

The Gulf between Behavioural Psychology and Fundamental Physiology: a systematic attempt to bridge the gap

Monograph 15: Brunel University, Institute of Cybernetics, UK.
April 1976

Robert R. Traill

email: rtrail4@dodo.com.au — *Tel.* (61)-3-9598-9239

republished online by: Ondwelle Publications, 29 Arkaringa Cres., Black Rock 3193, Vic., Australia
April 2007 (b)

and also by: Brunel University Research Archive (BURA).

© Copyright R.R.Traill, 1976, 2007.

Users are permitted to use this article for single-copy non-commercial purposes provided that the original authorship is properly and fully attributed to both author and publisher.

If an article is subsequently reproduced or disseminated not in its entirety but only in part
or as a derivative work, this must be clearly indicated.

For commercial or multi-copy permissions, please contact Copyright Agency Limited:

Contact details for Copyright Agency Limited (CAL):
email: info@copyright.com.au ;
Tel.: +61 2 9394 7600; *Fax:* +61 2 9394 7601;
Address: Level 19, 157 Liverpool Street, Sydney, NSW 2000, Australia.

This paper is part of a project to find *sound biological explanations for human mental abilities*. The project soon split into two streams: .

STREAM 1 focussed on realistic *coding-mechanisms for memory* — an area in which lab-work can only scratch the surface, hence rigorous interdisciplinary theory was invoked instead. This led to strong suggestions implicating *molecular coding* — ideas consistent with the theories of *Piaget* and *W.R.Ashby*.

STREAM 2 emerged as the parallel problem of *intercommunication* — but it's solutions then unexpectedly also offered explanations to other "unrelated" problems! (Moreover, lab-testing of *these Stream 2 ideas* is much more feasible, so we might now hope for such future investigations).

A summary of the whole project is now available:

<http://www.ondwelle.com/OSM12.pdf> . 1-1-10

The occasional changes made in this 24 April 2007 edition are either (i) obvious from dates or technology changes etc., notably updating references and links &/or (ii) within square brackets "[...]", &/or (iii) any footnote, &/or (iv) trivial editing, — and (v) All subheadings are newly inserted. (27 & 29/4/07 — some further minor adjustments, in dark-blue). **2-Jan-2010: Fixed an error in copy-from-original, in Fig.(iv), see note.**

CONTENTS

Title Page	1
Preface to this 2007 online edition	2
<i>The Gulf between Behavioural Psychology and Fundamental Physiology: ... —</i>	4
The interdisciplinary approach — microstructure — and theory	4
The Ultra-micro column in Fig.(i) — molecules, quanta, myelin, and infra-red:	6
The merely Micro. — Feasible mechanisms for Piagetian “schemes”	8
A Darwinian sub-mechanism?	9
The Dependent Macro Phenomena	10
REFERENCES, Old & New — (Originals of 1976 are marked “→”)	11

Preface to this 2007 online edition

This paper had first set out to **summarize** previous work on the search for feasible mechanisms which might explain real psychology and intelligence — using interdisciplinary insights in an effort to get beyond apparent log-jams in theoretical progress. (The works in question were the first five Traill-papers listed within the *references section* below). The main tentative conclusion was that, *in addition to the accepted synaptic memory-record*, there must also be some more-discrete (more “digital”) form of *linear one-dimensional* coding for some types of memory-plus-thought; and if so, then linear molecules *like RNA-or-protein* seemed the best candidates.^A

However that molecular-code conclusion raised a **new compatibility problem** for internal signals — a problem akin to expecting a whale-to-ant conversation! Thus, how could the well-known *millisecond* action-potentials “talk efficiently” to discrete molecular sites whose quantum activity is likely to be measured in time-units of about 10^{-13} *sec?* — *I.e.* 1/10000 of a nanosecond, and hence 10^{10} times faster! — “A Morse-key talking to Broadband”?!

Thus it seems that if molecular sites really are code-carrying, we should expect *most of their own intercommunication* to use something more compatible to their own private dynamics (at least for the short distances “talking across the campus” between neighbouring molecules); — and it turns out that specialized short-range Infra-Red appears as a plausible candidate for this role, offering the new alternative possibility of what we may thus call the “[**R**]” system of intercommunication.^B

Meanwhile there would obviously still be a place for what I sometimes call the “[**A**]”-system — the Action-potential and its much-discussed synapse-configurations. However if there are to be two systems, then we might expect some division of labour, and arguably [**A**]’s key roles would be as part of a specialized language used *more for dealing with the outside world, or re-assessing triage-weightings*, etc.

^A Note that here the logic depends on *structure-and-dynamics* ideas from **Psychology** and **Information-Technology**; — see www.ondwelle.com/OSM02.pdf (Traill, 2005b) for details of this argument. Other theorists had reached similar conclusions (piecemeal), *but via quite different reasoning* based on **Biochemistry**-related disciplines. These other accounts encountered significant criticism from Steven Rose and other opponents — e.g. see Traill (2007: www.ondwelle.com/OSM07.pdf), and that first round of macromolecule-explanations had largely fallen from grace by about 1990, apparently due to their lack of overall coherence, and/or their lack of suggested logistical detail.

^B This association with Infra-Red is actually a *deduced* property (but more relevant to the immediate discussion here). The actual defining property of this hypothesized “[**R**]” system relates to it as depending on “RNA-like” linear strings of coding, though not necessarily RNA itself. (Traill, 1999, Appendix C, pp.76-77: www.ondwelle.com/BK0_MU6.PDF)

Meanwhile that could allow some delegating of internal intelligence-thought to the “[R]”-system with its likely capacity for faster mind-language, and for sharply-defined digital distinctions (problems of cognitive psychology), whereas [A] seems more obviously an issue for physiology outside the mind proper.

Feasibility of infra-red intercommunications?

So secondly this paper launched a digression into these new parallel lines of enquiry, dealing with new complications and opportunities which might be offered by nature’s own **infra-red broadband** if it exists:

This development was helped considerably by realizing (i) that myelinated nerve-fibres are essentially coaxial cables, and (ii) that coaxial cables operate much more efficiently at those high frequencies for which the wavelength is roughly the same size as the diameter of the cable. In fact it turns out that infra-red does tend to bear this relationship to axon size, so this suggested further investigation. (Although at a different scale, similar unexpected developments had evolved during the 1870s and 80s concerning the understanding of trans-Atlantic cables, and how much more efficient they could be if Radio^C-Frequencies were used).

Subsequently I have found it possible and useful to develop this idea further — sometimes in surprising ways, *e.g.* offering answers to questions which had not even been asked yet. Such later works include:

(1977/1980). Brunel Monograph 24 / Thesis, Part B (1978). www.ondwelle.com/MolecMemIR.pdf

(1988). “The case that mammalian intelligence is based on sub-molecular coding and fibre-optic capabilities of myelinated nerve axons”, *Speculations in Science and Technology*, **11**(3), 173-181.

(1999). Book A: *Mind and Micro-mechanism*, Chapters 3 and 7: www.ondwelle.com/BK0_MU6.PDF

(2000). Book B: *Physics and Philosophy of the Mind*, Part II: www.ondwelle.com/BK1_V28.PDF

(2005a). *Strange regularities in the geometry of myelin nerve-insulation*. www.ondwelle.com/OSM01.pdf

Parallel developments for Piagetian Psychology

While the above infra-red theory branched off on its own semi-autonomous path, the original task of exploring the more-obvious implications of string-like memory-embodiment also continued — in parallel. Here it will probably suffice to mention (i) the early collection in Brunel Monograph 18, (for which this present paper could chronologically have been “Chapter IV½”, at the time of the split into two streams); (ii) *Thesis, Part C* (1978): as 5 files on the Ondwelle website, or as a single 203p file on the BURA website; (iii) §5.4–5.6 (pp.34-39) in “Book A” (see above), discussing *Mind-theory evolution* in “five rounds”; and (iv) the latest paper specifically on Piagetian submechanisms: www.ondwelle.com/OSM02.pdf (Traill, 2005b).

“Reductionism” and “Mechanistic” — Should these be taboo-words?

To some critics, such approaches are anathema, so in this new edition I have taken some care to re-inspect my earlier use of these words.^D In fact I did also set out to write a lengthy appendix on the matter (partly agreeing with the critics — especially regarding the social sciences — but tending to treat their worries as largely alarmist in the present mind-modelling context). Anyhow this text kept expanding, so it will now be presented as a new separate paper: “*Notes on Reductionism and related matters*” (2007) — www.ondwelle.com/OSM07.pdf

Integrity of the present text

As far as practicable, the present text remains unchanged from the original hard-copy version of 1976. Indicators used to identify any changes are listed at the bottom of the title page. Note particularly that all the subheadings are new, and so are all the footnotes (here using capital letters like this^R — deliberately unusual as a reminder). In the circumstances too, many of the inserted references are to “future” works. Diagrams have been re-drawn in digital form, but they closely follow the originals.

R. R. Traill

Melbourne, 23 April 2007

^C Of course this is modern terminology. The word “radio” did not actually exist then.

In fact the invention of radio-signals arose in 1888 as a “mere byproduct” of this high-frequency cable research!

The Gulf between Behavioural Psychology and Fundamental Physiology: a systematic attempt to bridge the gap

(Paper presented at the Workshop on Memory during the
York conference of the British Psychological Society, April, 1976)

ABSTRACT

Direct experimentation in much of this area is very difficult or impossible. For such circumstances, it is argued that much can be achieved by a rigorous quantitative programme of interdisciplinary theorizing based on available data.

The paper then outlines progress arising from this approach from: (1) a Piagetian view of behaviour, through (2) a model for the “scheme” as a statistical *population* of discrete linear *molecules* (despite Hebb’s synapse suggestions), down to (3) the physics and chemistry of signal emission, transmission and absorption.

The latter analysis yields the surprising suggestion (corroborated by Cope’s work) that a vital frequency-component for neural signals occurs in the infra-red range: about 10^{13} cycles/second. This helps to explain several current mysteries concerning memory.

The interdisciplinary approach — microstructure — and theory

Many of the existing mechanistic or reductionist^D explanations of psychological phenomena seem to centre on too limited a view of what is now known about biological phenomena. Often this takes the form of supposing that some aspects of mental processing “must somehow” act in the same way as *digital computers*; or the emphasis may be laid too heavily on *holograms*, or *cells-as-logic-elements*, or *Skinnerian/Cartesian denial of mental mechanism*, etc.

The present study attempts to “decentre” its approach by the supposedly-fashionable^E technique of using an *interdisciplinary* attack on the problems — enlisting physiology, physics and ultramicro-histology where

^D The original word “**reductionist**” often has unfortunate unintended connotations of *extreme-atomism* — i.e. “*NothingBut-ism*” — the Mrs.Thatcher type of belief that a system is *nothing but* its elemental parts. [See “*Notes on Reductionism and related matters*”, (Traill, 2007: www.ondwelle.com/OSM07.pdf), for more discussion of reductionism as a philosophical issue — though, like me, you might sometimes wonder what all the fuss is about, since substructural possibilities seem fairly obvious].

Koestler (1969) offers the alternative term “*dissection*” instead of “reduction” as a way of avoiding such problems, as discussed in the new preface to my Brunel Monograph 18: www.ondwelle.com/OSM06.pdf pp.4-5, (published online in parallel with the present work). Koestler likewise coins the term “*holon*” for any subsystem which may be seen as both: ● a basic element (when viewed from a comparatively macro level), *and also* ● as a full open system (when viewed from a more micro level). So feel free to cross out “reductionist” and replace it with the word “dissectionist” if you prefer, though that might then begin to look like a surgery lesson! I marginally prefer “substructural analysis”, but the intended idea is the same in each case.

Anyhow note that it *is* important to acknowledge the existence and functioning of parts-within-parts,—within-... (despite what extreme holists may say), but these parts are virtually void of meaning unless participating within the dynamics of the whole system.

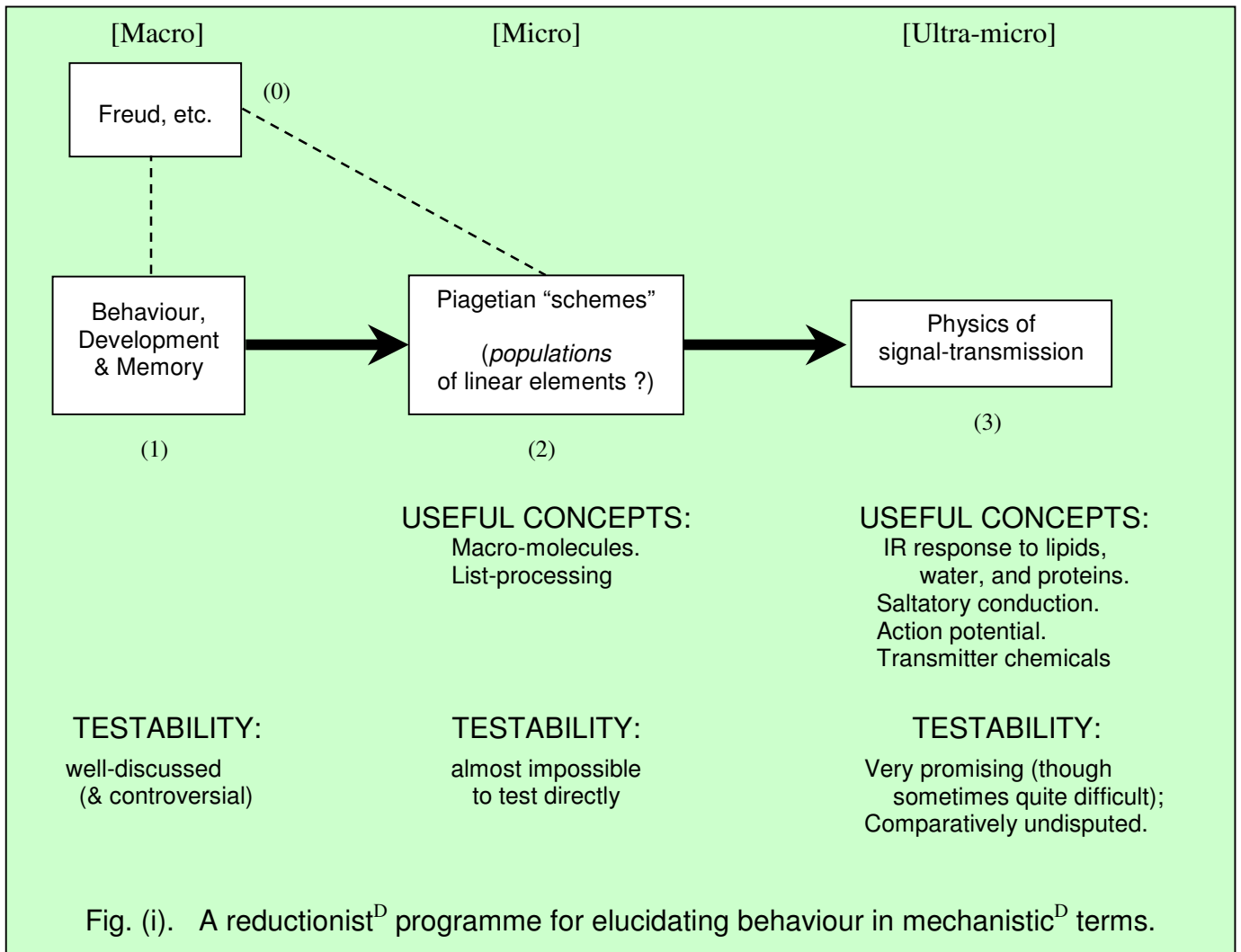
The word “**mechanistic**” is perhaps rather easier to defend (once one accepts hierarchical organization of natural systems, and settled any reductionist issues), since then it is possible to envisage restricting the most-mechanistic behaviour to the lowest-level components — levels often remote from any human interface (just as the most basic computer-coding is many levels away from the “magic” of dynamic screen-displays). Also see the previous paper in this series (Brunel Monograph 12: www.ondwelle.com/OSM04.pdf), where the term is applied.

^E Unfortunately this fashionability does not always translate into practice. After all, specialities are well entrenched, so combining them is not easy. One possible solution is to seek common ground at the ultramicro level; and that is attempted here.

appropriate. The study also uses the rather *less* fashionable procedure of decentering away from orthodox demands for “experimental verifiability *at every stage*” — (which I happen to regard as a very damaging piece of doctrinaire obstruction, of dubious historical validity: but I had better leave this inflammatory issue for subsequent discussion).

There are in fact many situations in which it is simply not possible to do a rigorous experiment — if indeed there is such a thing as a completely rigorous experiment; and if there is not, then where do we draw the line between experiment and theory? [Traill (1976, part II)^F]. Thus the approach in this study has been to look for rigorous coherence or mutual consistency of the interdisciplinary concepts wherever there was a shortage of better evidence. In practice this has meant striving to rid explanations of the word “somehow” and replacing it each time with a further hypothesis which was (hopefully) testable by experiment, or at least by its consistency with such unorthodox but necessary criteria as its wave-theory implications.

In short then, the programme has tried to live up to an ideal of rigorous reductionism^D [substructural analysis].^D The chain of progress in this direction has led (in the sequence 1,2,3 as shown) from the involved total system down toward the supposed fundamental “building elements”. (See fig. (i)).



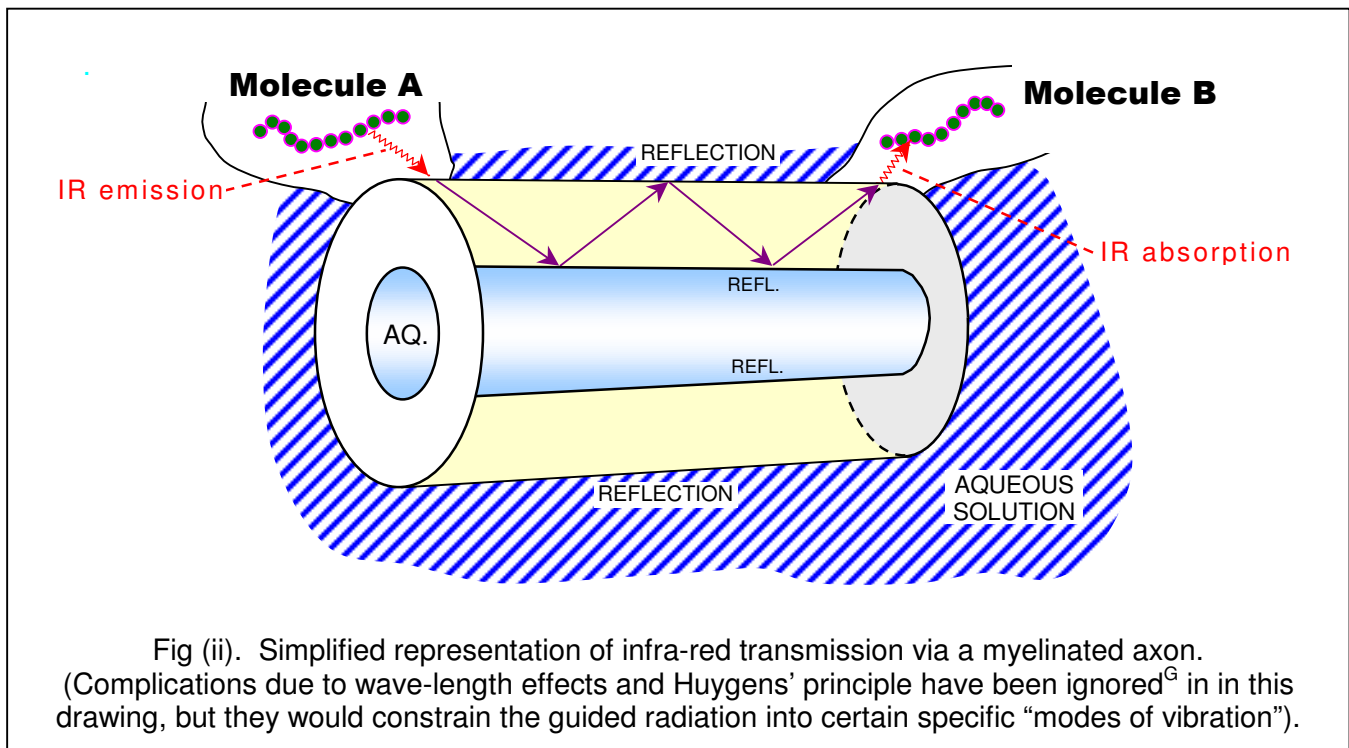
^F *Kybernetes*, 5, 73-82; — now also available as Chapter A2 within www.ondwelle.com/Mol-Intel-A.pdf (2006)

I shall now discuss these stages of the reductionist [substructural analysis]^D process in reverse order — starting with the supposed basic physics of memory storage and transmission.

The Ultra-micro column in Fig.(i) — molecules, quanta, myelin, and infra-red:

At least some memory must involve chemical encodings in molecules (whether singly or en masse); and the most plausible “language” for signal transmission between remote molecules consists of electromagnetic emission and absorption in the infra-red range of frequencies. At first sight there appear to be two serious objections to infra-red as a message-carrier, and I will return to these objections shortly; but let us first list some of the other supporting evidence and implications.

Firstly a close mathematical examination of “saltatory conduction” of nerve signals across myelin-insulated nerve-fibres in the vertebrates shows that such *co-axial cables* almost seem to be designed for the convenience of signals having carrier-frequencies in the infrared range. Moreover I was interested to discover a prior paper by F.W.Cope (1973) arguing the case for slightly-higher frequency infrared transmission in *unmyelinated* axon-membranes, and the *storage* of such infra-red as standing-waves in mitochondrial lipid membranes. This would appear to be useful confirmation because Cope started from rather different premises (involving redox potentials and energy transduction).



^G Cf. Traill (1977/1978/1980/2006; fig.4/1) *Thesis, Part B*: www.ondwelle.com/MolecMemIR.pdf — or almost-any standard engineering textbook on coaxial cable transmission.

This infra-red hypothesis appears to offer solutions to a number of current problems, of which I will itemize four briefly:

Fig (iii). PROBLEMS FOR WHICH THE INFRA-RED HYPOTHESIS OFFERS SOME SOLUTION

- (A). Inadequate *information-capacity* of postulated mental *holograms* (assumed to use audio-frequencies). (Pribram, 1971, p.165).
- (B). The need for “a *stable periodic source* of excitation” if hologram-memory is to be feasible. (Willshaw et al. (1970), quoted by Pribram).
- (C). If *glial cells* are involved in memory, how could they be accessed through the myelin “barrier”? (Whereas now some will be seen to be ideally situated).
- (D). What is the actual *mechanism of transmitter* substances like Acetyl-Choline, Nor-adrenaline, and 5HT? *Part of their action may be optical.*

As for the objections; the first is the prevailing stress laid on the importance of action-potential “spikes” in physiology (involving frequency components of roughly 1000 cycles per second) and of EEG potentials (about 10 cycles/sec.). I would simply say that these are useful-but-*gross* statistical manifestations of what is going on at the molecular level — just as government economic statistics (important though they may be) give only a vague generalized view of what is happening to individual people within the economy. Moreover, every radio-set depends on the superposition of two vastly different frequency bands, of which the higher frequency is more truly the one “transmitted”; so why not accept the same principle as a possibility for biological systems?^H

The second objection is that water is a very drastic absorber for most frequencies in the infra-red range, so how is it that the signals escape annihilation at the “reflecting” walls of the myelin wave guide? There are at least three possible solutions to this difficulty, but the most plausible of them is given by Cope in terms of an electrically conducting protein layer at the water-lipid interface. Cope even suggests that this protein (cytochrome oxidase) may be superconducting — thus providing an “ideal metallic” type of reflection, for infra-red at least.^I

^H I did not subsequently pursue this “*envelope*”-*model* of the action-potential (though it might still be useful to do so). Instead I was more interested in infra-red emission as a codeable medium *in its own right* — as a tool in a *second* mental network (more molecule-based, and more concerned with actual intelligence, as discussed below).

^I A much more thorough treatment of the *general* two-media case was given, in German, at about the time of World-War I (Hondros, 1909; Hondros and Debye, 1910; Zahn 1915, 1916 and Schriever, 1920) — based on earlier work by Poynting (1885), Heaviside (1885, 1887), J.J.Thomson (1893), and Sommerfeld (1899), as discussed more fully in Traill (2005a, §3.4). In this, their *general* case, each of the two media could be a conductor, OR an insulator, OR *anything in between* (if one is not too worried about resistance-attenuation)! Of course we traditionally assume that the centre “wire” is a conductor while its coating is an insulator; but they generalized from that, laying the basis for later fibre-optics. Meanwhile Southworth (1936) re-specialized by reversing the original assumptions: putting the insulator (usually air) in the centre of a carefully-shaped *metal pipe* — suitable for microwave-transmission.

In our present context, Cope was essentially suggesting a third thin medium-layer between the other two — a situation like the one discussed by Heaviside (May 1886). I now doubt whether this could play any key role, even if Cope was qualitatively correct — if only because of the quantum tunnelling through any such layer.

However it might help to define boundary conditions within a Hondros/Debye/.../Schriever explanation. RRT, 2007

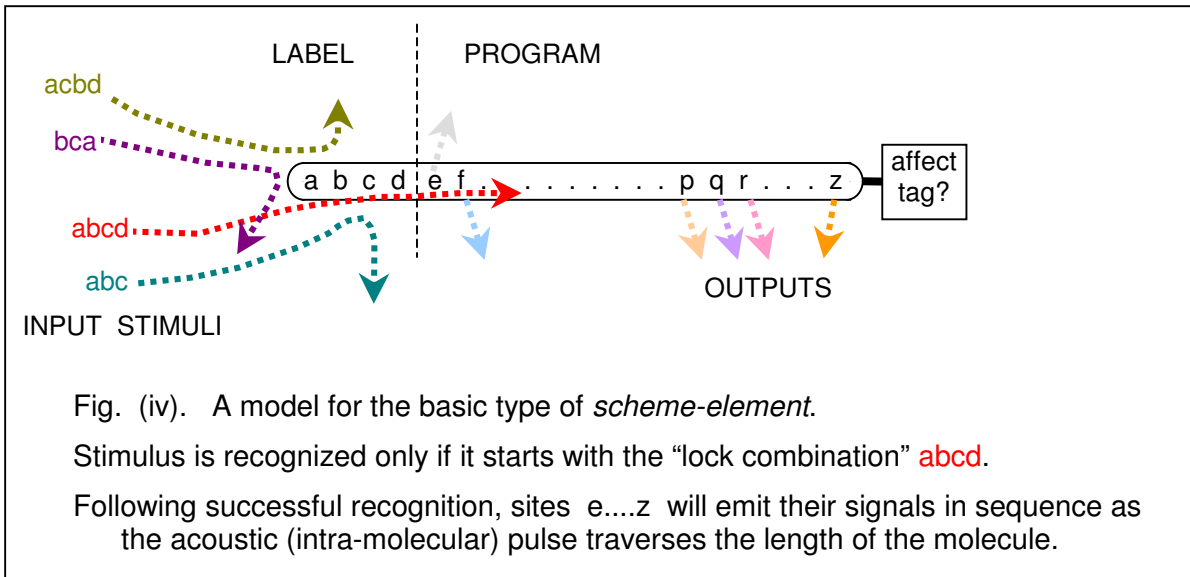
Moreover, in retrospect it is easy to see that a surrounding “insulation” of totally absorbing water may well be *essential* to prevent the indiscriminate spreading of signal leakages — a point which the orthodox explanation for saltatory conduction does not seem to have dealt with adequately.

The merely Micro. — Feasible mechanisms for Piagetian “schemes”

Let us now turn to *Box No. 2* of figure (i) to look at the supposed nature of the molecules which send and receive the messages which we have just been considering. There are a number of possible arrangements for the detail of this model which all appear, at this stage, to be both consistent with behavioural observations, and also apparently dependent on infra-red intercommunication. When discussing such detail I shall therefore confine my account to what currently seems to be the most likely alternative, pending more exhaustive investigation.

I should also mention that I will adopt a *neutral* position on the current “nature-nurture” controversy between (for example) the Oxford-Edinburgh school on the one hand, and the Geneva school on the other. The model I shall outline seems equally capable of accounting for either, or both — including the interesting borderline case of *imprinting*.

The key issue is to postulate a material basis for Piaget’s “scheme” and “schema”. I have previously proposed (Traill 1978 [Kybernetes 7, written 1975]; Traill 1975b [Brunel Monogr.18, Ch.I]) that linear macromolecules, using cross-feed communication to ensure co-ordination (see Monod & Jacob, 1961) might collectively be capable of producing gross behavioural effects in an organized and repeatable way — as required by the “scheme” concept.



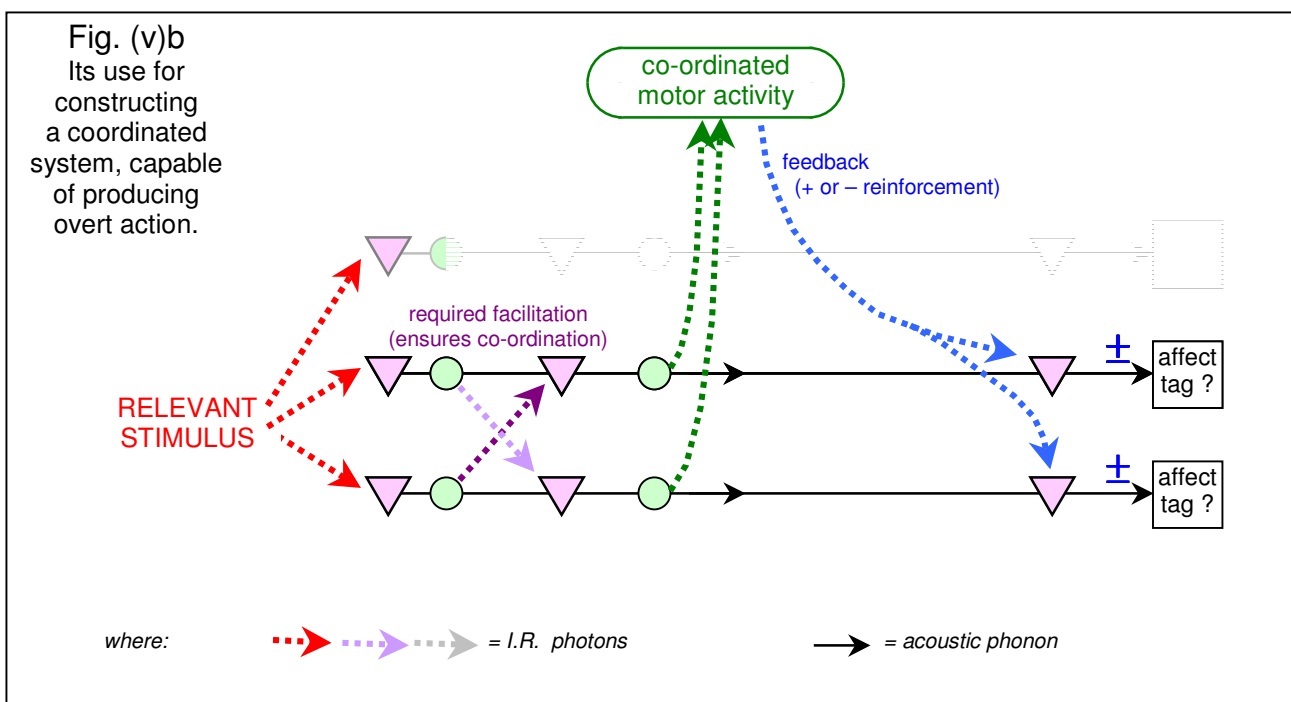
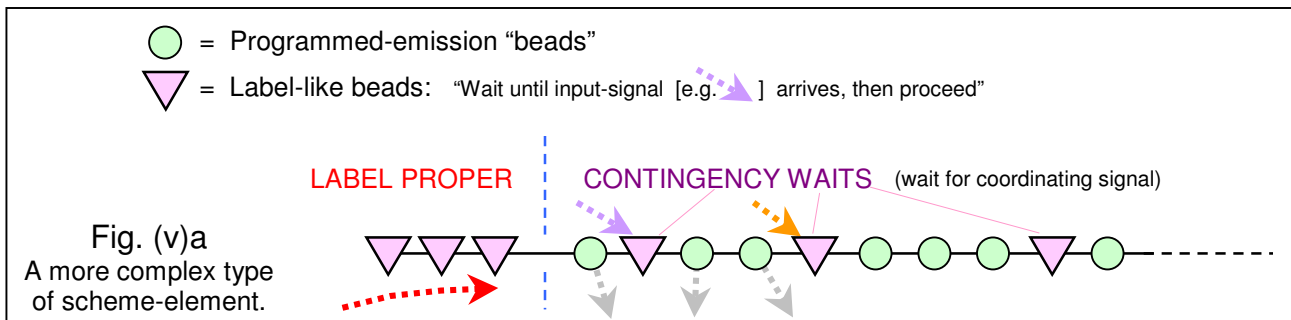
Fixed
2 Jan 2010:

Error in copy
from original:

(The red arrow
abcd
was also
deflected!)

These linear macro-molecules are probably DNA or RNA, though not necessarily so. Anyhow, they are assumed to consist of a series of bead-like sites — each capable of being *either* selectively activated by a highly specific key-like infra-red stimulus; *or else*, having been activated by a vibration phonon from its neighbouring “bead” within the molecule, it would be capable of *emitting* a coded infra-red signal into a neural wave-guide — thus potentially activating other remote sites.

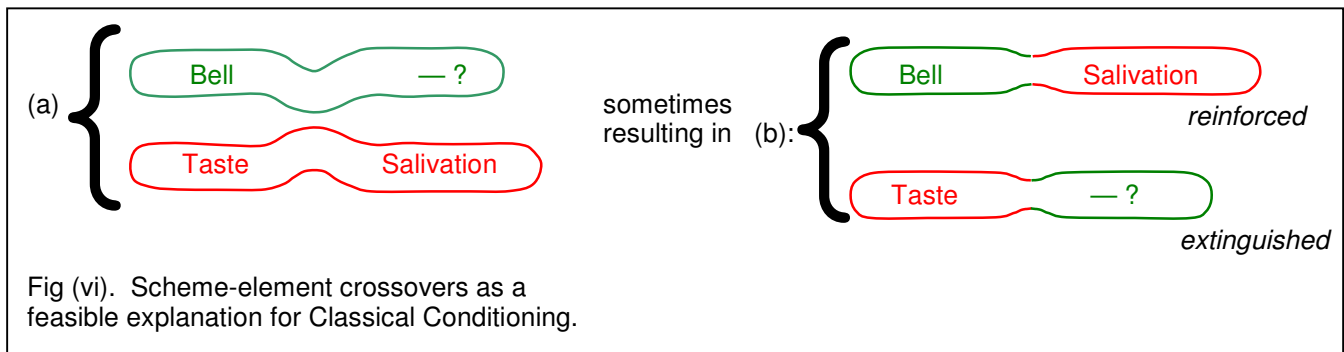
A more general layout for such a molecule is shown in *figure (v)a*. Such an arrangement would enable us to have co-ordinated systems such as that shown in *figure (v)b* :-



It seems quite feasible then to explain *hereditary* schemes as consisting of largish populations of such linear elements, which ultimately derive their pre-set coding from an inherited nuclear DNA-template.

A Darwinian sub-mechanism?

For *learned* behaviour including imprinting, there must be some way of changing such scheme structures *or* generating new ones. I am inclined to the view that such new schemes are *never directly* written as a record of experience — except for changes relating to affect tags and their implied “reinforcement score”. Instead I suggest that many hereditary scheme elements become “mutated” spontaneously — as a miniature version of *evolutionary* trial-and-error: a luxury which becomes feasible if it is undertaken at *molecular level*. I also suggest that when disparate events occur nearly simultaneously, then their respective scheme-elements come to be physically capable of *exchanging* segments, so that after an “evolutionary tidy-up” it may well be that the two original events have become linked mentally — thus offering an explanation for classical conditioning (Traill 1976 [Kybernetes 5]). [See fig.(vi)]



The Dependent Macro Phenomena

Before concluding, I would like to say just a few words about “Box 1” and “Box 0” in *figure (i)*. If we postulate scheme elements which have the special function of *listing* the label signals of other schemes, without necessarily calling them, then we have a physical basis for explaining the mental appreciation of mathematical *sets*, from which it is but a short step to discover equivalent *sequences of action*, thus attaining the concept of “mathematical groups”. On this basis, Piaget’s developmental stages and periods seem to be explicable (Traill (1978 [Kybernetes 7], 1975b [Chapter I, Monogr.18]).

The comparatively rigid and permanent structures developed in this way are identified with Piagetian *schemata*. If we apply these to “Box 0” in *figure (i)*, then there seems some possibility that some of the psychoanalytical concepts such as *ego* and *superego* can be explained in this way ...^J but as that is a major topic in itself, I shall conclude my account at this point.

^J *Ego* and *superego* are later discussed in some detail in *Thesis, Part C, Subsection C6.3* (1978), now available within www.ondwelle.com/Mol-Intel-C6.pdf (Traill, 2006), — plus references: www.ondwelle.com/Mol-Intel-Refs.pdf *Ego* is also extensively discussed regarding its role in explaining *Psychoses*. See Chapter C8 (*ibid.*): www.ondwelle.com/Mol-Intel-C8.pdf — or the larger 203-page file (BURA website) which includes all three.

There are also further details and illustrations, not given elsewhere, in the conference paper (Traill, 1975c): “*Self-construction of Personal Identity: an extension of the mechanistic mental object hypothesis*” — available as Chapter II within “Brunel Cyb. Monograph 18” (1976e/2007c): www.ondwelle.com/OSM06.pdf

REFERENCES, Old & New — (Originals of 1976 are marked “→”)

- Cope, F.W. (1973). “Electron-Phonon (Trapped Photon) coupling and Infra-red coaxial transmission line theory of Energy transport in mitochondria and nerve.” *Bulletin of Mathematical Biology*, **35**, 627-644.
- Heaviside, O., (1885). “On the transmission of energy through wires by the electric current” —*The Electrician*, **14**, 178- (10 Jan 1885). Also in his *Electrical Papers*, **1**, (1892/1970), 434-441.
- Heaviside, O., (1886). “Section XXVI. The transient state in a round wire with a close-fitting tube for the return current”. *The Electrician*, (14 May 1886). Also in his *Electrical Papers*, **2**, (1892/1970), pp.44-50. Chelsea: New York. [The following section (11 June, pp.50-55) is also of interest, though less Cope-related.]
- Heaviside, O., (1887). “The transfer of energy and its application to wires. Energy-current” — *The Electrician*, **19**, 211-. (14 Jan 1887). Also in his *Electrical Papers*, **2**, (1892/1970), 91-97.
- Hebb, D.O. (1949/1964). *The Organization of Behaviour*. Wiley
- Hondros, D., Debye, P., (1910). “Elektromagnetische Wellen an dielektrischen Drähten”. *Annalen der Physik (series 4)*, **32**(8), 465-476.
- Hondros, D., (1909). “Über elektromagnetische Drahtwellen”. *Annalen der Physik (series 4)*, **30**(15), 905-950.
- Koestler A. & J.R.Smythies (1969). *Beyond Reductionism*. Hutchinson: London.
- Koestler, A. (1969). “Beyond atomism and holism — the concept of the holon”; in Koestler & Smythies (opp.cit.); pp.192-232. [ch.7]
- Monod, J. & Jacob, F. (1961). “General conclusions: telenomic mechanisms in cellular metabolism, growth, and differentiation.” *Cold Spring Harbor symposia on quantitative biology*, **26**, 389-401.
- Poynting, J.H., (1885). “The connection between electric current and the electric and magnetic inductions in the surrounding field”. *Trans. Roy. Soc.*, **176**, 277-306. Also in his *Collected Papers*, (1920), Chelsea: New York, Ch.11, pp.194-223.
- Pribram, K.H. (1971). *Languages of the Brain*. Eaglewood Cliffs, N.J. Prentice-Hall.
- Schrieber, O., (1920). “Elektromagnetische Wellen an dielektrischen Drähten”. *Annalen der Physik (series 4)*, **63**(23), 645-673.
- Sommerfeld, A., (1899). “Ueber die Fortpflanzung elektromagnetischer Wellen längs eines Drahtes”. *Annalen der Physik (series 2)*, **67**(2), 233-290.
- Southworth, G.C., (1936). “Hyper-frequency wave guides — general considerations and experimental results”. *Bell System Technical Journal*, **15**(2), 284-309.
- Thomson J.J. (1893). *Notes on Recent Researches in Electricity and Magnetism*. [microfiche].

[The following "Traill" entries are listed in the order written,
rather than by publication date]

- Traill, R.R. (1976 [written early 1975]). "Acquisition of knowledge without transcendental assistance: an extended Piagetian approach". *Kybernetes*, **5**, 73-82.
— www.ondwelle.com/Mol-Intel-A.pdf (Chapters A1 and A2). #4/75
- Traill, R.R. (1975a). "Thinking as mental model-building: a Piagetian-cum-mechanistic explanation of the 'engram'." Monograph 12, Institute of Cybernetics, Brunel University, UK. — www.ondwelle.com/OSM04.pdf #6/75
- Traill, R.R. (1978 [written 1975]). "Analytical theory of sensori-motor spatial development". (Published 1978 as:) *Kybernetes*, **7**, 61-71. — www.ondwelle.com/Mol-Intel-A.pdf (Chapter A3). #7/75
- Traill, R.R. (1975b). *Sensori-motor development of object concepts: a mechanistic hypothesis*. Paper presented at the tenth annual conference of the Australian Psychological Society, La Trobe University, Bundoora 3083; (August 1975). [Also (later) as Traill (1976e)↓, Chapter I.] #11/75
- Traill, R.R. (1975c). *Self-construction of personal identity: an extension of the mechanistic mental object hypothesis*. Paper presented at the tenth annual conference of the Australian Psychological Society, La Trobe University, Bundoora 3083; (August 1975). [Also (later) as Traill (1976e)↓, Chapter II.] #12/75
- Traill, R.R. (1976e). *Short papers and letters on the 'linear micro-element' theory of mental mechanism; and related questions of scientific method*; Monograph 18, Institute of Cybernetics, Brunel University. — www.ondwelle.com/OSM06.pdf [collection]
- Traill, R.R. (1977/1980). *Toward a theoretical explanation of electrochemical interaction in memory use: the postulated role of infra-red components*. Monograph 24, Institute of Cybernetics, Brunel University (1977/1980). Also in *Thesis (opp.cit.:1978)* as "Part B" — www.ondwelle.com/MolecMemIR.pdf #17/75
- Traill, R.R. (1978). *Thesis, Brunel University*. Ondwelle: Melbourne, (see home-page: www.ondwelle.com for the seven-file version, or the BURA website for the two-file version: Part B + All the rest).
- Traill, R.R. (1988). "The case that mammalian intelligence is based on sub-molecular coding and fibre-optic capabilities of myelinated nerve axons", *Speculations in Science and Technology*, **11**(3), 173-181.
- Traill, R.R. (1999). *Mind and Micro-mechanism*. Ondwelle: Melbourne. www.ondwelle.com/BK0_MU6.PDF
- Traill, R.R. (2000). *Physics and Philosophy of the Mind*. Ondwelle: Melbourne. www.ondwelle.com/BK1_V28.PDF
- Traill, R.R. (2005a). *Strange regularities in the geometry of myelin nerve-insulation — a possible single cause*. Ondwelle: Melbourne. — www.ondwelle.com/OSM01.pdf
- Traill, R.R. (2005b). *Thinking by Molecule, Synapse, or both? — From Piaget's Schema, to the selecting/editing of ncRNA*. Ondwelle: Melbourne. — www.ondwelle.com/OSM02.pdf
- Traill, R.R. (2007). *Notes on Reductionism and related matters*. Ondwelle: Melbourne. — www.ondwelle.com/OSM07.pdf
- Wang, Q., J.Khillan, P.Gadue, & K.Nishikura (2000). "Requirement of the RNA editing deaminase ADAR1 gene for embryonic erythropoiesis". *Science*, **290**(5497), 1765-1768.
- Willshaw, D.J., Longuet-Higgins, H.C. & Buneman, O.P. (1970). *Nature*, **225**, 178.
- Zahn, H. (1915). "Über den Nachweis elektromagnetischer Wellen an dielektrischen Drähten. (Vorläufige Mitteilung)". *Physikalische Zeitschrift*, **16**(22), 414-419.
- Zahn, H. (1916). "Über den Nachweis elektromagnetischer Wellen an dielektrischen Drähten". *Annalen der Physik (series 4)*, **49**(8), 907-933.