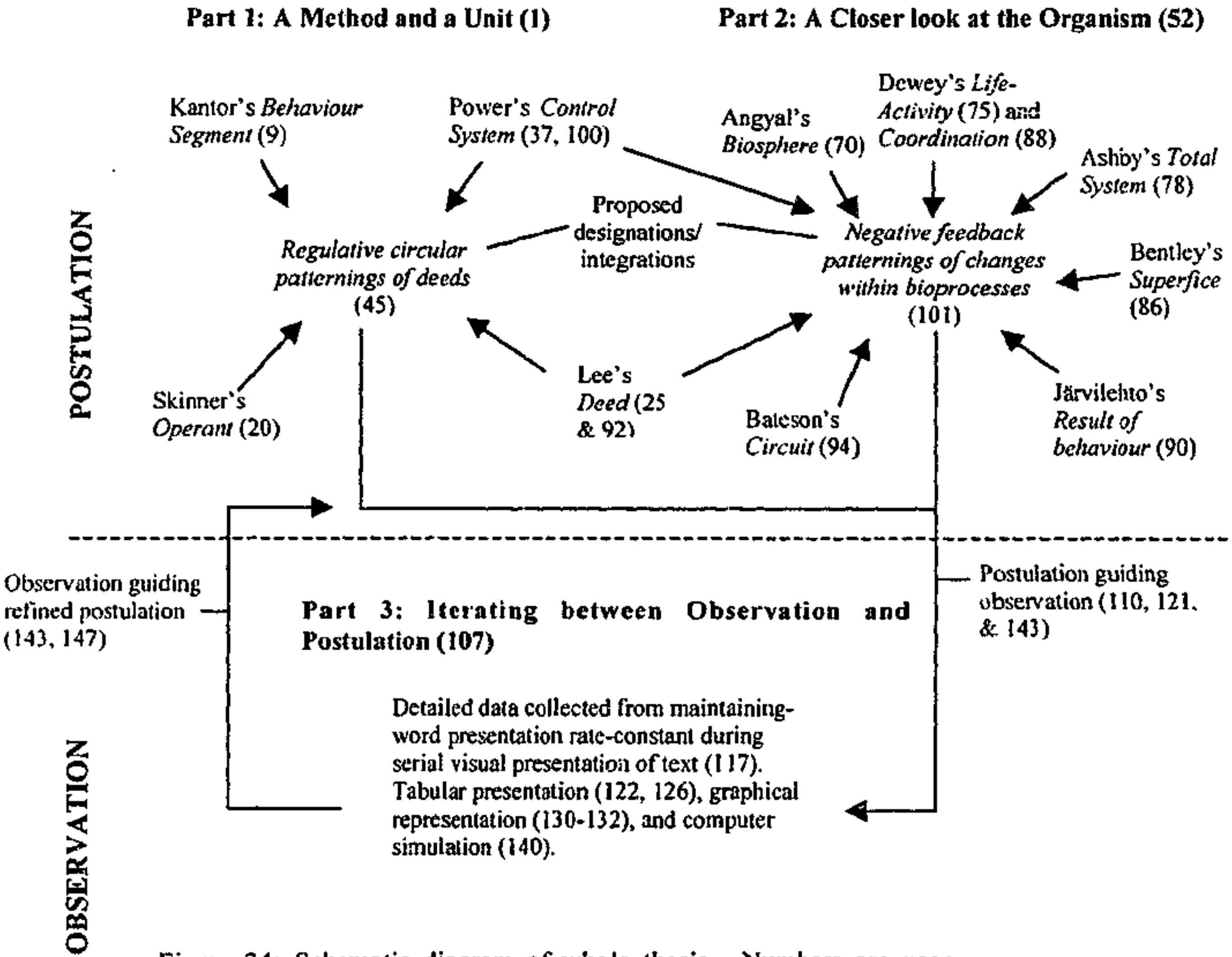

Figure 24: Schematic diagram of whole thesis. Numbers are page numbers. Arrows mean *contributed to.* The dashed line indicates the distinction between postulation (above) and observation (below). The postulations of Part 1 and 2 integrate the past postulations of the indicated scholars. Part 3 uses these integrations as postulations to guide observation and then to iteratively refine the postulations.

APPENDIX B: SERIAL VISUAL PRESENTATION AND COMPUTER-BASED SILENT READING: A CONTROL THEORY APPROACH

Daniel K. Palmer
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ABSTRACT: This paper explores a new technique for the computer based serial visual presentation of continuous text (SVPT) that draws on W. T. Powers' *Perceptual Control Theory* and allows the investigation of means-ends hierarchies within reading. Six participants each viewed 6 texts between 997 and 1207 words in length, with words presented individually and sequentially to a static central location on a computer monitor. A sine based disturbance pattern continuously influenced word presentation rate (WPR). At the same time, participants influenced WPR by tapping (Texts 1, 2, 5, & 6) or holding down (Texts 2 & 3) one key to increase WPR and another to decrease it. Participants were instructed to read (odd-numbered texts) or to merely maintain WPR constant (even-numbered texts). All participants opposed disturbances to WPR, maintaining it within a relatively narrow range. The disturbance was better opposed in (1) key hold as opposed to key tap conditions and (2) when participants were instructed to maintain WPR constant as opposed to reading the text. Representative data from two participants was simulated using the perceptual control theory model. Correlations of r = .941 and r = .994 between actual and simulated data support a control theory interpretation of how participants maintained WPR constant.

Perceptual Control Theory

W. T. Powers' *Perceptual Control Theory* (PCT) applies the cybernetic negative feedback principle to complex (and non-complex) human action (Powers, 1973; 1989). PCT begins with the observation that organisms act to control perceived environmental variables, where *control* means to maintain against perturbation or disturbance.[64] When driving, for example, one controlled variable is the lateral displacement of the car from the middle of the correct lane. Despite disturbances such as curves in the road and crosswinds, lateral displacement is kept at or near to zero. Such control can be modelled with a negative feedback organization between an observed goal or reference state (e.g., a lateral displacement of zero), the value of a perceived variable (e.g., lateral position), and the effects of behaviour (e.g., turning the steering wheel) on that perceived variable (e.g., Powers, 1979a).

In PCT's *Test for the Controlled Variable*, suspected controlled variables are disturbed (e.g., Marken, 2002b, p. 64; Powers, 1978). If the organism acts in a way opposing or cancelling out this disturbance, then the hypothesis that the variable is a controlled variable has experimental support. If I open the window on a cold day and you close the window, put on a sweater, or turn on the heater, the hypothesis that you were controlling for a body temperature within a certain range would have support.

Despite PCT's successes in describing, interpreting, modelling, and predicting human behaviour (see Marken, 1992), it has not received wide attention. Some commentators suggest the basis for this neglect lies in PCT's unconventional adoption of cybernetic closed-loop causality. Such causality is circular and not reducible to linear chains of cause and effect (Dewey, 1896; Marken, 1993). Contemporary cognitive and behavioural psychology, it has been argued, remain committed to linear analyses, where behavioural output is seen to result from environmental stimulation, internal mental processes, or a combination of the two (Bourbon & Powers, 1993; Marken, 2002a).

To sum up, PCT offers an untraditional theoretical base for psychological experimentation. PCT's parsimonious, simulation-based interpretation of complex empirical data warrants further experimental evaluation. The present paper describes an empirical application of PCT to a research paradigm called *serial visual presentation of text*.

[64] This is the reverse of the standard behaviour-analytic locution, in which the environment controls behaviour.

Serial Visual Presentation of Text

In serial-visual-presentation-of-text (SVPT)[65] reading interfaces, successive text segments of one or a few words are presented to a static position on a screen (Potter, 1984; Young, 1984). Differing from conventional reading in distributing words in time rather than in (page) space, SVPT compares well with regular page-by-page reading in speed and comprehension (e.g., Cocklin et al., 1984; Juola, 1988; Ward & Juola, 1982), though not without exceptions (e.g., Muter et al., 1988). SVPT has been used to investigate normal skilled reading (e.g., Juola et al., 1982; Masson, 1983; Rubin & Turano, 1992), to help readers with low vision (e.g., Arditi, 1999; Fine & Peli, 1995), and to explore alternatives to entire pages when display size is limited, as on a mobile phone or web page banner (e.g., Juola et al., 1995; Kang & Muter, 1989; Rahman & Muter, 1999).

Applying PCT to SVPT

Presentation Rate as a Controlled Variable

The present experiment took a PCT-informed approach to computer-mediated SVPT silent reading. The rationale was as follows. In reading, one variable controlled by readers is word presentation rate (WPR). Readers, that is, regulate the rate at which successive words (or other textual units) are fixated in such a way that the aims of reading (e.g., comprehension, answering an exam question, participating in a casual discussion about the text) are realizable. In SVPT research enabling some degree of reader control, WPR amounts to the rate at which words are updated in the static viewing window.

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[65] While this research is usually referred to as rapid serial visual presentation (RSVP), the R is deleted here because in much SVPT research, particularly self-paced SVPT research, the word presentation rate has not been rapid. Likewise, the T has been added in that other RSVP research has presented non textual units (e.g., nonsense symbols or pictures).

PCT's *Test for the Controlled Variable* was described above. Applying it to SVPT, a simple test for WPR as a hypothesized controlled variable entails disturbing (increasing or decreasing) WPR where the reader is empowered to oppose that disturbance (by acting to increase or decrease WPR).

The Present Experiment

From the perspective of obtaining detailed data from relatively regular silent reading, previous SVPT research has limitations. The following four sections show how four such limitations with previous SVTP research were overcome and integrated with PCT's test for the controlled variable.

Reader Control of Rate

In SVPT research, experimenters usually select word presentation rates (WPRs) unchangeable by the participant (e.g., Chen, 1986; Cocklin et al., 1984). Here, presentation rate is the independent variable, and a measure of accuracy (e.g., recall, comprehension tests) is the dependent variable. Such experimenter-controlled rates are not analogous to regular reading, where the reader has complete control over WPR and is free to adjust the speed with which successive words are fixated. For this reason, some researchers have explored methods for allocating more control to the reader (e.g., Arditi, 1999; Just, Carpenter, & Woolley, 1982; Muter et al., 1988; Rahman & Muter, 1999). One technique has been to have participants press a button to view each successive word (e.g., Arditi, 1999; Just et al., 1982). A problem with this technique is that participants are unable to read faster than they can repeatedly depress a button. Normal reading speeds of between 200 and 300 words per minute would call for an ongoing rate of between 3.33 and 5 button depressions per second. In another technique, Muter et al. (1988) let participants affect WPR by moving a mouse or pressing keys to increase and decrease presentation rate by ten percent. Reading speed and comprehension were equivalent for mouse (analogue) and key (digital) conditions. Finally, Rahman and Muter (also Castelhano & Muter, 2001; Rahman & Muter, 1999) had participants press a key to present an entire sentence at a preset rate, press again for the next sentence, and so on.

The present experiment overcame this limitation *and* integrated PCT's test for the controlled variable by simultaneously allocating rate-influence to reader *and* computer (i.e., experimenter). In all conditions, WPR was preset to vary in a smooth, semi-random disturbance pattern. Left unchecked, this disturbance made WPR sometimes too fast to read and other times so slow it inhibited fluent reading. This satisfied PCT's definition of a disturbed variable. Simultaneously, however, participants were free to oppose these disturbances by depressing one key to increase WPR and another to decrease it. This made it possible (given appropriately patterned key depressions) to maintain WPR relatively constant. Momentary WPR was thus an additive function of the pre-programmed disturbance *and* the action of the participant.

Whereas participants could always affect WPR by depressing either of two keys (one to speed up and one to slow down), two modes of key-operation were evaluated. In one mode readers tapped a key, with each tap increasing or decreasing WPR by a set amount. In the other mode, readers were required to press and hold the keys if WPR was to be affected. This comparison stemmed from pilot studies in which some participants had difficulty with the tap format.

Task Instruction and Comprehension Assessment

A second limitation with SVPT experimentation concerns the reading task assigned to participants. Instructions have been contradictory (e.g., Just et al., 1982), different across experimental conditions (e.g., Chen & Chan, 1990; Masson, 1983), or omitted from mention altogether (e.g., Juola et al., 1995; Kang & Muter, 1989). In the Just et al. (1982) procedure, "subjects were told to read naturally, without memorizing, and to orally recall what they could of each passage immediately after reading that passage" (p. 230). This instruction is problematic; it is surely difficult to "read naturally" when one knows one will be required to try and recall the text verbatim. As reported by Aaronson and Scarborough (1976), "patterns of word-by-word reading times differ for subjects who must later recall a sentence and subjects who must simply comprehend it" (p. 56). Given evidence of the large effects differences in task instructions have on performance, future SVPT research should make the task as clear and unambiguous as possible to participants. It would also be useful to further research the effects of different instructions.

A related difficulty is assessing the degree to which participants comply with instructions. The usual assessment tool is a multi-choice questionnaire. As noted by Rubin et al. (1992), however, "multiple-choice questions such as the type we and previous investigators have used, do not probe for detailed information" (p. 901). Another limitation of the multi-choice assessment format is that it once again makes reading abnormal. Reading in order to take a test is different from most everyday reading where such pressure is absent. It would be useful to develop alternative methods of comprehension assessment – preferably assessment that probes for more detailed information *and* allows the reading to be as natural as possible.

The present study addressed and further researched these limitations as follows. The task assigned to participants was systematically varied. On some texts (here called *read* texts), participants were asked to read the text in order to write a short casual summary of what they had read. This comprehension assessment format was evaluated as an alternative to the more conventional multi-choice test. On top of probing for more information, this format was used as an attempt to make the reading more realistic, in removing the pressure of sitting a multi-choice test or similar. On other texts (here called *control-rate-only* texts), participants were asked *not* to read the texts, but simply to "keep the speed at which words appear constant." This comparison of different tasks allowed a systematic evaluation of the effects of different instructions on what participants did. There is another reason this comparison was of interest. When the assigned task is to read and comprehend the text, the regulation of WPR is a means to the end of meeting this higher-order goal. It is not the primary end. This contrasts with a focus on maintaining a constant WPR and not on reading the text. Presumably the dynamics of rate regulation will differ across the two circumstances. The instruction manipulation allowed this hypothesis to be tested.

Completion Meters

A third limitation is that SVPT participants usually lack access to peripheral information about the proportion of the text that has been read and that remains to be read. Recognizing this problem, Rahman and Muter (1999, also Castelhano & Muter, 2001) displayed a completion meter in which a row of vertical bars was gradually converted into dots, each bar becoming a dot as each sentence was read. The completion meter did not interfere with reading efficiency (defined as speed multiplied by comprehension), and participants reported a preference for completion meters in post-session questionnaires. It would be useful to complement such findings with more objective and real-time assessment of participant preference for completion meters.

Accordingly, this experiment used completion meters, but differed from previous experimentation in imposing a response-cost on observational access (rather than having the completion meter always visible). Participants held down the space bar to reveal the completion meter, which was re-concealed when the key was released. It was assumed that the resulting data would indicate when and for how long participants looked at the completion meter.

Experimental Design

A fourth limitation of conventional SVPT research has been an exclusive reliance on group-designs and the analysis of data averaged across groups of participants. A typical example comes from Rahman and Muter (1999), who obtained reading speeds by dividing number of words read by time spent reading and then averaging the resulting value across 20 participants. Such averaging obscures momentary rate changes within individual data that might otherwise be of interest. The present experiment used a within-participant design. Comparisons of key operation modes and of task instructions were made within sessions for each participant. Instead of averaging data over large numbers of participants and then using inferential statistics, detailed data were collected from just six participants and analyzed using exploratory visual data analysis (as described by Lee, 1999b).

Predictions

(1) In the terminology of PCT, WPR was expected to be a controlled variable in the sense that disturbances to WPR would be cancelled out via key taps and holds. Further, superior control (disturbance cancelling) of WPR was expected in control-rate-only conditions, where maintaining a constant rate was the instructed task, relative to read conditions, where reading the text was the instructed task. It was unknown whether control would be superior in tap or press-and-hold conditions (hereafter referred to simply as "hold conditions").

(2) A trade-off between amount of control (again: the extent to which disturbances were cancelled out) and WPR was expected (i.e., a negative correlation). At higher speeds of word presentation, that is, it was expected that it would be more difficult to maintain a constant rate. This trade-off was expected to be greater in control-rate-only conditions than in read conditions. This was because during read conditions, WPR was being controlled only as a means to the higher-order end of comprehending the text. This would mean that a disturbance-induced change in WPR would only need to be countered if it interfered with text comprehension.

(3) On the basis of the high preference for completion meters reported by Rahman and Muter (1999) it was expected that participants would regularly obtain visual access to the completion meter by depressing the space key.

(4) As explained earlier, this experiment was based on PCT's test for the controlled variable. It was accordingly predicted that a PCT-based computer simulation of participants' control of WPR should produce data similar to that of actual participants. In this way the present study incorporated a test of the basic PCT model.

Method

Participants

In response to campus advertisements, six participants were recruited. Four were university students, one a university staff member and one a high-school student. The participants ranged in age from 14 to 35 years of age.

Participant age, sex, and session length are displayed in Table 3. All participants reported English as their first language, reported normal or corrected to normal vision, and were paid $2.50 per quarter-hour of participation. Each participant attended for one session only.

Participant	Age	Sex	Session Length
1	35 (Yrs)	F	55 (minutes)
2	14	F	52
3	25	M	67
4	22	M	94
5	20	F	71
6	24	M	107

Table 3: Participant age, gender, and session length. Session length is defined as time elapsed from the appearance of the first word of the first text to the disappearance of the last word of last text.

Apparatus

The experiment was conducted in a small office sparsely furnished with a table and an adjustable office chair. A sign telling participants that they were free to leave at any time was attached to the inside of the door. A note attached to the table between the keyboard and the monitor read "Use the up-arrow key (↑) to speed up. Use the down-arrow key (↓) to slow down. Press the space bar to see how much you've read." A further notice on the wall behind and above the monitor duplicated this information along with the instruction "Keep working until the computer tells you to come and get me."

Six articles from Reader's digest were used as experimental texts (Conniff, 2001; Linden, 2000; Mason, 2001; Postrel, 1999; Vansittart, 2001; Woodward, 2001). One article (Text 6) was slightly shortened, and in all articles, dashes surrounded by spaces were attached to the word they bounded (e.g., [The – very fat – cat] would become [the –very fat– cat]). Table 4 displays text length in words, number of between-sentence blank spaces (explained below), and Flesch reading ease scores.[66]

[66] The Flesch formula is 206.835 – (1.015 x ASL) – (84.6 x ASW), where ASL = average sentence length and ASW = average number of syllables per word.

Text	Word Length	Between-Sentence Spaces	Flesch Reading Ease Score
1	1207	71	58.6
2	1167	68	56.9
3	1181	64	57.6
4	997	44	51.2
5	1110	59	51.2
6	1161	53	59.2

Table 4: Text characteristics.

Texts were presented on a Macintosh G3 computer with a 19-inch monitor (1024 by 768 pixels at 75 Hz) fitted with a standard anti-glare screen. Words were presented individually and sequentially in a centred white rectangle (edit field) surrounded by a black background. The dimensions of the text-presentation edit field were 224 by 36 pixels (approximately 6.3 by 1 cm). Words (Black Geneva 36 font) were centred in the edit field. The definition of "word" for this study was any continuous series of characters (letters, digits, and punctuation marks) beginning and ending with a space. As a result, sentence-final words included a period (e.g., [circus.]). Following previous research (e.g., Castelhano & Muter, 2001; Juola, 1988; Masson, 1983), blank spaces were displayed between sentences for a duration equal to the current word duration. Although Text 1 was 1207 words long, for example, during its presentation the edit field was updated 1278 times. This was because of the 71 blank spaces presented between sentences. At a hypothetically constant word presentation rate of 120 wpm (2 words per second), presentation of Text 1 would take 1278/120 = 10.65 minutes.

Procedure

Upon reporting to the laboratory, participants were asked to read a short explanatory statement and to complete a consent form. The use of an explanatory statement and a consent form was required and had been approved by the Monash University Ethics Committee. The explanatory statement included the following section: "This research is about different ways of using a computer to present text to a reader. You are asked to interact with computer presented texts until the computer tells you to stop. The session is likely to take about one hour. The procedure for presenting texts will be explained to you shortly." The participant was then read the more detailed instructions shown in Attachment A.[67] The practice module program was then started and the participant was asked to follow the prompts on the screen.

Practice Module

Each participant's session began with a practice module that familiarized the participant with the word-by-word text-presentation format, the different conditions under which key depressions affected WPR (taps vs. holds), accessing the completion meter, and following computer-presented prompts. The experimenter remained present during the practice module, sat quietly behind the participant and did not interact with them until the practice module was finished. Initially, the participant was required by a prompt on the computer screen to "hit the s key to begin." Words were then presented at a rate of 50 WPM.

Screen-presented prompts then required the participant to (a) increase WPR to 300 by tapping, (b) decrease WPR to below 50 by tapping, (c) increase WPR back to 300 by holding, (d) decrease WPR back to 50 by holding, and (e) access the completion meter three times. The computer then congratulated the participant on completing the practice module. All participants completed the practice module within 2 minutes 40 seconds. The experimenter then manually quit out of the practice-module program, started the experiment-proper computer program, and left the room for the remainder of the experiment.

Experimental Module

The computer initially displayed the following instructions (in size 24 Geneva font):

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[67] Appendices to this experimental report are designated *attachments* to differentiate them from the appendices to the thesis (of which this report is the first).

1) Your task is to READ this next story in order to write a short summary at the end.

2) TAP the up-arrow key to speed up and TAP the down-arrow key to slow down (holding will not work).

3) Hit s to start.

And in a separate frame and in a smaller font (Geneva 18) at the bottom of the screen:

Remember that you can press the space bar at any time during the story to see how many words have appeared/remain to appear.

When the participant depressed the s key, the first word of the first text was presented. The first text for each participant was in the tap and read format, with the reminder prompt, "TAP (holding won't work)" visible below the first five words of the text (a similar prompt accompanying all six texts). WPR followed a preset semi-random sine wave pattern unless the participant depressed the speed-up or the slow-down key. Details of the sinusoidal disturbance to WPR and the influence of key depressions on WPR are now described (though both were simultaneously operational during each text).

On all texts the initial WPR was set at 46 wpm (1304 ms per word) but then constantly varied due to the application of an ongoing disturbance. The disturbance variable initially increased, following a time-based sine wave pattern set to vary randomly above and below a base value of 320 wpm, a base amplitude of 300 wpm, and a base period of 1 cycle every 2 minutes. See the line representing the disturbance in Figures 25-27 for a visual depiction of this disturbance pattern over time. The disturbance was preset to select a new random amplitude and period each time it crossed the axis (320 wpm) by multiplying the base amplitude and period with a random number between 0.5 and 1.5. The amplitude could thereby vary from 150 to 450 wpm and the period from 0.5 to 1.5 cycles per 2 minutes. These ranges were selected such that no combination could result in a rate of change higher than the participant could counter (oppose/cancel out) with key depressions, which are explained next.

In tap conditions, when WPR was below 150, each tap of the up-arrow increased an opposition variable by 15 wpm. Likewise, each tap of the down-arrow key decreased the opposition variable by 15 wpm. When WPR was equal to or above 150, however, each tap instead added or subtracted 10 percent from the opposition variable.[68] During hold conditions, holding down the key affected the action variable by 15 wpm (if WPR below 150) or 10% of WPR (if WPR above or equal to 150) three times per second (i.e., every 0.33 seconds). Holding down either the up- or down-arrow key for 1 second in the hold conditions, in other words, had the same effect as three taps in the tap conditions.

During all texts the opposition variable was initially set at zero and changed only as a function of up- and down-arrow key depressions (taps or holds). At each moment, WPR was equal to the sum of the disturbance and opposition variables (WPR = D + O). If the disturbance variable had a value of 600, and the opposition variable had a value of -390 (after, for example, 26 down-arrow key taps), WPR would be 210 wpm. The only exception was any combination of disturbance and opposition that resulted in a WPR lower than 5 wpm. The computer was programmed such that the lowest possible WPR was 5 wpm.

During text presentation, pressing the space bar revealed a completion meter with a red bar moving left-to-right above a white background (224 by 15 pixels) immediately below the text edit field. The length of the red bar corresponded to the proportion of words shown. Pressing the space bar did not

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[68] This avoided the problem that 15 wpm becomes an increasingly tiny proportion of WPR at high values (i.e., above 150 wpm), making it easy to lose control of the rate during an increasing disturbance. To include the 10% of WPR alternative below 150 wpm, however, is also problematic, in that 10% of, say, 10 wpm is only 1 wpm, meaning an excessive number of depressions is required to influence WPR. The present compromise afforded ample influence at both high and low WPRs.

disable the speed-up or slow-down keys, and text continued to appear. The completion meter remained visible until the space bar was released.

After the final word of Text 1 was removed from the edit field, the instruction "End of story. Click the mouse button when you are ready to summarize the story" appeared. When the (single) mouse button was depressed, a summary edit field (824 pixels by 19 lines at size 24 Geneva font) appeared, and the summary task began. During the 2-minute summary period, a completion meter with the same attributes as above was permanently visible at the top right of the screen, with the red bar indicating the time elapsed.

When 2 minutes had elapsed, the summary edit field was automatically removed, and the instructions for Text 2 were displayed, which differed from the above instructions only on Point 1:

> 1) Your task during this next story is ONLY to keep the RATE at which words appear as constant as you can. You are NOT required to read, and there will be no summary.

A depression of the s key initiated presentation of the first word of the second text, which was presented in the control-only and tap format.

After the presentation of the last word of the second text, which was not a reading condition and thus required no summary, instructions for the third text were displayed. These instructions were the same as the instructions for the first text except for point 2, which read:

> 2) PRESS and HOLD the up-arrow key to speed up and PRESS and HOLD the down-arrow key to slow down (tapping will not work).

Text 3 was followed by a summary, and Texts 4, 5, and 6 were presented according to the specifications shown in Table 5 (which combines an ABABAB and an AABBAA design).

Text Number	Instruction	Key Operation	Summary
1	Read text	Tap	Yes
2	Maintain rate	Tap	No
3	Read text	Hold	Yes
4	Maintain rate	Hold	No
5	Read text	Tap	Yes
6	Maintain rate	Tap	No

Table 5: Instruction, key operation, and whether a summary was required for each of the six texts (same for all participants).

After the final word of Text 6 had been presented, the following prompt was displayed:

The session is now finished. Please get the experimenter.

The experimenter then went through an 8-question questionnaire (reproduced in Attachment B) with the participant. The participant was paid and thanked for participation before leaving.

Results

Disturbance, opposition, and actual rate variables across the entire experiment (i.e., six texts) for each participant are plotted in Figures 25 - 27. Figure 25 plots Texts 1 and 2, Figure 26 Texts 3 and 4, and Figure 27 Texts 5 and 6. Also reported for each text is the *S* (stability) score,[69] the time spent on that text, and mean WPR. Participants are ordered (and have been named) from highest to lowest average *S* scores. Asterisks indicate completion meter visibility (i.e., when the space bar was depressed). These specifications apply also to Figures 29 and 30, the top panels of which (representatively) present

[69] The stability (*S*) formula is 1 minus the square root of the ratio of expected variance to obtained variance (1 - sqrt(ev/ov)). Expected variance is the sum of the variances of the disturbance and opposition variables. Obtained variance is the variance of the controlled variable (WPR in this instance). The more negative the *S* value, the more the opposition equally and oppositely countered the disturbance (for more detail see Powers, 1978).

Text 1 for Participant 1 and Text 6 for Participant 6 at a higher resolution than Figures 25 - 27 (the bottom panels of Figures 29 and 30 will be explained later).

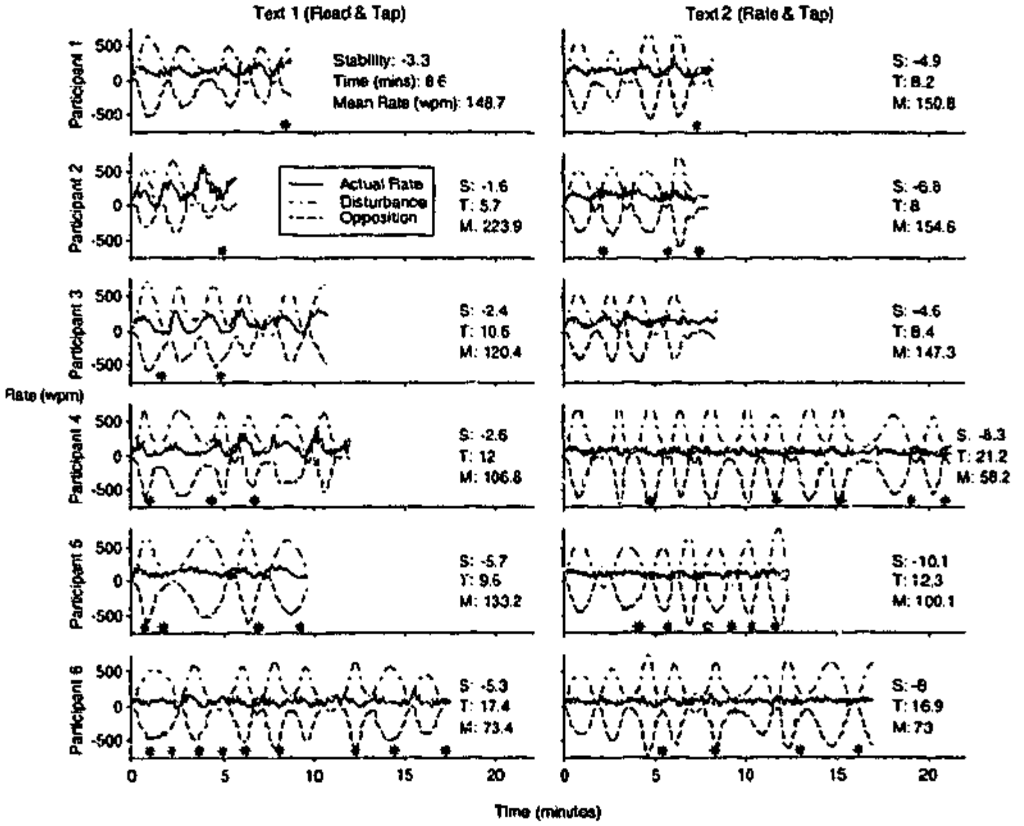

Figure 25: Actual rate, disturbance, and opposition variables during Texts 1 and 2 for each participant. Variables are plotted over time in units of words per minute. Asterisks indicate completion meter visibility (i.e., when the space bar was depressed). Stability (*S*) score (see Footnote 69 for explanation), time in minutes, and average word presentation rate are shown for each text.

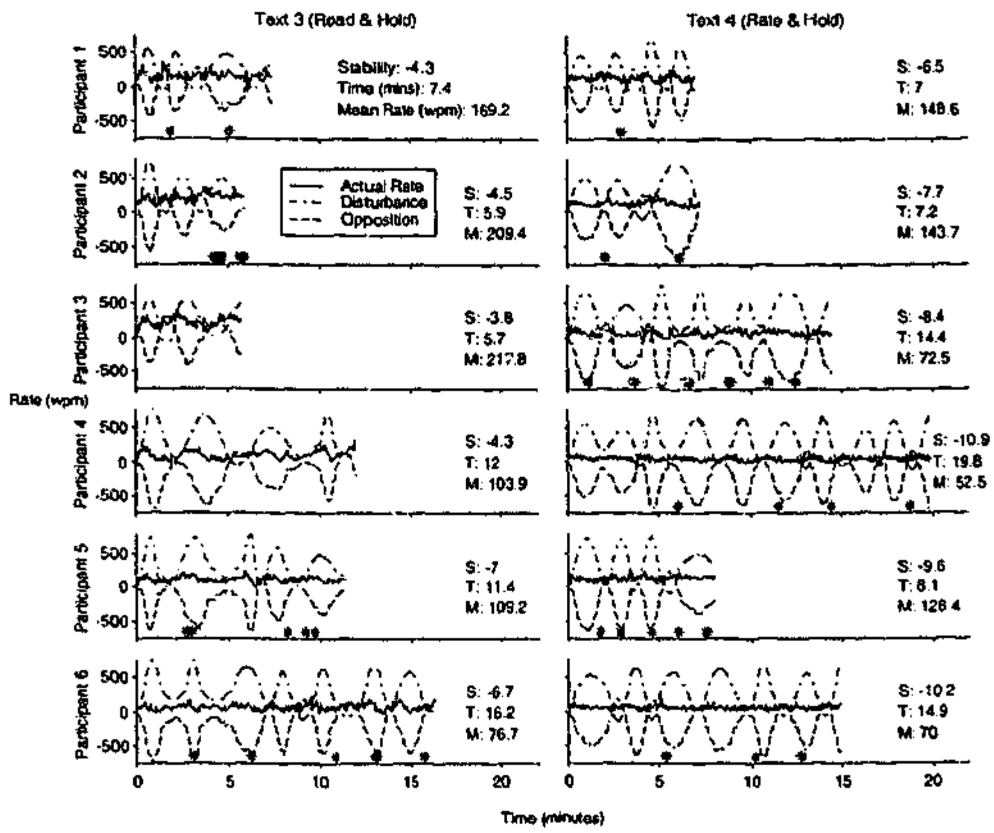

Figure 26: Actual rate, disturbance, and opposition variables during Texts 3 and 4 for each participant. Other details as in Figure 25.

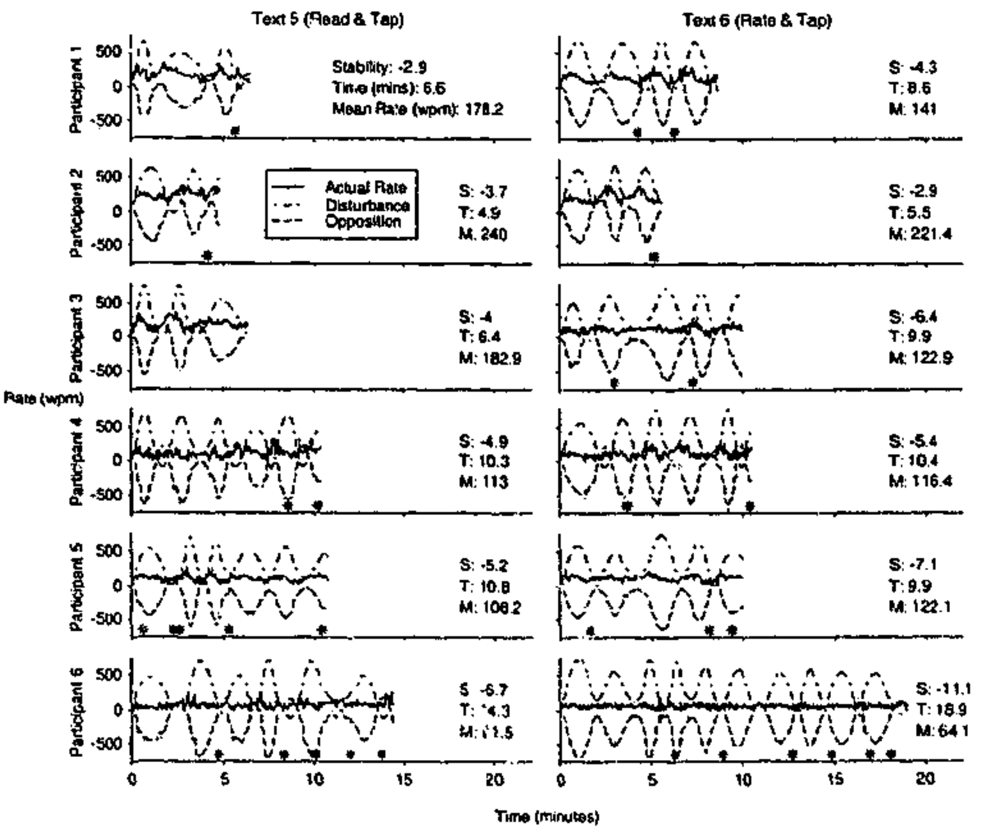

Figure 27: Actual rate, disturbance, and opposition variables during Texts 5 and 6 for each participant. Other details as in Figure 25.

The degree to which participants maintained a constant rate despite the disturbance is visible in three ways: the horizontal straightness of the rate line; the horizontal symmetry (or equal and opposite 'mirroring') of the opposition and disturbance variables around the rate line as axis, and the *S* scores. The more negative the *S* score, the higher the control.

All participants tapped or held the up- and down-arrow keys to influence the opposition variable and thus WPR. Participants used the keys to lessen the effect that the disturbance variable would otherwise have had on WPR (remembering that if opposition remained zero, WPR would equal disturbance). In other words, participants acted to control WPR. This said, and despite high control overall, control varied greatly both within and across participants. Participants 1-4 controlled relatively poorly on Text 1, with Participant 3 letting WPR hit its floor value of 5 wpm on four occasions (no other participants letting WPR get this low). Participants 1-4 exerted more control in subsequent conditions (excepting Participant 1, Text 5), suggesting it took some time for these participants to get used to the task.

Pearson's r was obtained for the correlation between mean WPR and *S* scores across all participants and texts (0.68) and separately for read (0.56) and control-rate-only (0.81) texts. These data indicate that as word presentation rate increased, *S* increased (and control accordingly *decreased*), with this correlation much higher in control-rate-only as opposed to read conditions.

Read versus Control-Rate-Only

Because the experiment alternated between read and control-rate-only instructions for six texts, it can be viewed as three successive comparisons of these two instructions. The instructions had a clear effect on control levels, as indicated by the fact that for 17 out of 18 of these comparisons, control was noticeably higher (and *S* scores thus lower) in the control-rate-only conditions (the exception being Participant 2 Texts 5 and 6). This result is likewise reflected in lower average *S* scores (and control thus higher) in control-rate-only as opposed to read conditions for all six participants.

Regarding mean reading rates, all but Participant 5 had higher average .nean WPRs during read as opposed to control-rate-only conditions. The two values were the same for Participant 5. In sum, participants achieved lower mean WPRs and higher control when instructed to control-rate-only than when instructed to read the texts in order to complete a two-minute written summary.

Tapping versus holding

Despite 5 of 6 participants reporting a clear preference for tap conditions (see below section on questionnaire data), four participants achieved their lowest *S* score during hold conditions, the second lowest *S* score obtained was during a hold condition (Participant 4, Text 4), and all participants averaged lower *S* scores in the hold than the tap conditions. That is, according to the primary index of control used here, control was higher during hold conditions despite participants being constrained to a rate of three taps per second while either key was held down. This differed from the tap conditions in which participants were free to increment or decrement WPR at the rate they tapped the keys. No such difference was observed in the averaged mean WPR of tap versus hold conditions. Two participants had higher average rates during tap conditions, and four had higher average rates during hold conditions (although Participant 6, of the second group, had almost identical average rates in both).

Completion Meter Data

The asterisks in Figures 25, 26, 27, 29, and 30 indicate the times at which participants obtained visual access to the completion meter by depressing the space bar. Participants 1, 2, 5, & 6 accessed the completion meter during every text. Participant 3 did not access the completion meter during Texts 2, 3, and 5, and Participant 4 did not access it during Text 3. Participants generally accessed the completion meter regularly, this tendency being clearest in those participants spending more time on the texts (e.g., Participants 5 & 6).

Reading-Summary Data

As Table 6 shows, participants wrote fairly short summaries in the two available minutes. Summaries ranged in length from 26 to 76 words (or 4.6 to 1.6 seconds per word or 13 to 38 words typed per minute).

Participant:	1	2	3	4	5	6
Text 1	49	54	37	47	57	26
Text 3	37	44	72	57	59	38
Text 5	49	76	69	64	52	41

Table 6: Summary length in words for each summary and participant. Summaries were only required after read-instruction texts (Texts 1, 3, & 5).

A closer look at the unusually short summary data of Participant 6 on Text 1 revealed that he wrote and deleted a five-word sentence. Also relevant is that during the post-session questionnaire Participant 6 reported "panicking" that he might run out of time during the summary task. Of the 18 summaries, 11 ended mid-word or sentence, suggesting that most participants ran out of time while writing and would have written more had they more time. Participant 3 was the only participant to end all summaries with complete sentences.

The following two passages display summary data for Participant 1, Text 3, and Participant 3, Text 3 (the shortest and the longest summary for Text 3):

Participant 1:

outlines a range of religions approach to and belief in miracles. All major religions include miracles in their doctrine. The Jewish are the least likely to believe, despite Pass over being the celebration of a miracle of

Participant 3:

For the most part the story argues for the existence of miracles, siting their presence within the belief structures of all five major religions, and backing this claim up with stories of faith healing from Christian and Jewish societies, an example of prophecy from an Islamic one and some brief mention of Hindu and Buddhist mythological traditions. At the end, it presents belief in miracles as a paradox to the religious mind.

As these examples indicate, none of the summaries could have been written had participants not been reading the texts. Given the aims of the study, it was decided not to develop a way of assigning relative comprehension scores to each summary. This issue is further addressed in the discussion.

Questionnaire Data

Participant responses to the post-session questionnaire can be summarized as follows (see Attachment B for the corresponding questions).

(1) All participants except Participant 2 reported a preference for tap over hold conditions, explaining that they felt that it gave them more control (which it did). Participant 2 felt that tapping sometimes didn't work (the data suggesting otherwise).

(2) All participants had no or very occasional trouble remembering whether to tap or hold. Participant 3 found himself sometimes "subconsciously" tapping in hold condition when only a small change to rate was required.

(3) All participants except Participant 3 detected no pattern to their up- and down-arrow key depressions. Participant 3 said it "felt like a kind of sine-pattern" (which it was).

(4) All participants except Participant 6 reported preference for the read over the control-rate-only conditions. Participant 6 found it "a bit stressful to take it all in" during the read conditions. Four Participants spontaneously noted that they found it difficult not to read during the control-rate-only conditions.

(5) All participants reported no trouble remembering when they were supposed to be reading versus controlling-rate-only.

(6) All but Participant 4 reported tapping (hand or foot), counting (in seconds or "123 - 123 - 123"), or "trying to imagine a slow voice." Participant 6 commented that he would "Try and remember which speed to come back to - tried to maintain starting speed."

(7) Participants reported that the completion meter was useful (Participants 2, 4 & 6), un-useful (Participant 1), that they "didn't use it a lot" (P 3) or used it just at the end of texts (P 5). Participant 1 said she "didn't use

it" when Figures 25-27 show that she accessed it on every text. These figures also shows that Participant 5 accessed it as often at the beginning as the end of texts (despite her claim to the contrary).

(8) When asked whether they ever "lost control" of the speed (i.e., wpr), participants respectively answered "all the time," "sometimes," "a few times," "quite often," "not really," and "not exactly, but I would sometimes have to use keys a lot to control speed."

Data Simulation

A task-specific variation of the basic PCT model was used to simulate the rate control process in real time for data from two texts (Participant 1, Text 1, and Participant 6, Text 6). The data recorded during these two texts were respectively representative of relatively low and relatively high control. As mentioned in the introduction, control can be modelled as a negative feedback organization among a goal or reference state, the value of a perceived variable, and the effects of behaviour on that perceived variable. Figure 28 displays the variables and functions used to simulate the present data (adapted from Powers, 1973, p. 61; 1990a, p. 52).[70,71]

[70] The model to be used here assumes identity between the controlled and perceived variables ($p = WPR$). The variable p and the function i therefore cancel out and are omitted from further discussion (put another way, if $e = r - p$ and if $p = WPR$ then $e = r - WPR$).

[71] This model makes the assumption of dynamic stability, or that "after any transient disturbance, the system-environment relationship will come to a steady-state equilibrium quickly enough to permit ignoring transient terms in the differential equations that actually describe the relationship" (Powers, 1978, p. 422).

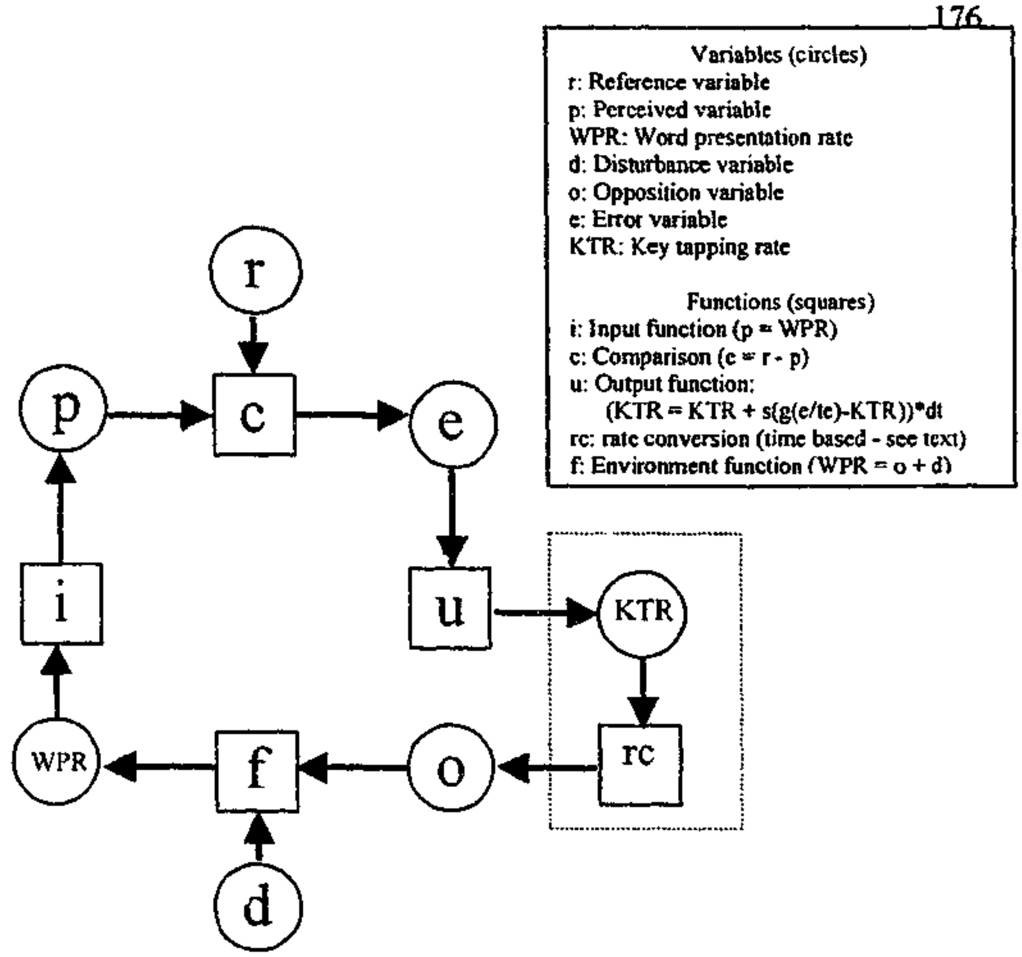

Figure 28: The version of the basic PCT model with which the present data were simulated. Circles represent variables, and boxes represent mathematical functions relating variables. The value of any variable is completely determined by the arrows feeding into it (i.e., only r and d can change independently of the other variables). The contents of the dashed rectangle are task-specific additions to the standard PCT model (with an arrow usually going straight from u to o).

Starting with WPR, the following walks the reader clockwise around the simulation loop, which executed 10 times per second during each simulation run. As during the experiment proper, WPR was equal to the sum of the disturbance and opposition variables (WPR = d + o). The disturbance variable underwent the same continuous sine-wave based fluctuation as the disturbance during the modelled text, and the opposition variable will be arrived at and explained shortly.

The comparison function subtracted WPR from the reference value to arrive at the momentary value of the error variable (recalling that p is equal to WPR and thus omitted along with i for simplicity). The error variable represented the difference between the preset goal or reference rate and the actual rate. It was the simulation's business to eliminate this difference. The reference rate was simply the average WPR during the text being simulated

(148.7 or 64.1 wpm). Note that error was expressed in units of wpm. During the experimental texts being simulated, however, participants could not directly affect WPR. These texts required tapping, and all participants could directly change was which key they were tapping and the rate at which that key was tapped (key tapping rate or KTR). A KTR of zero, for example, corresponded to not tapping at all.

The error value was therefore converted from units of words per minute (wpm) to the equivalent units of taps per minute (tpm). This happened in the output function, the component operations of which are now described. The output function was $KTR_{n(ew\ value)} = KTR_{p(revious\ value)} + (s*(g*(e/te)-KTR_p))*dt$, and executed the following sequence of operations:

(1) e/te: This transformed error in wpm into a KTR in tpm (taps per minute). The value of te (tap effect on opposition) was 15 (if WPR was less than 150 wpm) or WPR * 0.1 (if WPR was equal to or greater than 150 wpm). In other words, this operation calculated the number of taps per minute required to remove the error. If the error was 30 and WPR was below 150, the calculated KTR would be 30/15 = 2 tpm. Note that this step could have been represented in Figure 28 with a separately indicated variable and function. Because the step is so simple, however, it was decided to include it within the output function for simplicity of diagrammatic presentation.

(2) g*(e/te): The resulting KTR was next multiplied by the gain parameter (g). The gain parameter, also called loop gain, is the unit action (here change in KTR) per unit of error. If I ask you to keep your hand still and I then try to displace it with 1 unit of force, you would usually oppose that displacement with a force greater than 1 (to overcome the displacement and rapidly return the hand to its initial position). In the present simulations, the gain values best fitting the data were discovered by trial and error to be either 5 (Participant 1, Text 1) or 30 (Participant 6, Text 6).

(3) $g*(e/te)-KTR_p$: The previous value of KTR was next subtracted. This was like saying "if you need to apply X units of action, don't forget that you are already applying Y units of action, and thus only need to apply an extra X minus Y units of action."

(4) $(s*(g*(e/te)-KTR_p))$: The resulting value was then multiplied by s, the slow parameter (sometimes called the slowing factor). In all control systems, there is a lag between a change in the controlled variable (presently WPR) and a change in the opposition variable necessary to cancel the initial change out. This lag is dealt with by the slow parameter (s), which is a value greater than 0 and less than 1 determining what proportion of the KTR required to remove any difference between WPR and the reference value translates into the new value of KTR. In the present simulations, trial and error yielded a slow value providing satisfactory fits to the data of 0.01 for both data sets.

(5) $(s*(g*(e/te)-KTR_p))*dt$: The constant dt was simply the time slice duration, here 1/10 because there were 10 iterations of the loop per second (one every 6 ticks in the language of Macintosh timing).

(6) $KTR_p + (s*(g*(e/te)-KTR_p))*dt$: The final step in the output function was to take the time integral of KTR by adding its previous value to its newly calculated change in value (which could be negative and thus make the operation subtraction rather than addition). In other words, the just-calculated change in KTR was added to the sum of the previous changes.

Having calculated the new value of KTR (i.e., KTR_n), the simulation program next dealt with translating that KTR into appropriate changes in the opposition variable. Besides expressing the new KTR in units of tpm, and expressing opposition in units of wpm, another constraint needed to be met. Recall that during the experiment proper, opposition could change only in increments of 15 (if WPR $<$ 150) or 10 percent of WPR (if WPR $>=$ 150). This constraint was incorporated into the simulation as follows. The rc, or rate conversion function, converted KTR_n into intertap interval (iti) which was simply $60/KTR_n$ (to give an iti in Macintosh standard timing units of ticks where 1 tick = 1/60 second). It then asked whether time elapsed from the last change in the opposition variable was equal to or greater than the *absolute* value of iti. For note that so far KTR, and thus iti, is just as likely to be negative as positive. Note that a negative rate is meaningless. A negative value of KTR indicated only that scheduled changes to the opposition variable were to be decrements, or equivalent to the effect of taps on the down-arrow as opposed to the up-arrow key. If a change in opposition was appropriate, the program used the sign of iti to establish which 'key' to tap, and then incremented (if iti > 0) or decremented (if iti < 0) the opposition variable by 15 (if WPR < 150) or 10 percent (if WPR >= 150).

On the next iteration of the simulation loop, the new value of the opposition variable (which was often its old value, no change having been scheduled) fed into the environment function (f), along with the current value of the disturbance, to determine the new value of WPR. This brings us back to our point of origin and closes the loop – all variables, parameters, and constants accounted for.

The simulations were tested in Matlab® and then run in real time in futureBasic III for the Macintosh (Attachment C displays the Matlab® code for each iteration of the simulation loop). During the simulation of Participant 1's data, the simulation's maximum KTR was 1.74 taps per second (tps) on the down- and 1.83 tps on the up-arrow key (converting from tpm to tps here for ease of visualization). For the simulation of Participant 6's data, these values were respectively 3.25 and 2.93 tps. The maximum obtained KTR on either key during the experiment proper (i.e., from the participants) was 4.62 tps for Participant 1, Text 1 and 7.5 tps for Participant 6, Text 6 (with respective median rates of 1.18 and 5 tps for both keys combined). What this means, in short, is that the simulation never tapped the keys at a rate greater than the participants. For this reason, it was not necessary to include a tap-rate limit in the simulation.

Figure 29 compares the data from Participant 1, Text 1 (top plot) with a simulation run using the same disturbance pattern (bottom plot).

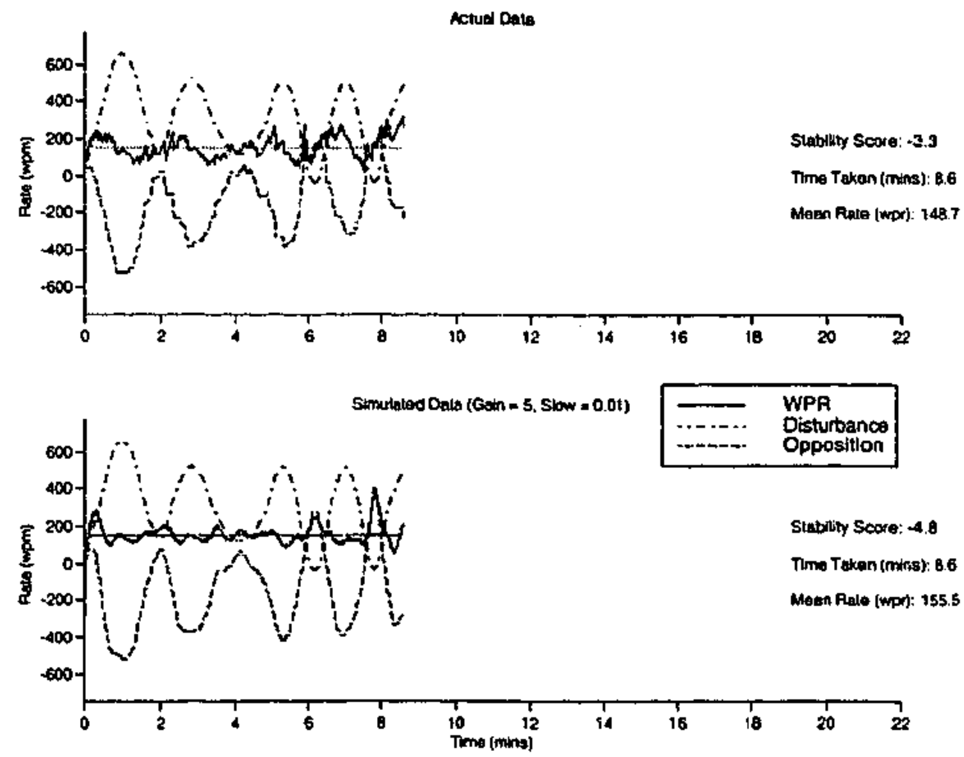

Figure 29: Actual rate, disturbance, and opposition variables during Text 1 for Participant 1 (top plate) and for a computer simulation of Participant 1's opposition during this text (bottom plate). Other details as in Figure 25.

Using a gain parameter of 5 and a slow of 0.01, the correlation between Participant 1's actual and simulated opposition was r = .941. Although high, there were at least two limiting factors. First was the tendency of the simulation to lose control during high rates of change in the disturbance variable. This occurred during the final two troughs in the disturbance pattern. Increasing the gain (also increasing the slow) would curb this out-of-control behaviour, but would improve control during the remainder of the condition to an extent where the closeness of fit was decreased rather than increased. Second was that although the simulation was programmed to control for a rate of 148.7 (the mean WPR of the actual data), Participant 1 tended to let the disturbance drive WPR above or below this mean value and then oppose it. In other words, Participant 1 acted in accord with a changing reference value whereas the simulation's reference value was held constant.

Figure 30 compares the data from Participant 6, Text 6 (top plot), with a simulation run using the same disturbance pattern (bottom plot). The correlation between the actual and simulated opposition variables was r = .994. In other words, the simulation reproduces Participant 6's molar pattern of key taps with an extraordinary accuracy for this kind of model.

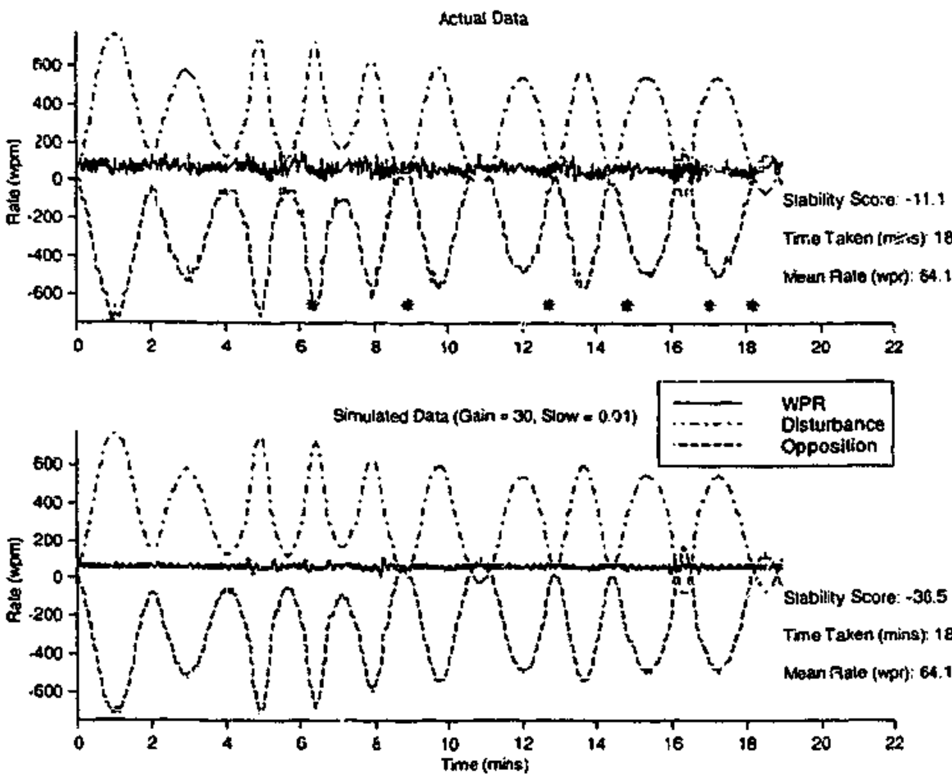

Figure 30: Actual rate, disturbance, and opposition variables during Text 6 for Participant 6 (top plate) and for a computer simulation of Participant 6's opposition during this text (bottom plate). Other details as in Figure 25.

Again, despite the similarity between actual and simulated changes to opposition, the actual and simulated WPR are easily distinguished. A more molecular look at Participant 6's pattern of key tapping during Text 6 revealed that rather than increasing or decreasing the rate of key tapping, he would increase or decrease the rate and length of *bursts* of tapping. During these bursts the inter-tap interval was usually a little under a quarter of a second, and the number of taps in each burst was usually in the range of 3 to 6. Another difference between the participant and the model is that the model altered key-tapping rate in response to *any* change in the error variable. An error of 0.01 wpm would change the rate at which key taps occurred, whereas the participants were probably unable to detect such small deviations. For participants, there was in effect a dead band of difference inside which error was not perceived. Although it would be possible to modify the simulation to produce more similar patternings, this is beyond the present scope of merely evaluating the degree to which the PCT model produces near-identical patterns of opposition. For present purposes, the point of diminishing returns was considered met.

Discussion

This study had university students read continuous prose text one-word-at-a-time from a computer monitor. Word presentation rate (WPR) was a continuous mutual function of a pre-arranged computer disturbance and participant's depressions of speed and slow keys. The main finding was that participants controlled reading rate. WPR was expected and observed to be a controlled variable - with disturbances cancelled out by appropriate key taps and holds. Participants displayed smoothly patterned opposition to a rhythmical, sine-based disturbance without reporting awareness of this underlying pattern (except for Participant 3).

Superior rate regulation was expected in control-rate-only conditions (where participants were explicitly instructed to focus on maintaining WPR constant) relative to read conditions (where participants controlled WPR only in order to complete the task of reading and comprehending the text in order to complete a summary). This prediction was also confirmed in the data, supporting previous studies showing the effects of different instructions on reading dynamics (e.g., Aaronson & Scarborough, 1976). This finding also contributes to the literature on nested means-ends relations in behaviour (e.g., Powers, 1973, p. 52). When reading, participants were controlling rate as a means to the higher-order end of comprehending the text. This meant that disturbances to WPR needed to be countered only if they disrupted that higher-order end. A change in WPR from 100 to 120 wpm might not impede the task of reading-with-comprehension. It would, however, impede the task of maintaining-a-constant-WPR.

The present SVPT format suggests different ways of investigating hierarchies of means-ends relations within reading. One example would be to prepare texts that alternated in difficulty every hundred words or so. For a easy text, the second hundred words might be replaced by more difficult synonyms, the next hundred word left untouched, the next hundred words increased in difficulty, and so on. When reading such a text for comprehension, an on-off alternation in average rate would be predicted, given that the more difficult section would have to be read more slowly to maintain a constant level of comprehension.[72]

This experiment also predicted and obtained a trade-off between amount of control and average WPR (i.e., a negative correlation), which was greater in control-rate-only conditions than read conditions. The better rate-control obtained at lower WPRs can be likened to trying to maintain the speed of a car without a speedometer, where it is easier to detect a difference between 5 and ten kilometres per hour than 100 and 105 kilometres per hour. Another consideration is that participants used several strategies to maintain WPR constant. These included counting and tapping in time with the words. It is possible that such strategies are likely to engender superior control when the rate is closer as opposed to high – above a WPR of 60 – or counting in seconds.

Although no predictions were made about the difference between tap and hold conditions, the result was retrospectively surprising. Control was higher in hold as opposed to tap conditions. This outcome is counterintuitive because the tap conditions technically enabled superior control over WPR (rather than a limit of three-taps per second in hold conditions). This fact was expressly mentioned by five of the six participants who spontaneously cited it as the reason they much preferred tap conditions. One reason for this finding might be that during the tap conditions, participants waited for a perceived difference between actual and optimal WPR, then tapped the appropriate key until this difference was perceived to have been eliminated, stopped tapping, and so on. In the hold conditions, however, it is possible that participants were holding

[72] Thanks to Rick Marken (personal communication, August 2001) for this suggestion.

down the appropriate key in such a way to approximately cancel out the disturbance in a continuous fashion. Another contributor might have been the effect of time needed to learn the task during the first two conditions (which were tap conditions) and a fatigue or boredom factor during the last two conditions (which were tap conditions). This finding has implications for future self-paced SVPT research. It suggests that if a key-depression format is used, that the hold format is possibly the better option (if anything it improves control, not to mention requiring less effort). Future SVPT research should also further explore the use of computer mice (e.g., Muter et al., 1988) or paddles (e.g., Chen & Chan, 1990) to affect the opposition variable in a more continuous way than the present key tap/hold format. It would be interesting to evaluate the Muter et al. (1988) reported finding that "...mouse control over speed produced no better performance than keyboard control..." (p. 481) when performance is defined as momentary rate control (as in the present study) rather than merely average speed and comprehension (as in Muter et al's work).

In accord with the high preference for completion meters reported in Rahman and Muter (1999), it was expected that participants would regularly obtain visual access to the completion meter by depressing the space key. This did happen, confirming the present observing-response technique as a way to record participant's visual access of the completion meter, while providing otherwise absent information to participants about their progress through the text. Completion meters ameliorate one of the main differences between SVPT and normal page reading: in normal page reading the reader has continuous access to the text read and the proportion of text remaining on the page (in the periphery of the words being fixated). An interesting related finding was the lack of any necessary correspondence between whether participants accessed the completion meter and whether they said they accessed it. This finding suggests that future SPVT research would do well to incorporate more objective measures on top of subjective post-session preferences. A correspondence between what participants do and what they say they did should not merely be assumed.

The present task was based on principles from Powers' perceptual control theory. This suggested that a working real-time simulation of the data should be constructible from the basic PCT model, which was developed in reference to just this sort of task. As explained by Bourbon and Powers (1993) "simulation of a well-posed model rigorously tests one's presumed knowledge of the causal principles at work in behavior" (p. 51). The success of the simulations in modelling changes to opposition (i.e., key tap patterns) supports Powers' control theory interpretation of behaviour as closed negative feedback loops (which he calls *control systems*). The PCT-based model appears to portray accurately the basic functional relations operating between the task components. As explained earlier, the simulation acted to eliminate perceived difference between actual and reference values of WPR. One important task for future research is the integration of continuous variable control-theory based models with the more discrete variable models and tasks of the experimental analysis of behaviour. Kemp and Eckerman's (2001) in-situ testbed suggests a possible medium of integration likely to be more productive than past exchanges between behaviour analysts and perceptual control theorists (see e.g., Powers, 1989, pp. 79-87, for such an exchange). Baum (e.g., 1989) and others have already laid the groundwork for more fully incorporating into behaviour analysis the loop-closing fact that although behaviour is a function of the environment, the environment is simultaneously a function of behaviour.

This experiment used a form of comprehension assessment unique to SVPT studies, which have usually relied on multi-choice questionnaires. The alternative used here was a two-minute casual summary, which appeared to ensure that reading was going on, but not without limitations: The two-minute time limit, which was in part selected to remind participants that nothing but a casual, short summary was required (as opposed to sort of formal 'test' of their ability), may have actually made the summary more 'test-like.' This was evidenced not only in participant reports but also in participants often being cut off mid word or sentence at the two minute cut-off. Increasing the time limit to three or four minutes is advised for future research on this comprehension method. A related problem was the expectation that the two-minute summary comprehension format would result in more normal, everyday reading than the conventional multi-choice question format. The reasoning was as follows: If participants expect a set of unknown (multi-choice) questions at the end of the text, they are less likely to relax, and read relatively normally, than if they expect to complete a casual two-minute summary of what they have read. Participant reports made it uncertain whether this reasoning was accurate. Future research could clarify this matter by directly comparing the two-minute summary and the multi-choice formats for comprehension assessment. A final limitation was that whereas the two-minute summary format did obtain information and understanding inaccessible by multi-choice questionnaires, there was no obvious method of quantitatively assessing the written summaries (e.g., assigning a score out of ten for overall comprehension). One option might be to have several people independently read the original texts along with the summaries and rate each one on different scales.

The present combination of SVPT and control theory has implications for future research on the reading of continuous prose. The technique's primary advantage is easily enabling reader *and* experimenter control of rate. Such mutual control is difficult and perhaps impossible to achieve in normal page reading (even with use of eye tracking technology), where experimenters have no control over the rate with which successive words are fixated.

To conclude, the present research supports the usefulness of a control-theory approach to the experimental domain of SVPT reading. It also suggests possibilities for mutually fruitful interchange between control theorists and behaviour analysts.

Attachment A

Spoken Instructions:

"Several short stories will be presented on the computer screen one word at a time. The words will appear at the same place in the middle of the screen. You are free to change the speed as often as you like, and the speed will also change by itself. On some stories you will be required to read the words, and on other stories you will only be required to keep the speed at which words appear constant. Read the instructions presented before each story carefully to be sure what it is you are required to be doing. After stories you are required to read, you will be asked to write a brief summary of what you have read, much as if you were summarising a magazine article for a friend in a casual conversation. You will have two minutes to summarise each story. After stories where you are required only to maintain the words at a constant speed, there will be no summary. Finally, remember that you can press the space bar at any time to find out how much you have read and how far you have to go. Please keep following the computer prompts until the computer tells you to come and get me."

Attachment B

Post-session questionnaire:

(1) Did you prefer it when you had to tap the arrow keys or when you had to press and hold the arrow keys?

(2) Did you have any problems remembering when to tap and when to press and hold?

(3) Did it ever feel like you had to tap or press and hold the keys in any particular pattern? If yes, what kind of pattern?

(4) Did you prefer it when you had to read the stories or when you had to keep the speed at which they appeared constant?

(5) Did you have any problems remembering when to read and when to keep the speed the same?

(6) Did you use any tricks, such as tapping your foot, to keep the same speed?

(7) How helpful was the bar that showed how much you had read?

(8) Did you ever lose control of the speed?

Attachment C

Matlab code used to test the simulation before direct conversion to futureBasic III. Comments follow % symbols:

```
for iterationCounter = 1:length(disturbanceGrid)
```

%Where each iteration corresponds to 1/10 second. The disturbanceGrid data files can be obtained on request from the author via email.

```
disturbance = disturbanceGrid(iterationCounter);
WPR = opposition + disturbance;
error = reference - WPR;

if WPR < 150
   KTR = KTR + (slow*(gain * (error/15)-KTR)*(1/10));
elseif WPR >= 150
   KTR = KTR + (slow*(gain * (error/(WPR*.1))-KTR)*(1/10));
end

iti = 1/KTR; % Convert KTR to intertap interval in seconds.

if iterationCounter > timeofLastPress + abs(iti)
   if iti > 0
            if WPR < 150
            opposition = opposition + 15;
            elseif WPR >= 150
            opposition = opposition + WPR *.1;
            end
   elseif iti < 0
            if WPR < 150
            opposition = opposition - 15;
            elseif WPR >= 150
            opposition = opposition - WPR *.1;
            end
   end
   timeofLastPress = iterationCounter;
 end
end
```

APPENDIX C: A SAMPLE OF UNMODIFIED DATA

21-row sample of data exactly as it was written to file by the computer during the experiment described in Appendix B. Unmodified version of contents of Table 2.

Column Number	Description of Contents
1	Change tag (1 = word update, 2 = key depression, 3 = key release)
2	Object changed (0 = viewing window, 30 = up-key, 31 = down-key)
3	Time in ticks (1 tick = 1 second/60) since session commencement
4	Word presentation rate (words per minute)
5	Disturbance (words per minute)
6	Opposition (words per minute)
7	Word duration (milliseconds)
8	Ordinal position of word in text
9	Word length in characters
10	Text number
11	Completion meter visible? (0 = no, 1 = yes)

1	2	3	4	5	6	7	8	9	10	11
1	0	355574	62.94	-27.063	90	953	723	5	6	0
1	0	355633	62.05	-27.949	90	967	724	4	6	0
2	30	355662	61.81	-28.193	105	971	724	4	6	0
3	30	355669	76.77	-28.229	105	782	724	4	6	0
2	30	355675	76.75	-28.254	120	782	724	4	6	0
1	0	355675	91.75	-28.254	120	654	725	5	6	0
3	30	355680	91.73	-28.27	120	654	725	5	6	0
2	30	355685	91.72	-28.282	135	654	725	5	6	0
3	30	355689	106.71	-28.289	135	562	725	5	6	0
2	30	355695	106.71	-28.294	150	562	725	5	6	0
3	30	355700	121.71	-28.293	150	493	725	5	6	0
1	0	355706	121.71	-28.289	150	493	726	2	6	0
1	0	355736	121.83	-28.172	150	492	727	5	6	0
2	31	355750	121.93	-28.068	135	492	727	5	6	0
3	31	355756	106.99	-28.014	135	561	727	5	6	0
2	31	355762	107.05	-27.954	120	561	727	5	6	0
3	31	355768	92.11	-27.888	120	651	727	5	6	0
1	0	355776	92.2	-27.804	120	651	728	7	6	0
1	0	355815	92.83	-27.17	120	646	729	4	6	0
2	31	355832	93.18	-26.822	105	644	729	4	6	0
3	31	355838	78.31	-26.689	105	766	729	4	6	0

Glossary of Key Words

Autonomy: Self-governance, inverse of heteronomy in Angyal (1941, see Chapter 5, p. 71).

Aspect: Component of a full situation or system knowable only as a component of that system.

Behaviour: Organic-environmental process; transdermal aspect of bioprocess. Can be analysed into patternings of dependencies between instances of different deed subclasses.

Behaviour Segment: Kantor's proposed psychological unit, involving the simultaneous contribution of an act of an organism, a stimulus object, contact media, interbehavioral history, and setting factors (see p. 9).

Behavioural Superfice: A name of "...the boundaries of any area in which organism-environment adjustments of the behavioral type are in progress" (A. F. Bentley, 1941c, p. 15). (see p. 86)

Bioprocess: A name designating a life-in-process only *within which* organism and environment are distinguishable (but not separable) as functionally defined complements.

Biosphere: A name Angyal used to designate the biological total process (i.e., the bioprocess).

Change: An instance of becoming different in the sense of meeting a stipulated criterion.

Characterize/Characterization: Designation in middle ranges of accuracy. Above cue and below specification. Inclusive of most everyday speech and dictionary definitions.

Consensible: A word used by Ziman (1978) to designate observations available to everyone, or observations that are public in the sense of remaining the same across different observers.

Contributor: Aspect *without which* a change *would not* have occurred ("X contributes to Y" is synonymous with "Y is dependent on X"). Similar to but more inclusive than *participating factor* (see Footnote 12 on p. 12).

Control System: Powers' proposed psychological unit, consisting of a negative feedback organization between a perceived, a reference, and an opposition variable (see page 37).

Cue: Least accurate (and most vague) grade of designation. Below characterization and specification.

Data: Records of the particulars observed during an experiment.

Deed: Originally (after Lee), a moment of a stipulated difference (i.e., a change) in the state of an object, surface, or medium contributed to by the physical efforts of at least one organism among many other contributors. Refined in Part 3 to include any change analysed within behaviour (i.e., within bioprocess).

Dependency: A relation between two things such that one thing would not have occurred without the other. To say X is dependent on Y is to say that Y contributes to X.

Designate/Designation: "To mark or point out; indication of a particular thing by gesture, words, or recognizable signs" (OED). Includes cue, characterization, and specification as its respective gradations of increasing accuracy/decreasing vagueness. Synonym of *name*.

Distinguish: To make different from a background.

Environment: 1: the medium through and by which a bioprocess goes on (from Dewey); 2: the heteronomously inclined phases of a bioprocess (Angyal). Not to be conflated with *surrounding world.*

Event: A change.

Heteronomy: Foreign-governance, inverse of autonomy for Angyal (1941, see also p. 71 of Chapter 5).

Morphological conception of organism: A postulate that (a) distinguishes an organism from a background at the skin of the organism's body, and (b) equates that background with the organism's environment.

Name: See designate/designation.

Negative feedback: a self-corrective organization in which "differences can be used to stimulate that which will make them not different" (Bateson). See page 96.

Operant: Skinner's proposed unit, a class of behavioural responses defined by a common environmental effect (see p. 20).

Organ: A tool, instrument, or functional component of a greater whole.

Organism: Process, act, or outcome of organizing; organization; one primary phase of a bioprocess (the other primary phase being environment). Not to be confused with organism's body.

Organize: To make into an organ.

Outcome: A change contributed to. To say Y is an outcome of X is to say that X contributes to Y, which is to say that Y is dependent on X.

Postulate (as noun): Something taken for granted as the true basis for reasoning or belief. A fixed, unquestionable assumption.

Postulation: A condition required for further operations, primarily observation. A provisional, working hypothesis.

Specify/Specification: Most accurate grade of designation. Above cue and characterization (see p. 6 & p. 54).

Subject matter: What is observed in a given inquiry.

Superfice: See *behavioural superfice*.

Surrounding World: That part of the world something distinguished is made different from; background. Not to be conflated with *environment*.

Transdermal: A name Bentley (1941c) used to designate any process occupying a region "...literally wider than any region enclosed by the skin" (p. 8).

Unit: "a single individual or thing ...; one of the separate parts ... of which a complex whole ... is composed or into which it may be analysed" (OED).

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