The answer to William James's Big Question:
What happens in the hemispheres of the brain?

The answer is given in terms of the synapse-state theory of the neural embodiment of mental life.

By this theory mental life is embodied in excitations in a network consisting of neurons, nodes where the neurons meet in large numbers, and synapses whose conductivity for neural excitations change with the excitations themselves in a plastic way. Each pair of nodes is connected through one synapse.

At any moment a certain part of the network is excited, a few nodes –those embodying the momentary attention–excited strongly, a large number weakly. The excitations in the network are in continuous change.

It is shown in the book that this neural activity will account for every feature of mental life:

- The stream of thoughts and feelings, with the ever changing attention and the retention of every item thought of for the duration of the specious present.
- The fringe of thoughts and feelings surrounding every item thought of.
- The experience of sensation by sight, hearing, taste, smell, and touch.
- The perception of familiar things.
- Recall of items thought of before.
- Association of items thought of.
- Imagination.
- Personality and self.
- Muscular action, including control of bodily balance.
- Speech.
- The education of the nervous system starting in the foetus.
- Dreams, hypnotic trance, alternating personalities.

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Peter Naur: The neural embodiment of mental life by the synapse-state theory

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Contents

Preface

The title of this book is meant to be taken literally. By the dictionary, embodiment means the act of embodying, and embody means to provide with a body; incarnate; make corporeal. Mental means: of or pertaining to the mind, and mind is explained as the element, part, substance, or process that reasons, thinks, feels, wills, perceives, judges, etc. This will here be taken in a wide sense, such that willing includes such movements of the body that are brought about instinctively or voluntarily.

This subject has been pursued successfully in the past. The generation around 1880 saw a breakthrough in the understanding of the way various types of bodily movement, either instinctive or voluntary, depend on the activity in various parts of the nervous system.

However, with the advent of behaviorism from 1913 and, later, cognitivism, from 1960, the further development in the understanding, which would embrace also the phenomena of the stream of thought, was stalled by ideological misconceptions. The present treatise starts from a rejection of cognitivism and further adds a novel, as of 2004, understanding of the structure and operation of the central nervous system, called the synapse-state theory. The synapse-state theory builds upon a few hypotheses concerning the nervous system. The theory was first conceived in November 2003 and described in a brief forms in Naur (2004), Naur (2005), Naur (2007a), and Naur (2007b). In the present treatise it is shown how on this basis a wide range of phenomena of mental life may be accounted for in neural terms.

In working out the book I have had steady support in the form of encouragement and criticism from Erik Frøkjær and Jesper Hermann. In the final processing of the text for publication I have had help from Bo Holst-Christensen. To all of them my thanks.

Gentofte, 2008 August 8
Peter Naur

1. Introduction

The book presents a description of the structure and function of that part of the nervous system of a human being which supports mental life. Mental life is here understood to include the person's experience of thoughts, feelings, sensations, and perceptions, being awake or dreaming, as well as his or her instinctive and voluntary bodily movements and speech activity.

As will be documented in detail below, no comparable description of mental life is to be found in scientific literature from around year 2000, in neither psychology nor neurology.

LITERATURE SOURCES IN PSYCHOLOGY. As seen from *psychology*, as presented in *Encyclopedia of Psychology* (2000, will be referred to as *EncPsych*), the closest approach to the topic of the neural embodiment of mental life is an article by M. R. Rosenzweig (2000):

> '*Biological psychology* … In fact, around the middle of the twentieth century, major advances were beginning to occur in research on the neural mechanism of learning and memory. Some of these resulted from recently developed techniques, such as single-cell electrophysiological recording, electron microscopy, and use of new neuro-chemical methods. Another major influence encouraging research on neural mechanisms of learning and memory was Donald O. Hebb's 1949 monograph, *The Organization of Behavior.* … Much current neuroscience research concerns properties of what are now known as Hebbian synapses.'

As discussed in detail in Naur (2005), Hebb's work falls far short of presenting a neural description of mental life, saying already in the very first paragraph of the *Introduction* on page *xi* that

> 'There is a long way to go before we can speak of understanding the principles of behavior to the degree that we understand the principles of chemical reaction.'

Another account of recent psychological approaches to the neural aspects of mental life is an article: *An Integrated Theory of the Mind* by J. R. Anderson, D. Bothell, M. D. Byrne, S. Douglass, C. Lebiere, and Y. Qin (2004). This article postulates that what is called cognition can be accounted for neurally by what is called processing in a number of modules and buffers, each module and buffer being associated with a particular cortical region.

This whole approach fails to contribute to insight into the neural embodiment of mental life, for several reasons:

1) The article describes the mental activity as a kind of information processing, in terms of the cognitivist idea of the brain as a kind of computer. However, a description of activity in such terms has no relation to mental life. These defects of the article are displayed in the following quotations from the article in which phrases that have no relation to mental life and for which no neural embodiment is given, have been put into italics:

> '… a set of modules, each devoted to *processing a different kind of information*', 'a declarative module for *retrieving information from memory*', 'the buffers of each module *passing information back and forth* to the central production system', 'The core production system can *recognize patterns* …', 'The buffers of these modules hold *the limited information that the production system can respond to*', 'The goal buffer keeps track of *one's internal state in solving a problem*', 'The retrieval buffer … holds *information retrieved from long-term declarative memory*', '… the contents of the visual buffers represent *the products of complex processes of the visual perceptive and attention systems*', 'The cortical areas corresponding to these buffers project to the striatum … which we hypothesize *performs a pattern-recognition function*', '… the critical cycle in ACT-R is one in which *the buffers hold representations determined by the external world and internal modules*, *patterns in these buffers are recognized*, a production fires, and the buffers are then updated for another cycle', 'As a matter of division of labor … ACT-R historically was focused on *higher-level cognition* and not perception or action', '… the parital region is probably holding *a representation of the problem*', '… it is the *information stored in declarative memory* that promotes things like long-term personal and cultural coherence', '… access to *information in declarative memory* is hardly instantaneous or unproblematic, and an important component of the ACT-R theory concerns *the activation processes that control this access.*'

Some of the objections to the article that have been displayed in these quotations can be stated differently by saying that in mental life no kind of information processing takes place. For example, the objection to the quotation saying that 'The core production system can recognize patterns in these buffers' is that no kind of pattern recognition takes place in mental life. As established in classical descriptive psychology by George Berkeley (1685-1753) and Thomas Reid (1710-96), and confirmed by William James (1890, II 240), in perception what is sensed acts merely as a sign that by habitual association invokes a meaning in the stream of thought of the person.

2) The overall coordination and development in time of the many processes that are claimed in the article to take place, are entirely unclear. In one place it is said

> '… the critical cycle in ACT-R is one in which the buffers hold representations determined by the external world and internal modules, patterns in these buffers are recognized, a production fires, and the buffers are then updated for another cycle.'

Later it is said that

> 'The architecture assumes a mixture of parallel and serial processing. … the processes within different modules can go on in parallel and asynchronously.'

The unclarity here reflects the fact that while the article talks extensively about cognition and perception, the properties of mental life that supply their dynamic context: *habit, stream of thought and feelings, association, knowing by acquaintance,* and *knowing about,* are unknown in the article.

3) Talking of time sharing between processes, the article at one point says 'the amount of interference will be minimal between two tasks that are well practiced' without noticing that being well practiced is a matter of *plasticity*, which is incompatible with cognitive information processing. It is basic to the processes carried out by computers that the execution of a process leaves the processor unchanged.

4) The description in the article assumes the activity of the brain to take place in a number of separate modules: a visual module, a manual module, a declarative module, a goal module, and perhaps others. No description of these modules and their activity in terms of neurons is presented. In other words, the article has no trace of description of the neural embodiment of mental life.

As a whole the article contributes nothing to the theme 'Theory of the Mind' mentioned in the title. This failure of the article is admitted on page 1057 where it says that 'No theory in the foreseeable future can hope to account for all of cognition.' As far as accounting for mental life more generally the article is silent.

LITERATURE SOURCES IN NEUROLOGY. The way mental life is treated in *neurology* around year 2000 will here be established from an examination of articles in *Encyclopedia of the Neurological Sciences* (2003, will be referred to as *EncycNeuro*). In this examination, six general features of the treatment will first be discussed. This is followed by a detailed discussion of 23 articles.

(1) THE TERMS OF PSYCHOLOGY. As a first survey of *EncycNeuro* it was determined which of 73 subject terms of mental life taken from James's *Psychology* (James, 1890) appear as key words. The result of this survey is shown in the list below, which shows the subject terms in alphabetic order, with those that were found as titles of articles in the *EncycNeuro* marked by italics:

acquainting	action	affection
association	*attention*	belief
concept	conception	conscious
consciousness	disposition	ego
element psychology	empirical ego	*emotion*
feeling	fringe	habit
image	imagery	imagination

imagine	imitation	*instinct*
intelligence	intelligent	introspection
James-Lange	knowing by acquaintance	knowledge
knowledge-about	*language*	meaning
memory	mental	mental object
mind	mood	*motor*
pain	*perception*	*plasticity*
present	psychology	reasoning
recall	redintegration	*reflex*
(remembered) recall	*self*	sensation
sense	*sensory*	*sexual arousal*
sign	skill	*smell*
(specious) present	stream of thought	state of consciousness
substantive part	synapse	*taste*
thing	thinking	thought
thought object	time	transitive part
visual	volition	voluntary
will		

What is highly significant in this listing is the smallness of the number of terms explained in the *EncycNeuro*: only 18 out of 73, and the fact that the omissions in particular include most of the central vocabulary of the description of mental life: habit; stream of thought; state of consciousness; thought; feeling; association; acquainting; knowing by acquaintance; knowledge-about. Merely in view of these omissions it is obvious that the treatment of those terms of that vocabulary that *are* included, namely attention, emotion, and perception, will be fragmentary, and that whatever neural embodiments of mental life are presented in the *EncycNeuro*, they can at best only be incomplete. This is confirmed in the detailed discussions given below.

(2) REFERENCES TO JAMES'S PSYCHOLOGY. The subjects of the 18 key words are treated in the *EncycNeuro* in 23 articles, each of which is discussed in detail below. The articles refer to the items of mental life using the subject terms quoted above. However, most terms are used without reference to any source which explains the psychological sense of the term adopted. Moreover, it holds in many cases that the establishment of the sense of the psychological terms used gives rise to uncertainty and extended discussion in the articles.

The only exception to this state of affairs is that in three places the articles in *EncycNeuro* refer to James's *Psychology* (1890). These references are significant. No other account of psychology is quoted in a similar way. Thus James's work is recognized as the primary source of insight into mental life. But as will be shown below, the references to James's work are distorted, so as to support the false claim that his work anticipates cognitivism.

The first reference is a direct quotation from James's Chapter XI in J. Fan, A. Raz, and M. I. Posner (2003):

> '*Attentional Mechanisms.* Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of thought.'

In the second reference to James, in G. B. Young (2003b), it is claimed that:

> '*Consciousness, Overview.* William James defined consciousness as awareness of oneself (or one's own cognitive experience) and the environment.'

This claim is entirely spurious. James nowhere defines consciousness. He describes 'the stream of consciousness' or, as the same thing, 'the stream of thought' (1890, I 239). What follows in *Consciousness, Overview* is a typical cognitive explanation in terms of such ghostly entities as 'complex brain functions that involve numerous discrete, if inter-related, qualities and components'. This has no support in James's descriptions.

Distorted references to James's notion of the stream of thought are found similarly in two other places in *EncycNeuro*. In G. B. Young (2003a) it is said that:

> '*Awareness* and alertness are the two principal components of consciousness. … Cognitive awareness implies that a person is fully aware in his or her mind of the present phenomenon being perceived or initiated and could describe it if verbal abilities allowed. Consciousness of self is probably necessary for cognitive awareness.'

In Young, G. B. (2003c) it is said that:

> '*Self-Awareness.* Mechanisms for self-awareness of one's own perceptions of the external environment, one's own body, or, more introspectively, one's own thoughts have not been adequately explained …'

These scanty quotations are the closest approach in *EncycNeuro* to an account of the fundamental issues of introspection of the stream of thought, the state of consciousness, thoughts, and feelings.

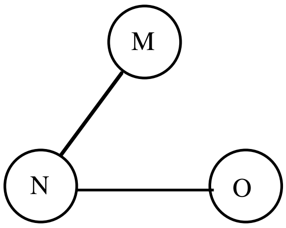
James is again referred to, distortedly, in J. H. Kramer (2003b):

> '*Memory, Overview.* … Another important division of memory, first proposed in 1890 by William James, makes the distinction between short-term and long-term memory.'

This reference is a straight falsification. While making the neural embodiment of the memory function entirely clear, James positively warns against the notion of memory as a container. What James says is this, first (1890, I 648):

> 'PRIMARY MEMORY. The first point to be noticed is that *for a state of mind to survive in memory it must have endured for a certain length of time.* … ANALYSIS OF THE PHENOMENON OF MEMORY. Memory proper, or secondary memory as it might be styled, is the knowledge of a former state of mind after it has already once dropped from consciousness; or rather *it is the knowledge of an event, or fact,* of which meanwhile we have not been thinking, *with the additional consciousness that we have thought or experienced it before.*'

Later James says [I 655]:



Retention and recall of the event *n*

> 'Let the nerve-centres, active in the thought of *m, n,* and *o,* be represented by M, N, and O, respectively; then the *existence* of the paths M–N and N–O will be the fact indicated by the phrase 'retention of the event *n* in the memory,' and the *excitement* of the brain along these paths will be the condition of the event *n*'s actual recall. The *retention* of *n*, it will be observed, is no mysterious storing up of an 'idea' in an unconscious state.'

(3) COGNITIVISM. In all the articles of *EncycNeuro* mental life is described in terms of cognitivism. The adoption of cognitivism is apparent in numerous details, as shown below in a few quotations in which the phrases that are shown in italics neither have any clear relation to mental life, nor are they explained in *EncycNeuro* in terms of neural embodiments:

In *Attention* [1,288]:

> 'the ability to prepare and to sustain alertness for *processing high-priority signals*', [1,291]: '*semantic processing* in humans',

In *Attention Mechanisms* [1,293]:

> '*information flow* in the nervous system', [1,294]: 'resolving conflict between *computations* occurring in different brain areas', [1,295]: '*representing specific information* over time (working memory)', '*executive control systems* develop strongly during later childhood', [1,296]: 'the *processing capability* of the sleeping brain'

In *Emotions* [2,135]:

> '*Cognitive processing* will modify an initial emotional response', [2,136]: 'The medial temporal lobe *integrates multimodal sensory information* for *storage and retrieval into memory* and attaches "limbic significance" to *sensory information* (i.e., pleasant or unpleasant, friend or foe, and fight or flight). It is in the medial temporal lobe where *information related to a conditioned stimulus is retrieved and processed*. There is no universal agreement regarding precisely which anatomical structures should be included in the limbic system …'

In *Language, Overview* [2,760]:

> *The speech sound sequences of language are assembled into a form that accesses words in the mental lexicon.*' - [2,760]: '*Words represent concepts that are stored in a form of long-term memory called semantic memory*'.

In *Memory, Overview* [3,79]:

> 'Our *memories include factual information and personal events*, and they *represent verbal, auditory, spatial, tactile, olfactory, and even emotional experiences*.'

In *Memory, Semantic* [3,83]:

> *Semantic memory* encompasses that *body of knowledge* held in common by members of a cultural or linguistic group. It is a *mental thesaurus of the organized knowledge an individual possesses about the meaning of objects, words, symbols, and all manner of facts*.'

In *Plasticity* [4, 5]:

> 'In the process of learning, the brain has to change to be able *to code for, and appropriately implement, the new knowledge*'.

In *Self-Awareness* [4, 223]:

> '… parallel *processing of information* is performed by a network of numerous interconnected modular *processors* across vast regions of cerebral cortex … Baars proposes that the brain works in a manner similar to global workspace computer models, allowing competition of a number of parallel processes …'

These quotations show how mental activity is described as data processing in a computer. The data are referred to as 'knowledge', 'information', or 'representations of verbal, auditory, spatial, tactile, olfactory, and emotional experiences'. The processes are referred to as 'learning', 'semantic processing', or 'computations'. These processes are claimed to take place in 'executive control systems'.

None of these cognitive phrases are explained anywhere in terms of neural embodiments. As shown more fully in the discussions of 23 articles below they fail to account for mental life.

(4) NEGLECT OF NEURAL EMBODIMENTS. Of the 23 articles in *EncycNeuro* discussed in detail below, the only ones that present neural embodiments are those that are concerned with the peripheral activity: *Motor Control, Peripheral* [3,219] and *Sensory Receptors, Overview* [4,231].

The neglect of neural embodiments is particularly prominent in the article on *Theodor Hermann Meynert* by P. J. Whitehouse and J. Ballenger (2003). In this article it is said that:

> 'Meynert also used his detailed anatomical studies to develop models of brain function that foreshadowed modern conceptions of relationships between cortical and subcortical structures …'

There is here no mention of the fact that Meynert's work included detailed graphical presentations of proposals for the neural components and structures that are involved in basic reflex and voluntary activity, proposals that were quoted in detail by William James (1890, I 27), who called these notions 'the Meynert scheme'. They are further discussed in section 2.5 below.

In summary, the basic defect of the cognitivist approach to neuroscience is that cognitivist writers express themselves in such terms as *'knowledge', 'meaning of objects, words, symbols, and all manner of facts', 'memory', 'information', 'representations of verbal, auditory, spatial, tactile, olfactory, and emotional experiences', 'learning', 'semantic processing', 'computations', 'executive control systems'. But there is nowhere any trace of suggestion neither what these terms denote, nor how they relate to neural embodiments.*

The destructive effect of cognitivism on the psychological understanding of mental life has been discussed at length in (Naur, 2005, sections 3.3 Flaws of cognitivism, 3.4 Cognitivist pseudo-problems, and 3.5 The American-psychology-enterprise 1945-2000).

(5) EXPERIMENTAL TECHNIQUES. In the articles empirical studies of the mental life are referred to as they have been used to detect enhanced activity in specific areas of the brain carried out by means of such techniques as neuroimaging, positron emission tomography (PET), single-cell recordings, transcranial magnetic stimulation (TMS), functional magnetic resonance imaging (fMRI), electroencephalography (EEG), computer assisted tomography, and single photon emission computed tomography, as these techniques have been used in the years up to 2003.

Little attention is paid to what is said in *Emotions* [2,137], that 'These techniques have limitations, since a brain region may be more active metabolically, but this does not necessarily mean that this is the area in which an emotion is localized.'

Other reservations concerning the interpretation of experimental evidence of the localization of metabolic activity are mentioned in the discussion of the article on *Attention* [1,288] below.

(6) DOMINANCE OF MENTAL DISORDERS. The descriptions of human mental life in the articles are dominated by discussions of mental disorders and therapies for them, rather than of mental life in normal persons. Nowhere in the *EncycNeuro* is there any mention, neither of normal mental life as it happens in every person throughout life–described by James as the stream of thought–nor of the neural embodiment of normal mental life.

ARTICLES ON ATTENTION. The articles in *EncycNeuro* that come closest to discussing the stream of thought are *Attention* by T. Novakovic-Agopian (2003) and *Attentional Mechanisms* by J. Fan, A. Raz, and M. I. Posner (2003). *Attentional Mechanisms* opens with a quotation from William James (1890, I 402):

> 'CHAPTER XI. ATTENTION.… [I 403] Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of thought.'

This is quoted without any attention to the fact that James's explanation makes sense only in the context of his description of the stream of thought, where he describes attention as one of five characters of the way thinking goes on, James (1890, I 224):

> 'CHAPTER IX. THE STREAM OF THOUGHT. … [I 283] The last peculiarity of consciousness to which attention is to be drawn in this first rough description of its stream is that (5) *It is always interested more in one part of its object than in another, and welcomes and rejects, or chooses, all the while it thinks.* - The phenomena of selective attention and of deliberative will are of course patent examples of this choosing activity. But few of us are aware how incessantly it is at work in operations not ordinarily called by these names. Accentuation and Emphasis are present in every perception we have. We find it quite impossible to disperse our attention impartially over a number of impressions.'

Ignoring this J. Fan, A. Raz, and M. I. Posner (2003) continue to discuss attention from this starting point:

> '*Attention Mechanisms* … It is appropriate for neurologists to think about attention as an organ system not unlike the familiar ones of respiration and circulation.'

Putting this statement at the beginning of the article is revealing for its entire contents. As a matter of fact, the statement states what is merely an hypothesis, and an extremely implausible one. For one thing, what is the neurological content of the statement, what is a neural organ? Entirely unclear. And what is the similarity between attention on the one hand and respiration and circulation on the other? There is none. Attention is a matter of a concentration upon one thing out of a large number of a duration of about one second. It has no particular connection to any one of the organs of the body. Very differently, respiration and circulation continue in their several ways unchanged, lifelong, and have only slight influence on the person's experience. Both of them are closely coupled to specific organs, the lungs and the heart and veins.

As a further defect, the article *Attention Mechanisms* makes no reference to the person's experience of the stream of thought. The close relation of attention to the stream of thought may be illustrated by a consideration of the sentence written a few paragraphs above: 'This is quoted without any attention to the fact that James's explanation makes sense only in the context of his description of the stream of thought'. This sentence directly alludes to the way attention has been at work in the stream of thought of the authors of the article Jin Fan, Amir Raz, and Michael I. Posner. The sentence makes sense only on the assumption that at certain of the moments when these authors wrote and revised their article they had in their stream of thought a thought object having, as any such, a large number of parts, these parts being the thoughts of such things as William James, his book *Psychology*, attention, James's statement about what attention is, taking possession by the mind, objects or trains of thought, and a thousand others associated with them. What they actually wrote at that particular section of their article resulted from *attentive* selection from that thought object. This is a concrete example of the way the selective function of attention relates to the stream of thought and shows that explaining attention without the context of the personal experience of the stream of thought makes no sense. But this is how attention *is* explained in *Attention Mechanisms*.

The article *Attention* by T. Novakovic-Agopian (2003) demonstrates the impotence of the cognitive approach. Throughout it argues in terms of what is called 'cognitive operations', 'cognitive functions', 'neural systems', or 'mental processing'. In the context these are merely speculative designations. Of their neural embodiment nothing is said. The empirical investigations quoted, from the years 1985 to 1996, mostly of monkeys and patients with neurological lesions, try to relate the speculative cognitive operations to enhancement (greater discharge rate) of localized brain areas.

A main theme of *Attention* is a distinction introduced by Posner and Petersen between what is called three different aspects of attention, described thus: (1) 'the ability to prepare and to sustain alertness for processing high-priority signals,' (2) 'selective attention is orienting to sensory stimuli,' and (3) 'the detection of events.' The article claims to find neural support of these aspects in activations of three different areas of the brain. This approach is invalid, for several reasons. For one, aspect (1) is concerned with sustained alertness, which is quite different from attention, which changes from one thing to another from one second to the next. For another, the distinction between (2) and (3) is invalid and irrelevant. For example, is giving attention to a raindrop falling to the ground with a splash one of aspect (2) or (3)? It is both.

Attention is a matter of the momentary strength of the experience of something, not of the quality of that something. Therefore it makes no sense to try to classify what is attended to. The phenomenon of attention is such that I may within a few seconds direct my attention, first to the sound of traffic coming from the street outside, then to the slight pain in my right knee, then to what I am going to buy when I go shopping in half an hour, then to a phrase spoken to me: 'Remember to buy milk', etc., etc. Each of these states must be embodied neurally in a separate part of the brain's cells. I may at any time give attention to any one out of millions of different things. My giving attention to any one of them must be embodied in a distinct state of one particular part of the brain. The experimental approach of asking 'whether attention is a single unified system, or whether it consists of separate independent systems' is idle. Bringing in what in the article is called 'language tasks' merely adds confusion. Obviously we may attend to such items as phrases of spoken or written language, as among the millions of other things we may attend to, but neurally there is nothing special about the habitual use of certain sounds or sights as signs.

No attention is paid in *Attention* to the circumstance that even if it would make sense to say that a cognitive operation is related to a particular brain area, investigating the excitation of localized parts of the brain is a poor approach to detecting the neural embodiment of a function of attention, since other functions than attention will most likely be active at the same time, contributing to enhancements.

In fact what may be called the function of attention at any time will be in operation at the same time as a number of other functions, such as thinking, feeling, sensation, and perception. The neural activity pattern of the regions of the brain will at any moment embody every one of these functions. The investigation procedure described in *Attention* is like trying to find out the way of operation of one wheel of a clock from knowing the motion of the short hand and using a sledge hammer as tool.

Accordingly the results reported in *Attention* typically are said merely to 'support the idea that different anatomical areas carry specific cognitive operations', and are said to suggest that certain areas 'have a functional relationship'. Overall the results reported are at best vaguely suggestive, mostly just unclear and confused.

The final conclusion of *Attention* says that

> 'Although some of the neural systems underlying attention have become better understood, the anatomy and function of attention, particularly the anterior network, require further study.'

This way of talking is a euphemism. Attentive reading of the articles *Attention* and *Attention Mechanisms* reveals that the parade of certainty of insight is a sham.

ARTICLES ON LANGUAGE. The article *Language, Overview* by M. Grossman (2003) presents a number of statements that display the cognitive delusion. It opens:

> 'Language is the uniquely human capacity to communicate with others. This symbol system uses sound patterns, sequences of geometrical designs, and gestures to represent objects and actions as well as thoughts and feelings.'

Later in the article we find:

> 'The speech sound sequences of language are assembled into a form that accesses words in the mental lexicon'. - 'Words represent concepts that are stored in a form of long-term memory called semantic memory.' - 'Humans possess the unique capacity to appreciate syntax. This is the set of rules that allow words to be combined into a sentence that has a meaning greater than each of its components …'

These statements are a collection of confusions and falsities. There is nothing 'uniquely human' in any capacity 'to communicate with others'. All sorts of animals practise communication. There is no definite 'symbol system' involved in human communication. 'Concept' denotes nothing clearly. There are no such things, neither as 'the capacity to appreciate syntax', nor as 'rules that allow words to be combined into a sentence'. Both the use of something as a sign to represent something else, and the combination of words into sentences are entirely matters of people's individual habits. Grammatical rules and dictionaries are *descriptions* of certain persons' habits.

In the opening the article continues to quote Chomsky's claim that 'the human language system' can be partitioned into phonology, syntax, and semantics. It pays no attention to the fact that as said by Chomsky himself (1971) this description applies only to what he calls 'linguistic competence'. It has no clear relation to the way people speak and understand speech.

The article continues to describe various kinds of aphasia, and neuroimaging studies from the years 1985 to 2000 attempting to localize aphasic syndromes in the brain. It concludes:

> 'Indeed, it has proven exceedingly difficult to map impairments of theoretically important language components, such as phonology, syntax, and semantics, onto these classical language zones.'

This conclusion confirms the failure of the cognitive notions of language.

The remaining sections of the article headed *Phonology, The Mental Lexicon and Word Meaning,* and *Syntax and Grammatical Relations,* present a series of unclear generalities failing to present any confirmation of the cognitive approach.

Two articles *Language and Discourse* by S. B. Chapman and G. Sparks (2003) and *Language Disorders, Overview* by J. S. Snowden (2003) are both misnamed. 'Language' does not denote anything definite in mental life. The titles of the articles more properly should mention diagnosis of neurological diseases from disturbances of habits of speech and sign perception. Disturbances of speech habits are useful for diagnostic purposes since speech is the most elaborate kind of voluntary action whose result is readily observable in behavior. However, concluding from particular disturbances to their neural cause depends on an understanding of the neural mechanism involved in the action. No such is presented. The explanations given, for example in *Language and Discourse*: 'Discourse abilities entail a complex interplay of basic linguistic skills, cognitive processes, and information-handling abilities', is merely cognitivist twaddle. Of neurological sense there is none.

ARTICLE ON INSTINCT. The article *Instinct* [2,664] (Sarah E. B. Gibbs) is remarkable for its ignorance of well established insight. Typical of the behavioristic approach the main part of the article is concerned with animal behavior. When finally addressing human mental life it ignores the rich insight into the subject of instincts presented in James's *Psychology* (1890). Thus it is misguided, first of all, by the ignorance or neglect of the most basic of all general properties of living creatures, that they are bundles of *habits* (discussed further below concerning *Plasticity*). In this way the discussion fails to recognize the important pattern of behavior by which the individual's experience of his own instinctive behavior gives rise to the development of habits. Adopting the cognitivist view of language as a special, human-specific behavior, the article ignores the way the instincts of imitation and vocalization in humans give rise to the development of the habits of speech and perception of language signs. It fails to recognize how human sexual behavior develops from instincts.

The article says that 'the degree to which humans display instinctive behavior is controversial' and that 'some of the most informative methods of studying instincts are unique to animal studies because the early experiences of human infants are not manipulated for obvious ethical reasons'. This ignores that in order to study the instincts of human infants one just has to observe these infants, as done by any parent. By such observations one will find, as James (1890, II 383ff) says, that man has more instincts than any other mammal. He describes them under the headings: sucking; biting; clasping; pointing; expressing desire by sound; carrying to the mouth; crying; smiling; protrusion of the lips; turning the head aside; holding head erect; sitting up; standing; locomotion; climbing; vocalization; imitation; emulation or rivalry; pugnacity; anger; resentment; sympathy; the hunting instinct; fear of strange men and animals, of black things and holes, of high places, of the supernatural; appropriation or acquisitiveness; kleptomania; constructiveness; play; curiosity; sociability and shyness; secretiveness; cleanliness; modesty, shame; love; jealousy; parental love.

About the neural embodiment of instincts the article says nothing. It further ignores the close relation of instincts to reflex movements and makes no reference to the article *Reflexes, Spinal Cord and Blink* by M. A. Fisher (2003) which presents the neural embodiment mostly of one particular reflex, the blink reflex.

ARTICLES ON MEMORY. The talk of memory as a mental container is a core issue of the cognitive delusion. It was dismissed already by William James as quoted above, when he says [I 655]: 'The *retention* of *n*, it will be observed, is no mysterious storing up of an "idea" in an unconscious state.' In the *EncycNeuro* the delusion is presented in seven articles: *Memory, Autobiographical* by E. Svoboda and B. Levine (2003), *Memory, Episodic* by J. H. Kramer (2003a), *Memory, Explicit/Implicit* by B. J. Cherry (2003), *Memory, Overview* by J. H. Kramer (2003b), *Memory, Semantic* by E. K. Warrington (2003), *Memory, Spatial* by L. F. Jacobs (2003), *Memory, Working* by J. A. Waltz (2003). These are a monotonous litany of introduction of speculative descriptive categories, such as in *Memory, Overview* on page [3,79]:

> 'Our memories include factual information and personal events, and they represent verbal, auditory, spatial, tactile, olfactory, and even emotional experiences',

continuing with neuroexperimental evidence, mostly concerning patients with mental disorders, showing that the categories do not work, followed by introduction of further speculative category complications, then showing that they also do not work, etc. on and on.

An example of the basic defect of speculative descriptive categories is presented in the interpretation of a patient's impaired performance. The example is in *Memory, Semantic* on page [3,84] in a section opening:

> 'Category specificity - Neuropsychological disorders of semantic memory are frequently selective to particular categories of semantic information'.

As empirical support of this kind of description it is said that 'one remarkable patient was unable to demonstrate the actions "push" and "pull" or to point to pictures representing these actions.' This is claimed to demonstrate that the patient suffers from a disorder of the 'categorical organization of semantic memory.' However, it does nothing of the sort. The patient's trouble may directly be understood to be a defect in the perception concerning just the two words "push" and "pull", resulting from a decay of the activity of one or two of the billions of neurons in the brain.

As a sample of what is presented as the results of the empirical investigations, this is stated in *Memory, Overview* on page [3,82]:

> 'Studies of retrograde amnesia in patients have helped refine our understanding of *episodic memory*. It is apparent that initial *acquisition of information* does

> not guarantee *permanent storage*. Rather, a process must take place during which *the neural circuitry underlying a particular memory* undergoes consolidation. The precise parameters and biological mechanisms of *consolidation* are poorly understood, but it is clear that consolidation can take place over a period of years.'

In this statement the words and phrases put into italics are cognitivist twaddle, saying nothing, neither of mental life nor of its neural embodiment.

Typical conclusions of the empirical investigations reported in the articles on memory are, in *Memory, Overview* on page [3,82]:

> 'Advances in cognitive neuroscience have begun to delineate key memory constructs and have identified several neuroanatomical structures that are integral to the process of learning';

in *Memory, Semantic* on page [3,85]:

> 'The categorical organization of the semantic knowledge base is firmly established. However, it is not known whether this level of representation is stored in a unitary all-purpose system or whether there are multiple meaning systems.';

in *Memory, Spatial* on page [3,88]:

> 'The cognitive/behavioral research is generally consistent, however, with the view that the right hippocampus is specialized in some way for spatial memory, although it does not have an exclusive role in this capacity. – This raises the issue of the independence of spatial memory from other types of memory. Even if spatial memory can be dissociated in this way, this does not mean that spatial memory is a separate memory system. Its status, however, is currently a matter of debate.';

in *Memory, Working* on page [3,95]:

> '… questions remain regarding the issues of what exactly constitutes an executive process, what the cognitive representations are on which executive processes operate, and the precise sources of working memory capacity limitations …'.

Stating nothing but uncertainty and unsettled questions, these pronouncements are admissions of failure. They merely confirm that the last 40 years of research in this area based on the idea of memory as a kind of container has led to no insight into the nervous system. The notion of memory as a container of something is as misleading and invalid in neuroscience as it is in psychology, as discussed in Naur (2005, section 4.8 The 'memory'-fallacy of cognitivism).

ARTICLES ON MOTOR ACTIVITY. The motor activity is described in the *EncycNeuro* in *Motor Control, Peripheral* by D. A. Chad (2003), *Motor Cortex* by J. C. Rothwell (2003), and *Motor System, Overview* by C. G. Goetz (2003). In *Motor System, Overview* we are presented immediately with a cognitive assumption stated as though it were an obvious truth:

> 'The motor system controls the initiation, execution, and coordination of all movements that occur in health and disease. … The motor system is

anatomically organized in a hierarchical manner to execute and integrate the three types of movement'.

Later it is said:

'The motor system cannot function in isolation and requires a continual sensory input to produce accurate and appropriate movements.'

This remark makes it clear that the talk of 'the motor system' as a well defined part of the nervous system is senseless. This is confirmed in the two articles *Motor Control, Peripheral* and *Motor Cortex*. Here it may be noted that while the control of muscles, as this happens in the peripheral nervous system, is described in minute detail, what happens in the motor cortex is explained merely in general terms, giving no neural details. This difference is displayed in that *Motor Control, Peripheral* presents 14 figures with details of neural anatomy, while *Motor Cortex* has no figures at all. The way the neural activity is described in the latter article in vague descriptive terms is shown in the following quotations, in which phrases that are given no neural explanations are put in italics:

[3,227]: 'The implication is that *awareness of the effort of a voluntary movement* must arise in other areas of cortex', — [3,228]: 'The projection to sensory nuclei is important in controlling *the flow of information* during movement', — [3,229]: '*The activity of neurons in SMA and premotor areas* is more likely related to preparation, rather than execution, of movement', — [3,229]: 'It can be hypothesized that *processed sensory input* from this area [parietal cortex] can help the premotor regions select appropriate movements from a set of *stored commands'*.

A further source of unclarity in the articles on the motor activity relates to the influence of feeling on movements. It is said, for example [3,231]:

'The cereballar system … regulates the coordination and accuracy of movement by comparing the sensory feedback from the periphery with the descending motor commands.'

This statement is false. As described in detail by James (1890, quoted in section 2.3 below) movements depend on feelings originating in the moving part of the body, but it is false to say that these feelings give rise to 'comparing' with anything.

ARTICLES ON FEELINGS. The unclarity related to feelings as they influence movements is only one case of a general feature of the *EncycNeuro:* the neglect of feelings in accounting for mental life. *EncycNeuro* has no article titled feelings. The article that comes closest to feelings in its subject is *Emotions* by J. A. Israel and K. Yaffe (2003). In fact, seven lines into the article it defines emotions in terms of 'any strong feeling that is connected to a specific event or idea.' However, in the context this phrase makes the matter unclear, since there is no clear understanding in the article, neither of what here is meant by feeling, nor of what is meant by its being 'connected to' something, nor of the what and where of the 'specific event or idea' referred to.

This defective treatment of feelings is one side of a lack in *EncycNeuro* of a sound understanding of the stream of thought and the experience of thoughts and feelings.

Feelings and the way they are experienced and influence the stream of thought are most easily explained by a concrete example: A man is angry at his boss, who has given him a bad turn. But in the evening, when he is dating his sweetheart, this anger of his is as nothing, he just feels pleasant lust at the sensation of the sweetheart's feminine attractions. But if she happens to ask him: How is work? the feeling of anger immediately wells up in him and he shouts: 'My boss is a shit!'

We all know how this comes about: The word 'work' immediately by association arouses in the man's stream of thought the thought of his boss, and that thought has associated with it the feeling of anger. He cannot think of his boss without the anger being aroused. This feeling of anger is first decisive in the way the word 'work' *attracts his attention* to the associated thought of the boss, and is then influential in *directing his action* in the way and what he shouts.

In terms of this example it is clear that feelings, including emotions and pain, are integral parts of the experience of the stream of thought at any time, and are the parts of the momentary thought object that more than anything contribute to the way the thought object changes from one moment to the next. Feelings are primary sources or influences of the activity of the stream of thought.

Of all this common understanding of feelings and the way thinking goes on the article *Emotions* has not a trace. This in spite of the fact that the article says that 'a person's attempt to observe an emotion with the intent of describing it may change the emotion' and later talks of 'the inner feeling state' and 'a mental feeling state'. These phrases are an explicit admission of the experience of the stream of thought and of *introspection* as a source of insight into it. A taboo on talking about introspection and the stream of thought was a central issue of behaviorism when it was launched in 1913.

As to the neural embodiment of emotions, what should be considered is not just the embodiment of anger in the abstract, but the embodiment of such anger as is shown in the example above, with the connections to the person's thoughts. Consequently the discussion in *Emotions* on page [2,137] of attempts to determine by neuroimaging techniques 'where an emotion is localized' contributes only little to the insight.

In any case, as said in the article [2,134]: 'Emotions include fear, anger, love, joy, disgust, and hate, although there is no agreement on the exact number of emotions that exist.' To which one may answer: Why should there be? The feeling of an emotion has no identity. The feeling of anger toward somebody that I may experience at this moment most likely will be different from the feeling I have towards that somebody tomorrow or the day after, if I even think of that somebody. Feelings are indefinitely varied. No words can express their shades.

Such feelings that are called pain are given extraordinary attention in the *EncycNeuro*, in the form of two articles: *Pain, Assessment of* by J. Katz. and R. Melzack (2003) and *Pain, Basic Neurobiology of* by A. L. Oaklander (2003). In these articles there is no explicit recognition that pain is a kind of feeling and as such shares properties with any such.

However, the property of pain as sharing its properties with any other feeling is brought out indirectly in a passage in *Pain, Assessment of* [3,717]:

> 'These considerations led Melzack and Casey to suggest that there are three major psychological dimensions of pain: sensory-evaluative, motivational-affective, and cognitive-evaluative. These dimensions of pain experience are subserved by physiologically specialized systems in the brain.'

What is suggested here as a special understanding achieved in the 20th century to be special properties of such feelings that are called pain is nothing other than properties of any feeling as they were described by William James as an aspect of the stream of thought. The way these properties influence the stream of thought was described above in the discussion of the feeling (emotion) anger by an example.

In *Pain, Assessment of* and *Pain, Basic Neurobiology of* there is no recognition of the importance of the stream of thought and attention in the experience of pain, in that the feeling is only experienced when whatever it is mentally associated with comes forth in the stream of thought, and the more so, stronger, when the attention is turned to it. So in the two articles, where alleviation of the experience of pain is the main theme, it is nowhere mentioned that one way of reducing a patient's experience of pain is to have the patient turn the attention to other things. The most obvious way of doing that is to present the patient with sense impressions that are pleasant and interesting to the patient and can keep the patient's attention riveted continuously. With some patients this may be achieved by having him or her listen to certain music.

We have feelings of our body all the time. At any time we can, if we turn our attention to them, note all kinds of itches and pressures from all parts of our body. As long as they are faint we mostly ignore them, that is we turn our attention elsewhere. But if they are strong, painful, they arouse our attention and so we cannot easily ignore them.

Pain, Basic Neurobiology of fails to deliver what its title suggests. The subsection 'Pain Processing in the Brain' merely mentions a number of brain areas involved in pain, saying 'It has become clear that there is no single pain center in the brain.' The remaining contents and the conclusion are exclusively concerned with aspects of chronic pain. About the neural embodiment of pain as an aspect of the stream of thought the article says nothing.

ARTICLE ON INTELLIGENCE. The article *Intelligence* by A. L. Powell (2003) starts by quoting several different definitions of the word intelligence, and then says:

> 'It has come to mean different things to different people. Despite such ambiguity, tests of intelligence are commonly used to assess an individual's aptitude for an occupation or for education.'

The article continues to sketch a number of applications of what are called 'tests of intelligence' that are widely used in selecting pupils for education, for monitoring patients for changes over time, and in other applications.

The accounts of the applications repeatedly state reservations about their validity, such as

> 'Test scores and intelligence are thereby equated, but there are no data supporting this conviction.' - 'In reality, there is no proof that a particular person who scores higher than another individual is more intelligent.' - 'Another tenet underlying the use of such devices [IQ scores] is that cognitive processes in different people are the same. However, there has been no discussion about whether this notion is correct.'

In spite of these reservations, there is nowhere in *Intelligence* any questioning of considering the word intelligence to designate an ability, in other words, questioning the assumption that a person's ability to perform specific tasks is a result of the person's having a certain amount of a particular thing: intelligence.

However, the assumption that it makes sense to consider a person's ability to perform a specific task to be a measurable property of the person is unreasonable. Consider for example athletic performance, a human activity the performance of which is accurately quantifiable. Consider Jesse Owens, who at the 1936 Olympic Games listed world record in the running broad jump, 8.06 meter, a record that stood for 25 years.

Any suggestion that Owens's achievement may be understood in terms of a particular ability had by him is obviously false. His achievement is clearly the result of a great variety of abilities, such as of the way to harness his resources, of the proper planning of training, of the best way of doing the bodily movements, in addition to the training before the final performance. This whole activity has been a matter of the athlete having over a period of years been developing and training a large number of different habits. This activity has obviously been dependent on his intelligence, but only in the vague sense this word is commonly understood.

Moreover, Owens's championship is not the result of a permanent characteristic of his organism. He has performed his feat at one particular day of his life. His championship depended on his state on that day. Quite possibly, his state one month later might be so that he would not be able to do it again.

In other words, taking the word 'intelligence' to denote a measurable characteristic of each person is senseless. The word makes sense only when used as in the following quotation from James (1890, I 8):

> '*The pursuance of future ends and the choice of means for their attainment are thus the mark and criterion of the presence of mentality* in a phenomenon. We all use this test to discriminate between an intelligent and a mechanical performance. We impute no mentality to sticks and stones, because they never seem to move for *the sake of* anything, but always when pushed, and then indifferently and with no sign of choice. So we unhesitatingly call them senseless.'

Calling Jesse Owens's behavior intelligent is in full accord with this explanation.

In summary, there are two circumstances related to the word intelligence giving rise to unclarity and confusion: (1) The word is used sometimes to denote the quality that makes living creatures differ from inanimate ones, sometimes to denote a quality of individual living creatures; (2) When used about individual creatures the word is sometimes assumed to denote, not only a general quality, but a measurable quantity.

The following sections of *Intelligence: Fundamental Concepts*, *Heredity and Environment*, *Products of Collaboration*, *Judgment*, and *Emotions*, open with a declaration of intent:

> 'Several important concepts underlie the brains's capacity for intelligence. From this perspective, it is possible to derive a neurologically relevant definition.'

As a whole the empty superficiality of these sections is beyond description. Failing to draw the obvious conclusion of the preceding section on intelligence testing, they skate along on pronouncement in terms of cognitive notions that have no relation whatever to human mental life and which are given no neural embodiments. The style of the pronouncements is shown by the following sample, in which the phrases put in italics have no clear meaning:

> 'The brain has three *elemental demands* placed on it. It must *represent the world* while evaluating *its models* for important patterns. The brain also *manipulates, modifying the information* it receives while concomitantly determining *its significance*. Lastly, the brain must allow *safe and constructive interaction* with the environment. The capacity to *modify information* is essential to intelligence.'

Typical of the quality of the discussion a section is introduced as follows:

> '*Emotions*. The role of emotion in intelligence is often ignored but is nonetheless important. Emotions establish the value of objects in the world. They determine what is desired and what is to be avoided. …'

This pronouncement reveals the author's ignorance of the central place of feelings in mental life.

The final sections, *History of Neural Correlation*, *History of IQ Tests*, and *Neuroanatomy*, sketch the historical development of faculty-psychology, from Gall until today. In this sketch one looks in vain for a clear statement of a conclusion to the studies described. It is said that

> 'During World Wars I and II, large numbers of nonlethal head wounds culminated in development of competing theories of intellectual ability, theories based on the structure and function of brain tissue.'

There is no mention of what these competing theories were. Instead the article continues with a mention of advances of technology in the years 1950 to 1980s. About these it is said that:

> 'These techniques allow investigators to correlate the effect of regional damage on mental processes and capability.'

The section *Neuroanatomy* opens:

> 'Paul Flechsig described the important contributions of the association cortex to intelligence at the beginning of the 20th century. By the end of the century,

> the cytoarchitectonic flow of neural information, from its entry into the cerebral cortex to subsequent processing, was well established.'

This is followed by an elaborate account, in terms of electrical engineering, of what happens 'According to current notions'. Typically we are told that:

> 'There is a structure and flow of information within such circuits. Incoming signals are evaluated for familiarity, in essence, the information is characterized as signal or noise.'

The passage concludes:

> 'Anatomical structures deep to the cortex, basal ganglia, thalamus, and cerebellum appear to play an essential role in cognition by regulating and coordinating the action with the cortex.'

This is immediately followed by this:

> 'A clinical integration of structure and function by D. Frank Benson during the mid 1980-s merits mention. He envisioned three brain areas by level of function. …'

This section ends:

> 'He believes that supramodal tissue provides executive control over other intellectual functions.'

The conclusion of the article says:

> 'Intelligence is now known to be the product of coordinated activity of connected neuron populations. It reflects the ability to combine and link sensations, memory, and thoughts, to discern patterns, and to anticipate outcome, as manifested by problem solving, creativity, insight, and the capacity to analyze.'

This pronouncement has not the slightest support in the article. A more presumptuous emptiness than the one presented in this statement it is hard to imagine.

ARTICLE ON PLASTICITY. The article *Plasticity* [4,5] by A. Pascual-Leone argues from a false notion of what the words 'plastic' and 'plasticity' are commonly used to designate, claiming that 'The brain's capacity to change is referred to as plasticity'. As a result the article is confusion throughout.

One particular instance is the passage:

> 'An obvious benefit of this capacity [plasticity] is the acquisition of new skills. In the process of learning, the brain has to change to be able to code for, and appropriately implement, the new knowledge.'

This is misleading cognitive confusion. If the learning of new knowledge is a matter of coding and implementing, then it is *not* a matter of plasticity. As said in the dictionary, plasticity is 'capability of being moulded, receiving shape, or being made to assume a desired form.'

However, the cognitive notion of learning as a matter of coding and implementing is invalid. Learning is a matter of practising, as it may be observed prominently in the way a musician has to practise the handling of his instrument. And practising is a matter of *habits*. But habits are unknown in *EncycNeuro*.

In a subsection headed *Mechanisms of Plasticity* it is said:

> 'There are a number of mechanisms for plasticity in humans that can be studied at different levels, ranging from systems physiology all the way down to cellular and molecular levels. Thus far our understanding of these mechanisms remains incomplete.'

This ignores that as noted in Naur (2005, section 4.3 The plasticity of the nervous system) plasticity at the neural level is a property of the synapses described by Sherrington (1906). However, synapses and their properties are unknown in *EncycNeuro.*

Confused cognitive notions of plasticity are found also in *Motor Cortex* by J. C. Rothwell (2003) which says:

> '*Plasticity of Primary Motor Cortex.* It has been known for many years that electrical stimulation at the same site in primary motor cortex does not always produce exactly the same movement on every occasion over a period of several hours. However, this capacity of the cortex to change its organization …'

Habit and plasticity were introduced as basic notions of psychology by William James (1890, 1, 104):

> 'When we look at living creature from an outward point of view, one of the first things that strike us is that they are bundles of habits.'

and further (1890, 1, 105):

> *the phenomena of habit in living beings are due to the plasticity* of the organic materials of which their bodies are composed.* *Note: In the sense above explained, which applies to inner structure as well as to outer form.

SUMMARY OF THE INTRODUCTION. The scientific literature of psychology and neurology from around year 2000 displays ignorance of the insight into mental life presented in James's *Psychology* from 1890. Despite much experimental effort, not a single item of solid insight into the neural embodiment of mental life has been obtained, the reason being that mental life is described in cognitive terms, centered on the misguided notion of memory as a mental container of something.

2. Mental life and the synapse-state theory

2.1 Reflex movements, voluntary movements, and the hemispheres

The empirical evidence which is accounted for by the synapse-state theory was established mainly during the years 1860 to 1910 through the work of a number of workers. In the sections 2.1 to 2.16 the work up to 1890 will be reviewed as it was presented by William James in his *Principles of Psychology* (1890), a work which, as found in an earlier study (Naur, 1995), is unsurpassed in its comprehensiveness and clarity.

Evidence on the overall structure and function of the neural system is presented by James thus (referred to throughout as [volume page]) [I 12]:

> CHAPTER II. THE FUNCTIONS OF THE BRAIN. If I begin chopping the foot of a tree, its branches are unmoved by my act, and its leaves murmur as peacefully as ever in the wind. If, on the contrary, I do violence to the foot of a fellow-man, the rest of his body instantly responds to the aggression by movements of alarm or defence. The reason of this difference is that the man has a nervous system whilst the tree has none; and the function of the nervous system is to bring each part in harmonious co-operation with every other. The afferent nerves, when excited by some physical irritant, be this as gross in its mode of operation as a chopping axe or as subtle as the waves of light, conveys the excitement to the nervous centres. The commotion set up in the centres does not stop there, but discharges itself, if at all strong, through the efferent nerves into muscles and glands, exciting movements of the limbs and viscera, or acts of secretion, which vary with the animal, and with the irritant applied. These acts of response have usually the common character of being of service. They ward off the noxious stimulus and support the beneficial one; whilst if, in itself indifferent, the stimulus be a sign of some distant circumstance of practical importance, the animal's acts are addressed to this circumstance so as to avoid its perils or secure its benefits, as the case may be. To take a common example, if I hear the conductor calling 'All aboard!' as I enter the depot, my heart first stops, then palpitates, and my legs respond to the air-waves falling on my tympanum by quickening their movements. If I stumble as I run, the sensation of falling provokes a movements of the hand toward the direction of the fall, the effect of which is to shield the body from too sudden a shock. If a cinder enter my eye, its lids close forcibly and a copious flow of tears tends to wash it out.

These three responses to a sensational stimulus differ, however, in many respects. The closure of the eye and the lachrymation are quite involuntary, and so is the disturbance of the heart. Such involuntary responses we know as ‘reflex’ acts. The motion of the arms to break the shock of falling may also be called reflex, since it occurs too quickly to be deliberately intended. Whether it be instinctive or whether it result from the pedestrian education of childhood may be doubtful; it is, at any rate, less automatic than the previous acts, for a man might by conscious effort learn to perform it more skillfully, or even to suppress it altogether. Actions of this kind, into which instinct and volition enter upon equal terms, have been called ‘semi-reflex.’ The act of running towards the train, on the other hand, has no instinctive element about it. It is purely the result of education, and is preceded by a consciousness of the purpose to be attained and a distinct mandate of the will. It is a ‘voluntary act.’ Thus the animal’s reflex and voluntary performances shade into each other gradually, being connected by acts which may often occur automatically, but may also be modified by conscious intelligence. … [I 14]

… Let us now look a little more closely at the brain and at the ways in which its states may be supposed to condition those of the mind.

THE FROG’S NERVE-CENTRES. Both the minute anatomy and the detailed physiology of the brain are achievements of the present generation … [I 14]

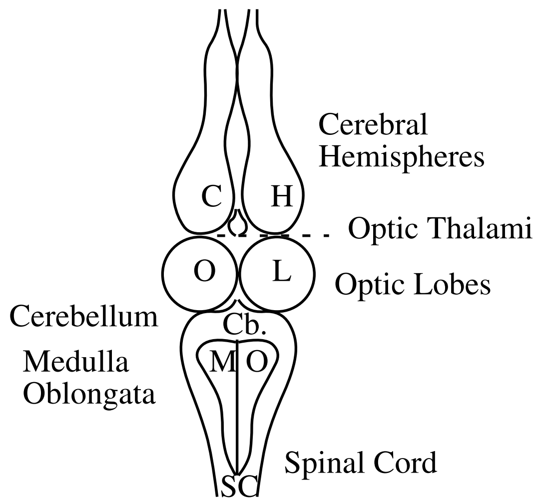


Fig. 2.1 The frog's nerve-centres

The best way to enter the subject will be to take a lower creature, like a frog, and study by the vivisectional method the functions of his different nerve-centres. The frog’s nerve-centres are figured in the accompanying diagram (Fig. 2.1), which needs no further explanation. I will first proceed to state what happens when various amounts of the anterior parts are removed, in different frogs, in the way in which an ordinary student removes them; that is, with no

> extreme precautions as to the purity of the operation. We shall in this way reach a very simple conception of the functions of the various centres, involving the strongest possible contrast between the cerebral hemispheres and the lower lobes.

James continues on pages 15 to 18 to present detailed descriptions of the movements observed in frogs whose nervous system has been modified by a section at one of several points between the parts shown in Fig. 2.1. He continues [I 18]:

> Such are the phenomena commonly observed, and such the impressions which one naturally receives. Certain general conclusions follow irresistibly. First of all the following:
>
> *The acts of all the centres involve the use of the same muscles.* … [I 19]
>
> *The same muscle, then, is repeatedly represented at different heights;* and at each it enters into a different combination with other muscles to co-operate in some special form of concerted movement. *At each height the movement is discharged by some particular form of sensorial stimulus.* … [I 20]
>
> GENERAL NOTION OF HEMISPHERES. All these facts lead us, when we think about them, to some such explanatory conception as this: *The lower centres act from present sensational stimuli alone; the hemispheres act from perceptions and considerations*, the sensations which they may receive serving only as suggesters of these. But what are perceptions but sensations grouped together? and what are considerations but expectations, in the fancy, of sensations which will be felt one way or another according as action takes this course or that? … [I 20] and the *difference between the hemisphereless animal and the whole one* may be concisely expressed by saying that the *one obeys absent, the other only present, objects.*
>
> The hemispheres would then seem to be *the seat of memory.* Vestiges of past experience must in some way be stored up in them, and must, when aroused by present stimuli, first appear as representations of distant goods and evils; and then must discharge into the appropriate motor channels for warding off the evil and securing the benefits of the good. If we liken the nervous currents to electric currents, we can compare the nervous system, *C*, below the hemispheres to a direct circuit from sense-organ to muscle along the line *S…C…M* of Fig. 2.2. The hemisphere, *H*, adds the long circuit or loop-line through which the current may pass when for any reason the direct line is not used. … [I 23]
>
> In the 'loop-line' along which the memories and ideas of the distant are supposed to lie, the action, so far as it is a physical process, must be interpreted after the type of the action in the lower centres. If regarded here as a reflex process, it must be reflex there as well. The current in both places runs out into muscles only after it has first run in; but whilst the path by which it runs out is determined in the lower centres by reflections few and fixed amongst the cell-arrangements, in the hemispheres the reflections are many and instable. This, it will be seen, is only a difference of degree and not of kind, and does not change the reflex type. The conception of *all* action as

conforming to this type is the fundamental conception of modern nerve-physiology. So much for our general preliminary conception of the nerve-centres! Let us define it more distinctly before we see how well physiological observation will bear it out in detail. [I 24]

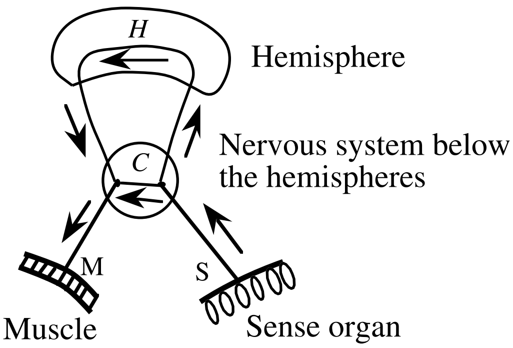


Fig. 2.2 Circuits of the nervous system

> THE EDUCATION OF THE HEMISPHERES. Nerve-currents run in through sense-organs, and whilst provoking reflex acts in the lower centres, they arouse ideas in the hemispheres, which either permit the reflexes in question, check them, or substitute others for them. All ideas being in the last resort reminiscences, the question to answer is: *How can processes become organized in the hemispheres which correspond to reminiscences in the mind?** (Footnote: * I hope that the reader will take no umbrage at my so mixing the physical and mental, and talking of reflex acts and hemispheres and reminiscences in the same breath, as if they were homogeneous quantities …)

James continues to describe how the education of the hemispheres may take place by what he calls 'the Meynert scheme', proposed by Theodor Meynert in 1874, saying [I 24]:

> Nothing is easier than to conceive a *possible* way in which this might be done, provided four assumptions be granted. These assumptions (which after all are inevitable in any event) are:
>
> 1) The same cerebral process which, when aroused from without by a sense-organ, gives the perception of an object, will give an *idea* of the same object when aroused by other cerebral processes from within.
>
> 2) If processes 1, 2, 3, 4 have once been aroused together or in immediate succession, any subsequent arousal of any one of them (whether from without or within) will tend to arouse the others in the original order. [This is the so-called law of association.]
>
> 3) Every sensorial excitement propagated to a lower centre tends to spread upwards and arouse an idea.

4) Every idea tends ultimately to produce a movement or to check one which otherwise would be produced.

Suppose now (these assumptions being granted) that we have a baby before us who sees a candle-flame for the first time, and, by virtue of a reflex tendency common in babies of a certain age, extends his hand to grasp it …

James continues here to present a description of the neural events taking place in the baby in this situation, including two figures showing paths of neural currents between various of the baby's organs, such as eyes and fingers. However, he concludes this description as follows [I 26]:

All this, as a mere scheme, is so clear and so concordant with the general look of the facts as almost to impose itself on our belief; but it is anything but clear in detail.

The lack of clarity of the Meynert scheme is a matter more particularly of the talk, in assumption 1, of (1) cerebral process, (2) the perception of an object, (3) an *idea* of the same object, and further of (4) the neural embodiment of assumption 2. These shortcomings reflect the fact that the Meynert scheme gives no attention to the neural embodiment of what James calls the stream of thought, to be discussed below.

Later, on pages I 72-80, James takes up the Meynert scheme again, discussing certain modifications of it. But as his final words on his discussion of the education of the hemispheres he says [I 80]:

Some such shadowy view of the evolution of the centres, of the relation of consciousness to them, and of the hemispheres to the other lobes, is, it seems to me, that in which it is safest to indulge. If it has no other advantage, it at any rate makes us realize how enormous are the gaps in our knowledge, the moment we try to cover the facts by any one formula of a general kind.

2.2 The summation of stimuli

In the continuation James confirms his reservation [I 81]:

CHAPTER III. ON SOME GENERAL CONDITIONS OF BRAIN-ACTIVITY. The elementary properties of nerve-tissue on which the brain-functions depend are far from being satisfactorily made out. The scheme that suggests itself in the first instance to the mind, because it is so obvious, is certainly false: I mean the notion that each cell stands for an idea or part of an idea, and that the ideas are associated or 'bound into bundles' (to use a phrase of Locke's) by the fibres. …

Let us therefore relegate the subject of the *intimate* workings of the brain to the physiology of the future, save in respect to a few points of which a word must now be said. And first of THE SUMMATION OF STIMULI in the same nerve-tract. This is a property extremely important for the understanding of a great many phenomena of the neural, and consequently of the mental, life; and it behooves us to gain a clear conception of what it means before we proceed farther.

The law is this, that *a stimulus which would be inadequate by itself to excite* *a nerve-centre to effective discharge may, by acting with one or more other stimuli (equally ineffectual by themselves alone) bring the discharge about.*… [I 84]

We constantly use the summation of stimuli in our practical appeals. If a car-horse balks, the final way of starting him is by applying a number of customary incitements at once. If the driver uses reins and voice, if one bystander pulls at his head, another lashes his hind quarters, and the conductor rings the bell, and the dismounted passengers shove the car, all at the same moment, his obstinacy generally yields, and he goes on his way rejoicing. If we are striving to remember a lost name or fact, we think of as many 'cues' as possible, so that by their joint action they may recall what no one of them can recall alone.…

2.3 The law of diffusion

James describes another general property of the function of the nervous system known as the *Law of Diffusion* [II 372]:

CHAPTER XXIII. THE PRODUCTION OF MOVEMENT. … Every impression which impinges on the incoming nerves produces some discharge down the outgoing ones, whether we be aware of it or not. Using sweeping terms and ignoring exceptions, *we might say that every possible feeling produces a movement, and that the movement is a movement of the entire organism, and of each and all its parts.* What happens patently when an explosion or a flash of lightening startles us, or when we are tickled, happens latently with every sensation which we receive. The only reason why we do not feel the startle or tickle in the case of insignificant sensations is partly its very small amount, partly our obtuseness. Professor Bain many years ago gave the name of the Law of Diffusion to this phenomenon of general discharge... [II 374]

… I can briefly string together here a number of separate observations which prove the truth of the law of diffusion.

First take *effects upon the circulation.* … [II 376]

The effects upon respiration of sudden sensory stimuli are also too well know to need elaborate comment. … [II 377]

On the sweat-glands, similar consequences of sensory stimuli are observed. … [II 379]

Effects on Voluntary Muscles. Every sensorial stimulus not only sends a special discharge into certain particular muscles dependent on the special nature of the stimulus in question—some of these special discharge we shall examine under the heads of Instinct and Emotion—but it innervates the muscles generally. … [II 381]

Looking back over all these facts, it is hard to doubt the truth of the law of diffusion, even where verification is beyond reach. *A process set up anywhere in the centres reverberates everywhere, and in some way or other affects the organism throughout, making its activities either greater or less.*

2.4 Habitual chains of muscular contractions

James states the fundamental issue of habit [I 104]:

> CHAPTER IV. HABIT. When we look at living creatures from an outward point of view, one of the first things that strike us is that they are bundles of habits. … [I 105] … *the phenomena of habit in living beings are due to the plasticity* of the organic materials of which their bodies are composed.* (Footnote: *In the sense above explained, which applies to inner structure as well as to outer form.)…

James describes the function of habit and feelings in the performance of muscular acts [I 114]:

> … *habit diminishes the conscious attention with which our acts are performed.*
>
> One may state this abstractly thus: If an act require for its execution a chain, *A, B, C, D, E, F, G,* etc., of successive nervous events, then in the first performances of the action the conscious will must choose each of these events from a number of wrong alternatives that tend to present themselves; but habit soon brings it about that each event calls up its own appropriate successor without any alternative offering itself, and without any reference to the conscious will, until at last the whole chain, *A, B, C, D, E, F, G,* rattles itself off as soon as *A* occurs, just as if *A* and the rest of the chain were fused into a continuous stream. … [I 115]
>
> These results may be expressed as follows:
>
> In action grown habitual, what instigates each new muscular contraction to take place in its appointed order is not a thought or perception, but the *sensation occasioned by the muscular contraction just finished.* A strictly voluntary act has to be guided by idea, perception, and volition, throughout its whole course. In habitual action, mere sensation is a sufficient guide, and the upper regions of brain and mind are set comparatively free. Fig. 2.3 will make the matter clear:

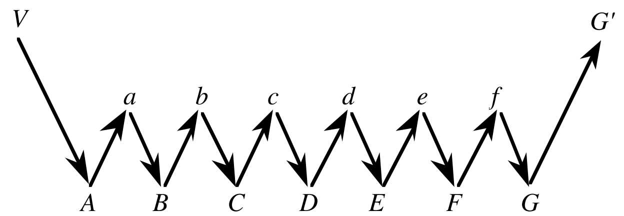


Fig. 2.3 Habitual chain of muscular contractions and sensations

> Let *A*, *B*, *C*, *D*, *E*, *F*, *G* represent an habitual chain of muscular contractions, and let *a*, *b*, *c*, *d*, *e*, *f* stand for the respective sensations which these contractions excite in us when they are successively performed. Such sensations will usually be of the muscles, skin, or joints of the parts moved, but they may also be effects of the movement upon the eye or the ear. Through them, and through them alone, we are made aware whether the contraction has or has not occurred. When the series, *A*, *B*, *C*, *D*, *E*, *F*, *G*, is being learned, each of these sensations becomes the object of a separate perception by the mind. By it we test each movement, to see if it be right before advancing to the next. We hesitate, compare, choose, revoke, reject, etc., by intellectual means; and

the order by which the next movement is discharged is an express order from the ideational centres after this deliberation has been gone through.

In habitual action, on the contrary, the only impulse which the centres of idea or perception need send down is the initial impulse, the command to *start*. This is represented in the diagram by *V*; it may be a thought of the first movement or of the last result, or a mere perception of some of the habitual conditions of the chain, the presence, e.g., of the keyboard near the hand. In the present case, no sooner has the conscious thought or volition instigated movement *A*, than *A*, through the sensation *a* of its own occurrence, awakens *B* reflexly; *B* then excites *C* through *b*, and so on till the chain is ended, when the intellect generally takes cognizance of the final result. The process, in fact, resembles the passage of a wave of 'peristaltic' motion down the bowels. The intellectual perception at the end is indicated in the diagram by the effect of *G* being represented, at *G'*, in the ideational centres above the merely sensational line. The sensational impressions, *a*, *b*, *c*, *d*, *e*, *f*, are all supposed to have their seat below the ideational lines. That our ideational centres, if involved at all by *a*, *b*, *c*, *d*, *e*, *f*, are involved in a minimal degree, is shown by the fact that the attention may be wholly absorbed elsewhere. We may say our prayers, or repeat the alphabet, with our attention far away.

2.5 The idea of a voluntary movement

James later returns to the questions of the nervous control of movements [II 486]:

> CHAPTER XXVI. WILL. ... we may start with the proposition that the only *direct* outward effects of our will are bodily movements. … The movements to the study of which we now address ourselves, being desired and intended beforehand, are of course done with full prevision of what they are to be. It follows from this that *voluntary movements must be secondary, not primary functions of our organism. …* [II 487]
>
> As we must wait for the sensations to be given us, so we must wait for the movements to be performed involuntarily,* (Footnote: *I am abstracting at present for simplicity's sake, and so as to keep to the elements of the matter, from the learning of acts by seeing others do them.) before we can frame ideas of what either of these things are. … [II 488]
>
> *A supply of ideas of the various movements that are possible left in the memory by experiences of their involuntary performance is thus the first prerequisite of the voluntary life.*
>
> Now the same movement involuntarily performed may leave many different kinds of ideas of itself in the memory. If performed by another person, we of course *see* it, or we *feel* it if the moving part strikes another part of our own body. …
>
> But in addition to these impressions upon remote organs of sense, we have, whenever we perform a movement ourselves, another set of impressions, those, namely, which come up from the parts that are actually moved. These *kinæsthetic* impressions, as Dr. Bastian has called them, are so many *resident* effects of the motion. …

… the tendons, the ligaments, the articular surfaces, and the skin about the joints are all sensitive, and, being stretched and squeezed in ways characteristic of each particular movement, give us as many distinctive feelings as there are movements possible to perform. … [II 492]

… We may consequently set it down as certain that, *whether or no there be anything else in the mind at the moment when we consciously will a certain act, a mental conception made up of memory-images of these sensations, defining which special act it is, must be there.*

Now *is there anything else in the mind when we will to do an act?* We must proceed in this chapter from the simpler to the more complicated cases. My first thesis accordingly is, that *there need be nothing else*, and that *in perfectly simple voluntary acts there is nothing else, in the mind but the kinæsthetic idea, thus defined, of what the act is to be.* … [II 497]

Now if we analyze the nervous mechanism of voluntary action, we shall see that by virtue of this principle of parsimony in consciousness the motor discharge *ought* to be devoid of sentience. If we call the immediate psychic antecedent of a movement the latter's *mental cue*, all that is needed for invariability of sequence on the movement's part is a *fixed connection* between each several mental cue, and one particular movement. … [II 518]

If the ideas by which we discriminate between one movement and another, at the instant of deciding in our mind which one we shall perform, are always of sensorial origin, then the question arises, "Of which sensorial order need they be?" It will be remembered that we distinguish two orders of kinæsthetic impressions, the *remote* ones, made by the movement on the eye or ear or distant skin, etc., and the *resident* ones, made on the moving parts themselves, muscles, joints, etc. Now do resident images, exclusively, form what I have called the mental cue, or will remote ones equally suffice?

There can be no doubt whatever that the mental cue may be either an image of the resident or of the remote kind. Although, at the outset of our learning a movement, it would seem that the resident feelings must come strongly before consciousness (cf. p. 487), later this need not be the case. The rule, in fact, would seem to be that they tend to lapse more and more from consciousness, and that the more practised we become in a movement, the more 'remote' do the ideas become which form its mental cue. What we are *interested* in is what sticks in our consciousness; everything else we get rid of as quickly as we can. Our resident feelings of movement have no substantive interest for us at all, as a rule. What interest us are the ends which the movement is to attain. … [II 519]

The idea of the end, then, tends more and more to make itself all-sufficient. … An end consented to as soon as conceived innervates directly the centre of the first movement of the chain which leads to its accomplishment, and then the whole chain rattles off *quasi*-reflexly, as was described on pp. 115-6 of Vol. I (page 36 above).

The reader will certainly recognize this to be true in all fluent and unhesitating voluntary acts. The only special fiat there is at the outset of the performance. A man says to himself, "I must change my shirt," and involuntarily he has taken off his coat, and his fingers are at work in their accustomed manner on his waistcoat-buttons, etc.; … [II 520] —All these are plain results of introspection and observation. … [II 521]

I trust that I have now made clear what that 'idea of a movement' is which must precede it in order that it be voluntary. It is not the thought of the innervation which the movement requires. It is the anticipation of the movement's sensible effects, resident or remote, and sometimes very remote indeed. … [II 522]

IDEO-MOTOR ACTION. The question is this: *Is the bare idea of a movement's sensible effects sufficient mental cue* (p. 497), *or must there be an additional mental antecedent, in the shape of a fiat, decision, consent, volitional mandate, or other synonymous phenomenon of consciousness, before the movement can follow?*

I answer: Sometimes the bare idea is sufficient, but sometimes an additional conscious element, in the shape of a fiat, mandate, or express consent, has to intervene and precede the movement. The cases without a fiat constitute the more fundamental, because the more simple, variety. The others involve a special complication, which must be fully discussed at the proper time. For the present let us turn to *ideo-motor action*, as it has been termed, or the sequence of movement upon the mere thought of it, as the type of the process of volition.

Whenever movement follows *unhesitatingly and immediately* the notion of it in the mind, we have ideo-motor action. We are then aware of nothing between the conception and the execution. All sorts of neuro-muscular processes come between, of course, but we know absolutely nothing of them. We think the act, and it is done; and that is all that introspection tells of the matter. Dr. Carpenter, who first used, I believe, the name of ideo-motor action, placed it, if I mistake not, among the curiosities of our mental life. The truth is that it is no curiosity, but simply the normal process stripped of disguise. Whilst talking I become conscious of a pin on the floor, or of some dust on my sleeve. Without interrupting the conversation I brush away the dust or pick up the pin. … [II 523]

In all this the determining condition of the unhesitating and resistless sequence of the act seems to be *the absence of any conflicting notion in the mind.* … [II 526]

We may then lay it down for certain that *every representatic movement awakens in some degree the actual movement which is its object; and awakens it in a maximum degree whenever it is not kept from so doing by an antagonistic representation present simultaneously to the mind.*

The express fiat, or act of mental consent to the movement, comes in when the neutralization of the antagonistic and inhibitory idea is required. … [II 527]

… Movement is the natural immediate effect of feeling, irrespective of what the quality of the feeling may be. It is so in reflex action, it is so in emotional expression, it is so in the voluntary life. …

2.6 The education of the will

James continues [II 579]:

THE EDUCATION OF THE WILL. … [II 580] Now *how can the sensory process which a movement has previously produced, discharge, when excited again, into the centre for the movement itself?* On the movement's original occurrence the motor discharge came first and the sensory process second; now in the voluntary repetition the sensory process (excited in weak or 'ideational' form) comes first, and the motor discharge comes second. To tell how this comes to pass would be to answer the problem of the education of the will in physiological terms. Evidently the problem is that of the formation of *new paths;* and the only thing to do is to make hypotheses, till we find some which seem to cover all the facts.

How is a fresh path ever formed? All paths are paths of discharge, and the discharge always takes place in the direction of least resistance, whether the cell which discharges be 'motor' or 'sensory'. The *connate* paths of least resistance are the paths of instinctive reactions; and I submit as my first hypothesis that *these paths all run one way, that is from 'sensory' cells into 'motor' cells and from motor cells into muscles, without ever taking the reverse direction. …* [II 582]

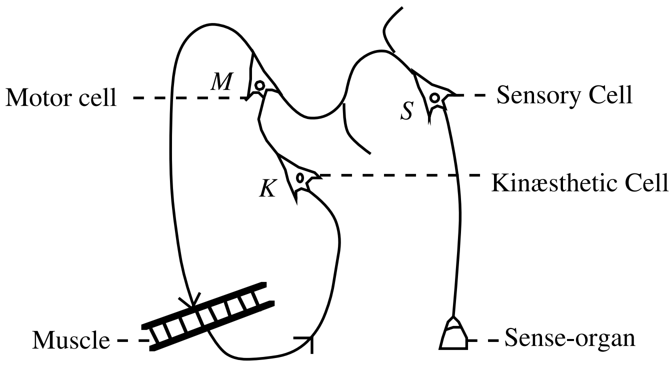


Fig. 2.4 Muscular control by the Meynert scheme

The diagram (Fig. 2.4) shows what happens in a nervous system ideally reduced to the fewest possible terms. A stimulus reaching the sense-organ awakens the sensory cell, S; this by the connate or instinctive path discharges the motor cell, M, which makes the muscle contract; and the contraction arouses the second sensory cell, K, which may be the organ either of a 'resident' or 'kinæsthetic,' or of a 'remote,' sensation (see above in section 2.4). This cell K again discharges into M. If this were the entire nervous mechanism, the movement, once begun, would be self-maintaining, and would

> stop only when the parts were exhausted. And this, according to M. Pierre Janet, is what actually happens in *catalepsy*. A cataleptic patient is anæsthetic, speechless, motionless. … [II 583]
>
> We may call this circle from the muscle to K, from K to M, and from M to the muscle again, the 'motor circle.' *We should all be cataleptic and never stop a muscular contraction once begun, were it not that other processes simultaneously going on inhibit the contraction. Inhibition is therefore not an occasional accident; it is an essential and unremitting element of our cerebral life. …*

James continues on pages II 583-87 to present descriptions, including 6 figures, of the formation of fresh paths in the nervous system. These descriptions are formed from the following neurophysiological elements shown in Fig. 2.4: paths, sense organs, muscles, sensory cells, kinæsthetic cells, and motor cells. The descriptions include the following [II 584]:

> … let us turn to the conditions under which new paths may be formed. Potentialities of new paths are furnished by the fibres which connect the sensory cells amongst themselves; but these fibres are not originally pervious, and have to be made so by a process which I proceed hypothetically to state as follows: *Each discharge from a sensory cell in the forward direction* * (* Footnote: That is, the direction towards the motor cells.) *tends to drain the cells lying behind the discharging one of whatever tension they may possess. The drainage from the rearward cells is what for the first time makes the fibres pervious. The result is a new-formed 'path,' running from the cells which were 'rearward' to the cell which was 'forward' on that occasion; which path, if on future occasions the rearward cells are independently excited, will tend to carry off their activity in the same direction so as to excite the forward cell, and will deepen itself more and more every time it is used.*

James accompanies the descriptions on his pages II 582-87 with the following reservation, stated as a note to Fig. 2.4 [II 582]:

> *This figure and the following ones are purely schematic … . The reader will of course also understand that none of the hypothetical constructions which I make from now to the end of the chapter are proposed as definite accounts of what happens. All I aim at is to make it clear in some more or less symbolic fashion that the formation of new paths, the learning of habits, etc., is in *some* mechanical way conceivable.

James's own reservation here may be amplified by noting that James argues in terms of a number of descriptive items without explaining how these items are embodied neurophysiologically. One such case was noted above in the remarks to the Meynert scheme.

Another such item of inadequacy is James's talk of *'ideas of the various movements that are possible left in the memory by experiences of their involuntary performance'* said on page II 488 to be *'the first prerequisite of the voluntary life'*. No such ideas are embodied in the neurophysiological descriptions.

Another inadequacy is that the plasticity of the neural materials mentioned on page I 105 is not clearly located in the neurophysiological descriptions on page II 582 and following.

Further unclarity creeps in with the talk of 'cerebral processes'. What is shown in James's figures are merely the paths of certain neural stimuli as these stimuli are active at a certain moment, without regard to the physiological properties of these paths as these might influence what happens at other times.

The limitations of James's neurophysiological descriptions are brought out in another way by a consideration of what James writes on page I 23: 'In the 'loop-line' …, the action, so far as it is a physical process, must be interpreted after the type of the action in the lower centres. If regarded here as a reflex process, it must be reflex there as well. The current in both places runs out into muscles only after it has first run in; ….'

The inadequacy of this description of action as being always a reflex process emerges prominently by a consideration of such an activity as the muscular actions of a well-trained pianist who plays at sight from music. His muscular hittings of the keys of the instrument are undoubtedly brought about from the visual sensations of the music, but not in the manner of a reflex reaction. The strength of his muscular exertions does not depend on the strength of the visual sensation. Moreover, the muscular activations, while dependent on the visual sensations, happen only when the player is in a particular mental state of intending to play. When not in such a state the player may have visual sensations of the music without reacting by muscular activations.

These facts suggest that the direct effect of the visual sensations is merely to excite what James calls 'the ideas of the various movements.' However, James's neurophysiological descriptions lack an embodiment of such ideas. They do not accommodate the possibility that in some cases, perhaps in most, the excitation from sensory and kinæsthetic cells acts merely so as to open a path from an internal excitation source into 'motor' cells.

This suggests that James's talk on page II 583 of *inhibition* as an important element of our cerebral life may be misleading. Much rather, the release of an action may depend on a *summation of stimuli* (James I 82), some coming from sensations, some from the internal state. Thus when the sensations fail to release the action the reason may be that the internal state is not proper. Example: the pianist who senses the music when he is not in the situation of playing.

2.7 Summary of the neurophysiological description of movements

In summary of this discussion of James's neurophysiological descriptions of movements, in so far as they are grounded in the Meynert scheme they are inadequate, as realized by James himself. However, even so they present several valuable ideas that—as will be seen in more detail below—support the synapse-state theory:

1) The notion presented on page I 12 that actions result from neural excitations of muscles.

2) The distinction presented on page I 13 between reflex, semi-reflex, and voluntary actions and the corresponding picture on page I 20 (Fig. 2.2) of the role of the hemispheres.

3) The realization expressed on page I 81: 'The scheme that suggests itself in the first instance to the mind, because it is so obvious, is certainly false: I mean the notion that each cell stands for an idea or part of an idea, and that the ideas are associated or "bound into bundles" (to use a phrase of Locke's) by the fibres.'

4) The property of *summation of stimuli in the same nerve-tract*, emphasized by James on page I 81 as one important phenomenon of the neural life. In the synapse-state theory this phenomenon is basic, embodied in the way the excitations arriving in a node add together in the excitation of that node.

5) The notion stated on page I 105 that *'the phenomena of habit in living beings are due to the plasticity of the organic materials of which their bodies are composed.'* The plasticity of synapses is the core idea of the synapse-state theory.

6) The notion developed on pages I 115-17 that in concatenated series of actions, each action is activated from the feelings developed in muscles by the previous action in the series.

7) The Law of Diffusion discussed by James on pages II 372-81. This is embodied in the synapse-state theory in that the nervous system is one connected whole, every node connected through a synapse to every other.

8) The notion developed on pages II 486-88 to the effect that *'A supply of ideas of the various movements that are possible left in the memory by experiences of the involuntary performance is thus the first prerequisite of the voluntary life.'* According to the synapse-state theory such ideas are embodied in the nervous system in th form of nodes.

9) James's assumption on page II 584 of the perviousness of the nervous fibres forming new 'paths'. The characteristics of the fibres described here are quit similar to those assumed of the synapses in the synapse-state theory.

2.8 The stream of thought and feelings

The *stream of thought* is a central issue in James's description of the mental life. He says first [I 183]:

> CHAPTER VII. THE METHODS AND SNARES OF PSYCHOLOGY. … [I 185]: All people unhesitatingly believe that they feel themselves thinking, and that they distinguish the mental state as an inward activity or passion, from all the objects with which it may cognitively deal.

Later he says [I 224]:

> CHAPTER IX. THE STREAM OF THOUGHT. … *The first fact for us, then, as psychologists, is that thinking of some sort goes on.* … [I 229]
>
> 2) *Thought is in constant Change.* … [I 230] *no state once gone can recur and be identical with what it was before.*…[I 237]
>
> *Within each personal consciousness, thought is sensibly continuous.* … [I 239]
>
> Consciousness, then, does not appear to itself chopped up in bits. Such words as 'chain' or 'train' do not describe it fitly as it presents itself in the first instance. It is nothing jointed; it flows. A 'river' or a 'stream' are the metaphors

by which it is most naturally described. *In talking of it hereafter, let us call it the stream of thought, of consciousness, or of subjective life*. … [I 243]

This difference in the rate of change [of our thoughts] lies at the basis of a difference of subjective states of which we ought immediately to speak. When the rate is slow we are aware of the object of our thought in a comparatively restful and stable way. When rapid, we are aware of a passage, a relation, a transition *from* it, or *between* it and something else. As we take, in fact, a general view of the wonderful stream of our consciousness, what strikes us first is this different pace of its parts. Like a bird's life, it seems to be made of an alternation of flights and perchings. The rhythm of language expresses this, where every thought is expressed in a sentence, and every sentence closed by a period. The resting-places are usually occupied by sensorial imaginations of some sort, whose peculiarity is that they can be held before the mind for an indefinite time, and contemplated without changing; the places of flight are filled with thoughts of relations, static or dynamic, that for the most part obtain between the matters contemplated in the periods of comparative rest.

Let us call the resting-places the 'substantive parts', and the places of flight the 'transitive parts', of the stream of thought. It then appears that the main end of our thinking is at all times the attainment of some other substantive part than the one from which we have just been dislodged. And we may say that the main use of the transitive parts is to lead us from one substantive conclusion to another.

James stresses the all-pervasive role of *feelings* [I 245]:

If there be such things as feelings at all, *then so surely as relations between objects exist in rerum naturâ, so surely, and more surely, do feelings exist to which these relations are known.* There is not a conjunction or a preposition, and hardly an adverbial phrase, syntactic form, or inflection of voice, in human speech, that does not express some shading or other of relation which we at some moment actually feel to exist between the larger objects of our thought.

2.9 The cognitive function of thoughts and thought objects

As core issues James introduces *the cognitive function of thoughts* and *thought objects* [I 271]:

Human thought appears to deal with objects independent of itself; that is, it is cognitive, or possesses the function of knowing … [I 275] … what is the mind's object when you say 'Columbus discovered America in 1492'?… the *Object* of your thought is really its entire content or deliverance, neither more nor less. … The object of my thought in the previous sentence, for example, is strictly speaking neither Columbus, nor America, nor its discovery. It is nothing short of the entire sentence, 'Columbus-discovered-America-in-1492'. And if we wish to speak of it substantively, we must make a substantive of it by writing it out thus with hyphens between all its words. Nothing but this can possibly name its delicate idiosyncrasy. And if we wish to *feel* that idiosyncrasy we must reproduce the thought as it was uttered, with every word fringed and the whole sentence bathed in that original halo of obscure relations, which, like a horizon, then spread about its meaning. … [I 276]

The object of every thought, then, is neither more nor less than all that the thought thinks, exactly as the thought thinks it, however complicated the matter, and however symbolic the manner of the thinking may be. It is needless to say that memory can seldom accurately reproduce such an object, when once it has passed from before the mind. It either makes too little or too much of it. Its best plan is to repeat the verbal sentence, if there was one, in which the object was expressed. But for inarticulate thoughts there is not even this resource, and introspection must confess that the task exceeds her powers. The mass of our thinking vanishes for ever, beyond hope of recovery, and psychology only gathers up a few of the crumbs that fall from the feast.

The next point to make clear is that, *however complex the object may be, the thought of it is one undivided state of consciousness.*

2.10 Sensation and perception

As further characteristics of thought objects James describes the phenomena of *sensation, perception, attention,* and *imagination*. First sensation and perception [II 1]:

CHAPTER XVII. SENSATION. … SENSATION AND PERCEPTION DISTINGUISHED. *The words Sensation and Perception* … name processes in which we cognize an objective world; both (under normal conditions) need the stimulation of incoming nerves ere they can occur; Perception always involves Sensation as a portion of itself; and Sensation in turn never takes place in adult life without Perception also being there. They are therefore names for different cognitive *functions*, not for different sorts of mental *fact*. The nearer the object cognized comes to being a simple quality like 'hot,' 'cold,' 'red,' 'noise,' 'pain,' apprehended irrelatively to other things, the more the state of mind approaches pure sensation. The fuller of relations the object is, on the contrary; the more it is something classed, located, measured, compared, assigned to a function, etc., etc.; the more unreservedly do we call the state of a mind a perception, and the relatively smaller is the part in it which sensation plays.

Sensation, then, so long as we take the analytic point of view, differs from Perception only in the extreme simplicity of its object or content. Its function is that of mere *acquaintance* with a fact. Perception's function, on the other hand, is knowledge *about* … a fact; and this knowledge admits of numberless degrees of complication. But in both sensation and perception we perceive the fact as an *immediately present outward reality*, and this makes them differ from 'thought' and 'conception,' whose objects do not appear present in this immediate physical way. *From the physiological point of view both sensations and perceptions differ from 'thoughts' (in the narrower sense of the word) in the fact that nerve-currents coming in from the periphery are involved in their* *production. In perception these nerve-currents arouse voluminous associative or reproductive processes in the cortex; but when sensation occurs alone, or with a minimum of perception, the accompanying reproductive processes are at a minimum too. …*

2.11 Attention

James describes attention [I 402]:

> CHAPTER XI. ATTENTION. … [I 403]: Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of thought.

The embodiment of attention, with its influence on perception and muscular activation, is discussed by James as follows [I 432]:

> … The reader will recollect the fact noted in Chapter III (p. 93) that reaction-time is shorter when one concentrates his attention on the expected movement than when one concentrates it on the expected signal. Herr Münsterberg found that this is equally the case when the reaction is no simple reflex, but can take place only after an intellectual operation. … Even in this series of reactions *the time was much quicker when the reacter turned his attention in advance towards the answer than when he turned it towards the question. …* To understand such results, one must bear in mind that in these experiments the reacter always knew in advance in a general way the *kind* of question which he was to receive, and consequently the *sphere within which* his possible answer lay. In turning his attention, therefore, from the outset towards the answer, those brain-processes in him which were connected with this entire 'sphere' were kept sub-excited, and the question could then discharge with a minimum amount of lost time that particular answer out of the 'sphere' which belonged especially to it. When, on the contrary, the attention was kept looking towards the question exclusively and averted from the possible reply, all this preliminary sub-excitement of motor tracts failed to occur, and the entire process of answering had to be gone through with after the question was heard. No wonder that the time was prolonged. It is a beautiful example of the summation of stimulations, and of the way in which expectant attention, even when not very strongly focalized, will prepare the motor centres, and shorten the work which a stimulus has to perform on them, in order to produce a given effect when it comes.
>
> THE INTIMATE NATURE OF THE ATTENTIVE PROCESS. We have now a sufficient number of facts to warrant our considering this more recondite question. And two physiological processes, of which we have got a glimpse, immediately suggest themselves as possibly forming in combination a complete reply. I mean
>
> 1. *The accommodation or adjustment of the sensory organs;* and
>
> 2. *The anticipatory preparation from within of the ideational centres concerned with the object to which the attention is paid.*

> 1. The sense-organs and the bodily muscles which favor their exercise are adjusted most energetically in sensorial attention, whether immediate and reflex, or derived. But there are good grounds for believing that even intellectual attention, attention to the *idea* of a sensible object, is also accompanied with some degree of excitement of the sense-organs to which the object appeals. The preparation of the ideational centres exists, on the other hand, wherever our interest in the object—be it sensible or ideal—is *derived* from, or in any way connected with, other interests, or the presence of other objects, in the mind. It exists as well when the attention thus derived is classed as passive as when it is classed as voluntary. So that on the whole we may confidently conclude—since in mature life we never attend to anything without our interest in it being in some degree derived from its connection with other objects—that *the two processes of sensorial adjustment and ideational preparation probably coexist in all our concrete attentive acts.* … [I 438]
>
> 2. … This leads us to that second feature in the process, the '*ideational preparation* ' of which we spoke. *The effort to attend to the marginal region of the picture consists in nothing more nor less than the effort to form as clear an idea as is possible of what is there portrayed.* … [I 442]
>
> Every stir in the wood is for the hunter his game; for the fugitive his pursuers. Every bonnet in the street is momentarily taken by the lover to enshroud the head of his idol. The image in the mind *is* the attention; the *preperception*, as Mr. Lewes calls it, is half of the perception of the looked-for thing.
>
> It is for this reason that men have no eyes but for those aspects of things which they have already been taught to discern. … [I 444] In short, *the only things which we commonly see are those which we preperceive*, and the only things which we preperceive are those which have been labelled for us, and the labels stamped into our mind. If we lost our stock of labels we should be intellectually lost in the midst of the world. …

Briefly, the embodiment of attention is a matter of *excitations of the ideational centres concerned with the object to which the attention is paid.*

James adds some observations concerning *inattention* [I 455]:

> INATTENTION. … We do not notice the ticking of the clock, the noise of the city streets, or the roaring of the brook near the house; and even the din of a foundry or factory will not mingle with the thoughts of its workers, if they have been there long enough. … [I 456] How can impressions that are not needed by the intellect be thus shunted off from all relation to the rest of consciousness? Professor G. E. Müller has made a plausible reply to this question … He begins with the fact that 'When we first come out of a mill or factory, in which we have remained long enough to get wonted to the noise, we feel as if something were *lacking*. Our total feeling of existence is different from what it was when we were in the mill.' … [I 457] Müller's suggestion awakens another. It is a well-known fact that persons striving to keep their attention on a difficult subject will resort to movements of various unmeaning kinds, such as pacing the room, drumming with the fingers, playing with keys or watch-chain,

scratching head, pulling mustache, vibrating foot, or what not, according to the individual. There is an anecdote of Sir W. Scott, when a boy, rising to the head of his class by cutting off from the jacket of the usual head-boy a button which the latter was in the habit of twirling in his fingers during the lesson. The button gone, its owner's power of reciting also departed.

2.12 Imagination

James describes *imagination* [II 44]:

> CHAPTER XVIII. IMAGINATION. *Sensations, once experienced, modify the nervous organism, so that copies of them arise again in the mind after the original outward stimulus is gone.* No mental copy, however, can arise in the mind, of any kind of sensation which has never been directly excited from without.… Fantasy, or Imagination, are the names given to the faculty of reproducing copies of originals once felt. The imagination is called 'reproductive' when the copies are literal; 'productive' when elements from different originals are recombined so as to make new wholes.… The phenomena ordinarily ascribed to imagination, however, are those mental pictures of possible sensible experiences, to which the ordinary processes of associative thought give rise. … [II 45]
>
> OUR IMAGES ARE USUALLY VAGUE … [II 49] a blurred picture is just as much a single mental fact as a sharp picture is; and *the use of either picture by the mind to symbolize a whole class of individuals is a new mental function* … . Our ideas or images of past sensible experiences may then be either distinct and adequate or dim, blurred, and incomplete.… [II 50]
>
> INDIVIDUALS DIFFER IN IMAGINATION. The first breaker of ground in this direction was Fechner, in 1860. … [II 51] Fechner's intention was independently executed by Mr. Galton, the publication of whose results in 1880 may be said to have made an era in descriptive Psychology.
>
> > 'It is not necessary,' says Galton, 'to trouble the reader with my early tentative steps.…[II 52] To my astonishment, I found that *the great majority of the men of science to whom I first applied protested that mental imagery was unknown to them,* …[II 52] On the other hand, when I spoke to persons whom I met *in general society*, I found an entirely different disposition to prevail. *Many men and a yet larger number of women, and many boys and girls, declared that they habitually saw mental imagery, and that is was perfectly distinct to them and full of color.*'…[II 57]
>
> A person whose visual imagination is strong finds it hard to understand how those who are without the faculty can think at all. *Some people undoubtedly have no visual images at all worthy of the name*, and instead of *seeing* their breakfast-table, they tell you that they *remember* it or *know* what was on it. … [II 60]
>
> > '*The auditory type,*' says M. A. Binet [1886], '*appears to be rarer than the visual.* Persons of this type imagine what they think of in the language of

sound. … [II-61] The *motor type* remains—perhaps the most interesting of all, and certainly the one of which least is known. Persons who belong to this type … make use, in memory, reasoning, and all their intellectual operations, of images derived from movement.'…[II 63]

Most persons, on being asked *in what sort of terms they imagine words,* will say 'in terms of hearing.' It is not until their attention is expressly drawn to the point that they find it difficult to say whether auditory images or motor images connected with the organs of articulation predominate. … [II 65]

Touch-images are very strong in some people.

2.13 The specious present

The *specious present* is a matter of the gradual change of the thought object. James writes [I 606]:

CHAPTER XV, THE PERCEPTION OF TIME. … *The knowledge of some other part of the stream, past or future, near or remote, is always mixed in with our knowledge of the present thing.*

A simple sensation, as we shall hereafter see, is an abstraction, and all our concrete states of mind are representations of objects with some amount of complexity. Part of the complexity is the echo of the objects just past, and, in a less degree, perhaps, the foretaste of those just to arrive. Objects fade out of consciousness slowly. If the present thought is of A B C D E F G, the next one will be of B C D E F G H, and the one after that of C D E F G H I—the lingerings of the past dropping successively away, and the incomings of the future making up the loss. These lingerings of old objects, these incomings of new, are the germs of memory and expectation, the retrospective and the prospective sense of time. They give that continuity to consciousness without which it could not be called a stream. … [I 609]

THE SENSIBLE PRESENT HAS DURATION … The only fact of our immediate experience is what Mr. E. R. Clay has well called 'the *specious* present.' … the practically cognized present is no knife-edge, but a saddle-back, with a certain breath of its own on which we sit perched, and from which we look in two directions into time. The unit of composition of our thinking of time is a *duration*, with a bow and a stern, as it were—a rearward- and a forward-looking end.…

2.14 Retention and recall

In discussing thought objects, attention, and the specious present, James takes up their neural embodiment only in so far as he talks of ideational centres or objects. The embodiment of such items is presented more concretely when James discusses the function of memory. Here he has occasion to talk of *the neural embodiment of thinking of something*, saying [I 655, already quoted in the Introduction above]:

Let the nerve-centres (see Fig. 2.5), active in the thought of *m, n,* and *o,* be represented by M, N, and O, respectively; then the *existence* of the paths M–N and N–O will be the fact indicated by the phrase 'retention of the event *n* in the memory,' and the *excitement* of the brain along these paths will be the condition of the event *n*'s actual recall.

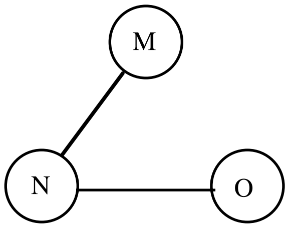


Fig. 2.5 Retention and recall of the event *n*

In other words James here assumes that there is a nerve-centre for each thing one may think of, such that when one is thinking of that something, the nerve-centre receives excitation. Further that some of these nerve-centres are connected by paths that may conduct excitations which are summed in the nerve-centres.

2.15 Association of objects experienced

The way the thought object changes from one moment to the next is described by James in terms of *association.* James states [I 550]:

> CHAPTER XIV. ASSOCIATION. … [I 561]: THE LAW OF CONTIGUITY. … the facts we have run over can all be summed up in the simple statement that *objects once experienced together tend to become associated in the imagination, so that when any one of them is thought of, the others are likely to be thought of also, in the same order of sequence or coexistence as before.* This statement we may name the law of *mental association by contiguity.* … [I 561]
>
> Whatever we name the law, since it expresses merely a phenomenon of mental *habit, the most natural way of accounting for it is to conceive it as a result of the laws of habit in the nervous system;* … [I 563]
>
> *The psychological law of association* of objects thought of through their previous contiguity in thought or experience *would thus be an effect, within the mind, of the physical fact that nerve-currents propagate themselves easiest through those tracts of conduction which have been already most in use.* Descartes and Locke hit upon this explanation, which modern science has not yet succeeded in improving. … [I 566]
>
> THE ELEMENTARY LAW OF ASSOCIATION. … Let us then assume as the *basis* of all our subsequent reasoning this law: *When two elementary brain-processes have been active together or in immediate succession, one of them, on reoccurring, tends to propagate its excitement into the other.*

James describes the neural embodiments of the phenomena of association and feelings in more detail when he discusses [I 583]:

> ASSOCIATION IN VOLUNTARY THOUGHT… It is now necessary to examine what modification is made in the trains of our imagery by the having of an end in view. The course of our ideas is then called *voluntary*. … [I 584] But in the theoretic as well as in the practical life there are interests of a more acute sort, taking the form of definite images of some achievement, be it action or acquisition, which we desire to effect. The train of ideas arising under the influence of such an interest constitutes usually the thought of the *means* by which the end shall be attained. If the end by its simple presence does not instantaneously suggest the means, the search for the latter becomes an intellectual *problem*. The solution of problems is the most characteristic and peculiar sort of voluntary thinking. Where the end thought of is some outward deed or gain, the solution is largely composed of the actual motor processes, walking, speaking, writing, etc., which lead up to it. Where the end is in the first instance only ideal, as in laying out a place of operations, the steps are purely imaginary. In both of these cases the discovery of the means may form a new sort of end, of an entirely peculiar nature, an end, namely, which we intensely desire before we have attained it, but of the nature of which, even whilst most strongly craving for it, we have no distinct imagination whatever. Such an end is a problem.
>
> The same state of things occurs whenever we seek to recall something forgotten, or to state the reason for a judgment which we have made intuitively. The desire strains and presses in a direction which it feels to be right but towards a point which it is unable to see. In short, the *absence of an item* is a determinant of our representations quite as positive as its presence can ever be. The gap becomes no mere void, but what is called an *aching* void. … [I 585] If we first study *the mode of recalling a thing forgotten*, we can take up with better understanding the voluntary quest of the unknown.
>
> The forgotten thing is felt by us as a gap in the midst of certain other things. If it is a thought, we possess a dim idea of where we were and what we were about when it occurred to us. We recollect the general subject to which it relates. But all these details refuse to shoot together into a solid whole, for the lack of the vivid traits of this missing thought, the relation whereof to each detail forms now the main interest of the latter. We keep running over the details in our mind, dissatisfied, craving somthing more. From each detail there radiate lines of association forming so many tentative guesses. Many of these are immediately seen to be irrelevant, are therefore void of interest, and lapse immediately from consciousness. Others are associated with the other details present, and with the missing thought as well. When *these* surge up, we have a peculiar feeling that we are 'warm,' as the children say when they play hide and seek; and such associates as these we clutch at and keep before the attention. Thus we recollect successively that when we had the thought in question we were at the dinner-table; and that our friend J. D. was there; then that the subject talked about was so and so; finally, that the thought came *á propos* of a certain anecdote, and then that it had something to do with a

French quotation. Now all these added associations *arise independently of the will*, by the spontaneous process we know so well. *All that the will does is to emphasize and linger over those which seem pertinent, and ignore the rest.* Through this hovering of the attention in the neighborhood of the desired object, the accumulation of associates becomes so great that the combined tensions of their neural processes break through the bar, and the nervous wave pours into the tract which has so long been awaiting its advent. And as the expectant, sub-conscious itching there, bursts into the fulness of vivid feeling, the mind finds an inexpressible relief.

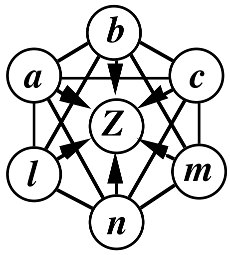


Fig. 2.6 Recalling a thing forgotten

The whole process can be rudely symbolized in a diagram (Fig. 2.6). Call the forgotten thing Z, the first facts with which we felt it was related, *a*, *b*, and *c*, and the details finally operative in calling it up, *l*, *m*, and *n*. Each circle will then stand for the brain-process underlying the thought of the object denoted by the letter contained within it. The activity in Z will at first be a mere tension, but as the activities in *a*, *b*, and *c* little by little irradiate into *l*, *m*, and *n,* and as *all* these processes are somehow connected with Z, their combined irradiations upon Z, represented by the centripetal arrows, succeed in helping the tension there to overcome the resistance, and in rousing Z also to full activity.

In summary of the neural embodiments stated in James's discussion of voluntary thinking and represented in his diagram: There are *neural centres* embodying such items as: *The forgotten thing (more generally, some desirable achievement, be it action or acquisition); *we were at the dinner-table; *our friend J. D. was there; *the subject talked about was so and so; *the thought came *á propos* of a certain anecdote; *it had something to do with a French quotation. While the process of voluntary thinking is taking place *the feelings give rise to irradiations* from each neural centre embodying an item thought of, into each other centre which is *the embodiment of an associate of that item.* The irradiations from several centres *combine* where they arrive in another centre, and they may thereby *rouse that centre to full activity.* The combination undoubtedly happens by such summation of impulses that was described in section 2.2 above.

2.16 Feelings and emotions

Concerning the embodiment of feelings and emotions James says this [II 442]:

> CHAPTER XXV. THE EMOTIONS. … *Instinctive reactions and emotional expressions thus shade imperceptibly into each other. Every object that excites an instinct excites an emotion as well.* … [II 449]:
>
> EMOTION FOLLOWS UPON THE BODILY EXPRESSION IN THE COARSER EMOTIONS AT LEAST. … My theory, on the contrary, is that *the bodily changes follow directly the perception of the exciting fact, and that ou feeling of the same changes as they occur* IS *the emotion.* … [II 450] … *every on of the bodily changes, whatsoever it be, is* FELT, *acutely or obscurely, the moment it occurs.* … [II 454] … *we immediately see why there is no limit to the number of possible different emotions which may exist, and why the emotions of different individuals may vary indefinitely*, both as to their constitution and as to objects which call them forth.

2.17 Sherrington's synapses and their plasticity

At the time of James's *Principles*, 1890, the biological ground of the plasticity of the organic materials was unknown, but only few years later the plasticity was established, largely through the researches of Charles S. Sherrington (1857-1952), as reported in the following quotations from his *The Integrative Action of the Nervous System* (1906, page 13-14):

> 'Nervous conduction has been studied chiefly in nerve-trunks. Conduction in reflexes is of course for its spatially greater part conduction along nerve-trunks, yet reflex conduction *in toto* differs widely from nerve-trunk conduction. - Salient among the characteristic differences between conduction in nerve-trunks and in reflex-arcs respectively are the following: Conduction in reflex-arcs exhibits: (1) slower speed as measured by the latent period between application of stimulus and appearance of end-effect, this difference being greater for weak stimuli than for strong; (2) less close correspondence between the moment of cessation of stimulus and the moment of cessation of end-effect, i.e. there is a marked 'after-discharge'; (3) less close correspondence between rhythm of stimulus and rhythm of end-effect; (4) less close correspondence between the grading of intensity of the stimulus and the grading of intensity of the end-effect; (5) considerable resistance to passage of a single nerve-impulse, but a resistance easily forced by a succession of impulses (temporal summation); (6) irreversibility of direction instead of reversibility as in nerve-trunks; (7) fatigability in contrast with comparative unfatigability of nerve-trunks; (8) much greater variability of the threshold value of stimulus than in nerve-trunks; (9) refractory period, 'bahnung', inhibition, and shock, in degrees unknown for nerve-trunks; (10) much greater dependence on blood-circulation, oxygen (Verworn, Winterstein, v. Baeyer, etc.); (11) much greater susceptibility to various drugs-anaesthetics.

Of these properties, (3), (5), (7), and (9) are matters of plasticity in the conduction in reflex-arcs.

As an example of the empirical basis of these assertions, this is quoted from Sherrington's observations related to (5), temporal summation (p. 36-37):

> We find striking instances of the summation of subliminal stimuli given by the scratch-reflex [of the dog]. The difficulty of exciting a reflex by a single-induction shock is well known. A scratch-reflex cannot in my experience be elicited by a single-induction shock, or even by two shocks, unless as physiological stimuli they are very intense and delivered less than 600 milliseconds apart. Although the strongest single-induction shock is therefore by itself a subliminal stimulus for this reflex, the summation power of this reflex mechanism is great. Very feeble shocks, each succeeding the other within a certain time—summation time—sum as stimuli and provoke a reflex. Thus long series of subliminal stimuli ultimately provoke the reflex. I have records where the reflex appeared only after delivery of the fortieth successive double shock, the shocks having followed each other at a frequency of 11.3 per sec., and where the reflex appeared only after delivery of the forty-fourth successive make shock, the shocks having followed at 18 per sec.

Sherrington discusses at length the evidence on what part of the organic material gives rise to the difference between conduction in reflex-arcs and nerve-trunks. Through this discussion his attention is drawn to (p. 15-17):

> the existence at the confines of the cells composing the organism of "surfaces of separation" between adjacent cells. … … The characters distinguishing reflex-arc conduction from nerve-trunk conduction may therefore be largely due to intercellular barriers, delicate transverse membranes, in the former. - In view, therefore, of the probable importance physiologically of this mode of nexus between neurone and neurone it is convenient to have a term for it. The term introduced has been *synapse*.

This in particular means that the most likely location of the plasticity of the organic material will be the synapses.

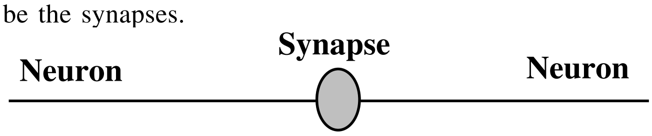


Fig. 2.7 Sherrington's synapse connection

To fix the ideas, Fig. 2.7 is a picture of the place of a synapse in the nervous system.

Sherrington further says (p. 157):

> There is abundant evidence that different synapses differ from one another. That neurones should differ in the threshold value of the stimulus necessary to excite them seems only natural. The arguments adduced by Goldschneider point in the same direction. Many of the phenomena considered in the first three lectures are easiest explicable by such differences. The distinctions between different synapses in regard to ease of alteration by strychnine and by tetanus toxin emphasize this probability further.

2.18 The synapse-state theory of mental life

By the synapse-state theory, mental life is embodied in *excitations* in a neural structure composed of *synapses, neurons,* and *nodes,* shown in Fig. 2.8. The excitations originate in the sense cells and in the *attention excitation* and the *specious pesent excitation*, and are transmitted along the neurons, through the synapses, and are summed and distributed in the nodes. The summation of excitations in the nodes embodies the *summation of impulses*.

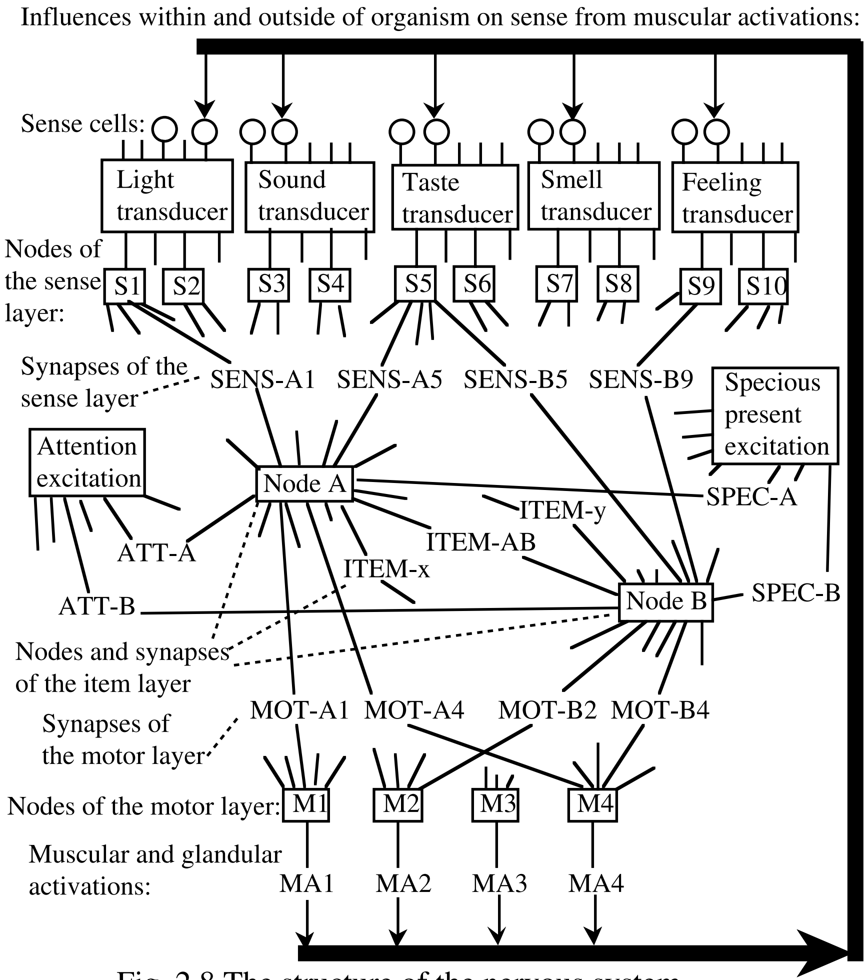


Fig. 2.8 The structure of the nervous system

FIVE LAYERS. The neural structure has five different *layers:* (1) *item layer*, (2) *attention layer*, (3) *specious-present layer*, (4) *sense layer*, (5) *motor layer*. In Fig. 2.8 the item layer is in the centre, the attention layer is to the left, the specious-present layer to the right, the sense layer is at the top, closely connected to the *sense transducers*, and the motor layer is below, connected to muscles and glands. Each of these layers has its own kind of synapses with specific properties. The nodes are shown within boxes, the neurons are lines, and the synapses are identified as ITEM, ATT, SPEC, SENS, or MOT.

ITEM LAYER. With its synapses this embodies the long term habits of the organism, in other words, all what is there through many years of our life, more or less prominently. It consists of nodes where the neurons join in large numbers. The figure shows two nodes: Node A and Node B. Of such nodes there are roughly 100,000. Each such node is connected to every other through a path consisting of a neuron, a synapse, and a neuron. One of these paths is shown in the figure: Node A, neuron, ITEM-AB, neuron, Node B. Such a connection with a synapse connects every pair of nodes in this layer. Thus there must be of the order of 10 thousand million synapses. These synapses have that plasticity which embodies all the long term habits of our mental life.

In the figure the many neurons that connect to each node are suggested by the many short lines. From each node there are about 100,000 of them, since they should connect to 100,000 others. These connections embody the *Law of Diffusion*. The nodes embody *acquaintance objects* and other items of mental life.

The plastic properties of the ITEM-synapses are such that in the newborn individual they have low conductivity. But the moment the two nodes to which a synapse is connected are both excited, the synapse becomes conductive. It will develop every time the two connecting nodes are excited, getting more conductive in a plastic way. In this way the items embodied in the two nodes become *associated,* with the effect that whenever one of them gets excited the other one becomes excited as well since the synapse connecting them will conduct the excitation. It will conduct in both directions. If no re-excitation takes place the synapse will slowly, gradually over years, lose the conductivity again.

ATTENTION LAYER. Each node in the item layer has one connection, through one attention synapse, to a common node, denoted *attention excitation*. So ATT-A and ATT-B are two attention-synapses. But their properties are entirely different from those of the synapses in the item layer. An attention-synapse, for example ATT-A, works such that if the connected node, here Node A, gets excited beyond a certain level of strength—and this may happen through its connection to and excitation from nodes of the sense layer, such as S1 and S5, or from other nodes in the item layer with which it is associated, e.g. Node B—if this excitation rises to a certain level it will excite the attention-synapse ATT-A, with the consequence that this synapse becomes conductive for a duration of about one second and conducts a strong excitation from the attention excitation into Node A. This will influence the summation of impulses in that node. If Node A is already strongly excited and then in addition receives excitation from the attention-synapse ATT-A, it will have extra strength. This is the impulse that—as we say—attracts the attention. At this moment the attention sits in Node A.

When the synapse ATT-A has delivered this impulse—it lasts only about a second—it will cease the excitation, and may be assumed to be tired after this action. Probably it will have to recover for perhaps 20 or 30 seconds before it is ready to act again.

SPECIOUS PRESENT LAYER. Each node in the item layer is connected to just one specious-present-synapse, denoted SPEC. Every SPEC-synapse is connected to a common node denoted *specious-present-excitation*. These synapses work somewhat like the attention-synapses, but slower. Normally they will have no conductivity, so no excitation will come through from the specious-present-excitation. But when their connected node becomes excited above a certain level—perhaps because the connected attention-synapse has delivered an impulse—the specious-present-synapse gets excited and will then conduct an excitation from the specious-present-excitation into the same node, and this extra excitation will gradually fall off within a time scale of about 20 seconds. This means that there may be a handful of these synapses, perhaps 5 or 10, that are all at some stage of falling off in their excitation. They form a queue of nodes that have been strongly excited within the latest minute or so, thereby embodying the specious present.

SENSE LAYER. The *sense layer* has a number of nodes of which only a few are shown: S1, S2, …, S10. Each such node gets excited from one of the senses. There is a certain transformation of sense impulses in the sense transducers, different for each sense, and the resulting impulses are sent to the nodes. From each such node there is a connection through a synapse to every one of the nodes in the item layer. A few of them are shown: SENS-A1, SENS-A5, SENS-B5, and SENS-B9. These synapses again are plastic. In the young individual they will have only low conductivity. But by being excited from both sides simultaneously they gain in a conductivity which is higher in the direction towards the node in the item layer, and lower in the opposite direction. Whenever we have a sensation there will therefore be a tendency that certain of the item-nodes become excited. When having a sensation of something specific a whole number of the nodes S1, S2, …, S10—there may be hundreds of them—will receive an excitation. And if from each of the hundred there is a conductive synapse into one particular item-node, this node by summation of the impulses will become strongly excited. When this excitation is strong enough to excite the attention-synapse of the node, this is called *perception* of the corresponding acquaintance object.

What is embodied in the node may for example be the acquaintance object of my mother. Certain impulses make me think of my mother, that is make my mother come forth in my stream of thought. It may be sense impressions, but it may also be many other things and combinations of things.

The conductivity in the opposite direction, from ITEM-nodes to SENS-nodes, is a matter of imagery. When we think of something we get an image in our stream of thought, by the excitations in the opposite direction. But in many people the image is faint and blurred. It is blurred because there is no strict relation between the set of impulses that excite the ITEM-node and the nodes in the sense layer.

THE EXPERIENCE. A very important matter should be said: the excitation of the nodes in the sense layer, S1, S2, …, S10, that is where the *experience* happens. That is what we see, hear, smell, taste, feel. Whenever one of these nodes is excited we experience it in the stream of thought.

MOTOR LAYER. Finally about the *motor layer*. It has a number of nodes, M1, M2, …, each of which may excite a muscle or a gland. Each of these nodes is connected through a synapse of a special kind, a MOT-synapse, to every node in the item layer. This is where the activations of muscles take place, depending on whether certain synapses have been made conductive, again plastically, and again with a long term plasticity, but with a shorter time scale than in the case of the ITEM-synapses—perhaps to be reckoned in weeks or months, where in the item layer it is a matter of years. The training of a muscular action decays quite rapidly. When in playing the flute one has trained a particular muscular figure, it takes no more that a week before it it noticeably deteriorated. It is a matter of the MOT-synapses.

But again it is so that the conductivity of the active synapses is increased by training.

INTERNAL FEELINGS. Finally Fig. 2.8 turns the attention to a general, important matter, with the thick black arrow that shows influences from muscular activations to sense cells. This is a phenomenon that William James points out very clearly, that all what we call *feelings* and *emotions* is a matter of the muscles having sense cells in them. When we feel something the primary phenomenon is that certain muscles or glands are activated. And then, in the muscles, anywhere in the organism, there are sense cells that are influenced by the activity. This is a very important process that happens all the time, that we in this way experience, feel, the state of our own body. That is what is indicated by the thick line.

It may also be a muscular action which one picks up visually, for example a movement of the hand. One sees the movement. The impulse goes the same way.

This connection is a decisive circumstance in the way our *movements* are controlled from the nervous system.

THE THOUGHT OBJECT - ASSOCIATIONS. The neural embodiment of a *thought object* is a matter of excitations of a large number of components of the item layer, as these excitations happen at one moment. Fig. 2.9 is a picture of the excitations of a small fraction of the components of one thought object, showing the nodes A, B, C, F, G, H, I, J, K, and L, of the item layer. The neural components of a thought object are excited to different degrees, a few being excited strongly and an indefinite number at various degrees of faintness. The relative strengths of excitation of some of the nodes are suggested roughly in the figure by the thickness of the frames, node C being the one most strongly excited.

The identifiers of nodes and synapses shown in the figure, such as A, S3, BMG, and SPEC-C, are there merely for the purpose of description. They are not represented in the nervous system. Identifiers written in the figure followed by …, such as ‘N-light…’ and ‘S1…’ are to be understood as representative of a group of components of the same kind that have the same position in the network. Thus for example the path from ‘Light transducer’ into node B shown through ‘N-light…’ and ‘S1…’ should be understood to consist of a number, perhaps thousands, of parallel paths. The neurons along such paths are shown as thick lines.

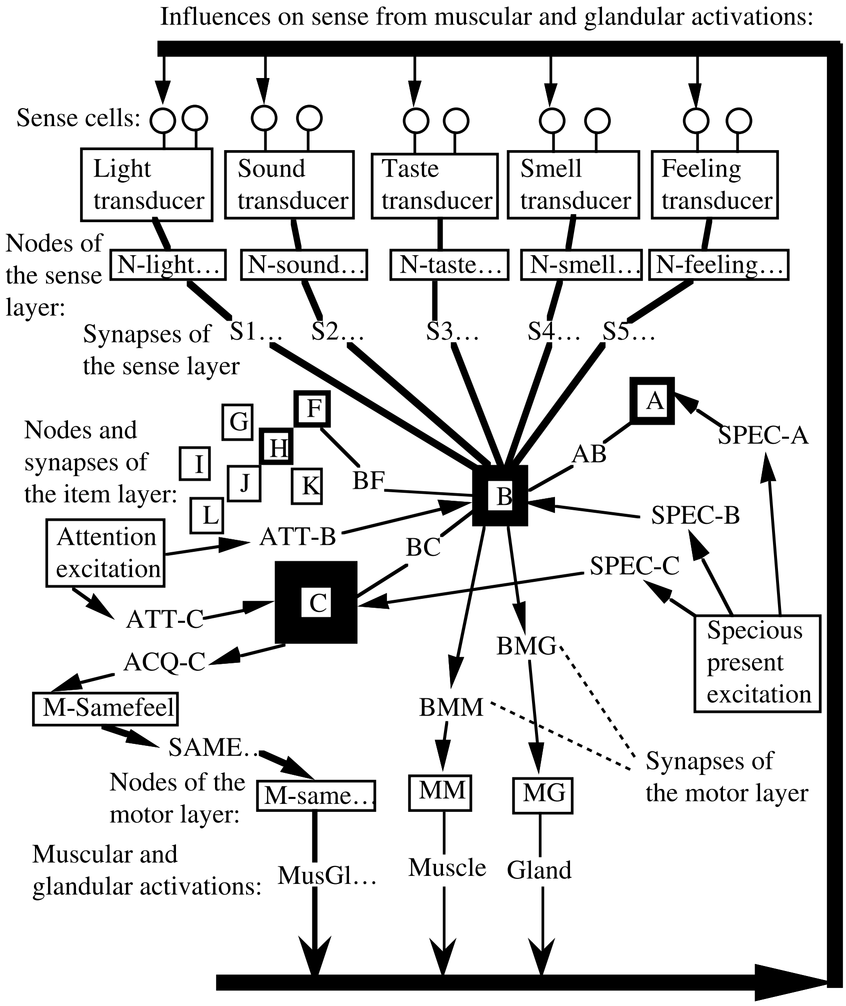


Fig. 2.9 Embodiment of thought object

The excitations originate in the sense cells and in the attention and specious present excitations. They are distributed into the nodes through the neurons, shown as lines or arrows, and the synapses, shown as letter combinations, such as BF, BMG, and S5…. The arrowheads on some of the lines of neurons show the direction of transmission of excitation along the neuron at the moment. They are not properties of the neurons. All synapses shown in the figure are such that as a result of the education of the nervous system have been put into states of lower or higher conductivity.

The excitation of each of the nodes of the thought object results from summation of several contributions. The contributions of excitations originate partly in sense cells, partly are the ones transmitted through the attention synapse ATT-C and the specious present synapses SPEC-A, SPEC-B, and SPEC-C. The contributions from the attention synapse and the specious present synapses cater for the enhanced excitation of the nodes A, B, and C, at the moment, C being the embodiment of the object of the momentary attention, and A and B the embodiments of some of the objects that have been excited from their attention synapse during the most recent specious present. There may be further objects: D, E, …, receiving excitements from their specious present synapses, whose embodiments are not shown in the figure. The remaining nodes of the item layer shown, F, G, H, I, J, K, and L, embody the *fringe* of the nodes A, B, C, D, E, …. They get excited from such other nodes with which they are connected through conductive synapses. In the figure one such connection is shown, the synapse BF, but many more must be assumed to be in effect. Through such connections the nodes of the fringe are excited to various strengths, but weaker than the nodes A, B, C, ….

The different excitation contributions that may form the excitation of each node will be explained more specifically only as they might excite node B and be distributed from there, but it must be understood that similar contributions might be transmitted at the same moment into every other of the nodes of the item layer shown. The contributions transmitted into node B may include:

(1) Excitations originating from sense impressions, transmitted through the node sets N-light …, N-sound …, N-taste …, N-smell …, and N-feeling …, and the synapse sets S1 …, S2 …, S3 …, S4 …, and S5 ….

(2) Excitations from other nodes of the item layer transmitted through such synapses as AB, BC, and BF. Such excitations embody the effect of the *associations* of the object embodied in node B and the objects embodied in nodes A, C, and F.

(3) Excitations transmitted from any excited node of the item layer through a path such as node B into synapse BMM, into node MM, activating a muscle, influencing the tissue, exciting a sense cell, through a transducer exciting nodes of the sense layer, such as N-taste…, N-smell…, or N-feeling…, transmitted through synapses of the sense layer, such as S3 …, S4 …, and S5 …, into a node of the item layer, which may be node B or another node. Those of the contributions to the excitations of nodes of this kind that are transmitted via the feeling transducer embody the effect of a *feeling* aroused by the thought of the object embodied in the node B.

(4) Excitations transmitted along a similar path as in (3), involving activation of a gland rather than a muscle.

(5) Excitation through the attention synapse ATT-B.

(6) Excitation through the specious present synapse SPEC-B.

NODE-SYNAPSE AGGREGATES. The various components of mental life as they may be excited or active at a given moment, such as for example (1) keeping upright balance, at the same time as (2) lifting the hand to take a cup, at the same time as (3) thinking of a tune being played, at the same time as (4) saying 'Listen to this', are embodied in a corresponding set of what shall be called *node-synapse aggregates*. Each node-synapse aggregate is embodied in a part of the thought network consisting of one or more nodes and a set of conductive synapses connected to them, the extent of each node-synapse aggregate being given by the conductive states of the synapses belonging to it. Node-synapse aggregates come in several kinds, having different functions, as will be further described in chapter 3 below.

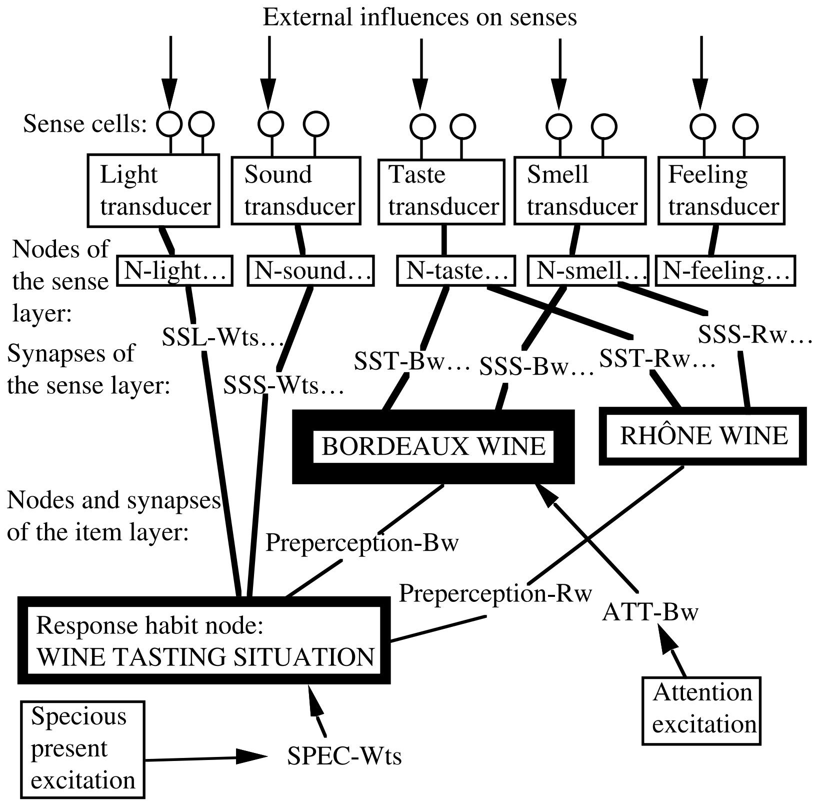


Fig. 2.10 Perception and preperception

PERCEPTION AND PREPERCEPTION. *Perception* is a matter of certain particular patterns of excitation in the thought object. Fig. 2.10 is an example of such a pattern, showing the embodiment of the person's perception that a certain taste and smell influencing the senses is what is known to the person as the taste and smell of Bordeaux wine. This perception is the result of the state of the synapses shown as SST-Bw… and SSS-Bw…. By the states of these synapses the node BORDEAUX

WINE will become strongly excited whenever the particular taste and smell of Bordeaux wine influences the person's taste and smell sense cells. The notations N-taste… and N-smell… stand for sets of nodes, and the notations SST-Bw… and SSS-Bw… stand for sets of synapses, showing how the node BORDEAUX WINE is excited through a number, perhaps hundreds or thousands, of parallel neural paths. By these excitations the node BORDEAUX WINE becomes excited sufficiently to excite its attention synapse ATT-Bw, and so the person's attention is drawn to BORDEAUX WINE, with whatever that implies to the person.

The perceptual excitation of the node BORDEAUX WINE results from summation of a large number of excitations. Thus the perception does not depend on any fixed set of criteria on the sensations. The person may recognize the taste as being of Bordeaux wine at one moment from the sensation one set of tastes and smells and at another moment from the sensation of a somewhat different set.

The perception that something experienced is the same at one occasion as it was at one or more previous occasions is a matter of the plastic properties of the synapses of the sense layer. These properties undoubtedly differ from one person to another and from one of the five senses to the others. Such individual differences will give rise to differences in person's long term reactions to sense impressions, in particular in their sensitivity to distinctions between similar subjects. They will also affect the quality and experience of imagery, to be discussed below.

Fig. 2.10 also accounts for the phenomenon of *preperception.* As said by James in describing attention [I 444], *the only things which we commonly see are those which we preperceive.* Preperception is a matter of the person being in a particular state of expectation to perceive certain things. Neurally each such state is embodied in the excitation of a node of a particular *response habit aggregate*, what shall be called a *response habit node,* to be discussed further in section 3.2 below.

In terms of Fig. 2.10, the person's being in a wine tasting situation is embodied in the excitation of the response habit node WINE TASTING SITUATION. A wine tasting situation may be set up by the sights and sounds of the particular place in which the person finds himself and of such things as bottles and glasses of certain kinds. Thus the excitation of the node WINE TASTING SITUATION comes from certain visual and aural sensations, transmitted through the synapse sets SSL-Wts… and SSS-Wts…. The excitation of WINE TASTING SITUATION will endure for the duration of the specious present, provided by the excitation from SPEC-Wts.

When WINE TASTING SITUATION is excited it will, through certain synapses, pass on its excitation to certain other nodes that embody the things that are preperceived in the situation. In Fig. 2.10 the synapses Preperception-Bw and Preperception-Rw, and the nodes BORDEAUX WINE and RHÔNE WINE are shown, but there may be further such synapses and nodes. Because of the preperception excitations these nodes will sooner excite their attention synapses when excitations from the taste and smell transducers arrive.

EXTERNAL SENSUAL EXPERIENCE. As said above, what is *experienced by the person* at any moment is embodied in excitations of the nodes of the sense layer shown in Fig. 2.9 as the nodes sets N-light…, N-sound…, N-taste…, N-smell…, and N-feeling…. These excitations arise by summation of the excitations received in each of these nodes from the neurons connected to them. Most often it is so that one of these excitations received in a node is dominant in the experience by its strength and so drowns out the others. The way this happens is different in the five senses and with the thought object. There are three sources of excitation that shall be called: (1) external sensual experience, (2) imagery experience, and (3) internal sensual experience. The external sensual experience is embodied in excitations coming from the five sense transducers. This arises by the excitation of the sense cells by agents external to the organism, such as light and sound coming from the environment, tasty substances entering the mouth from outside, smelly substances entering the nose, and mechanical influences upon the skin.

IMAGERY EXPERIENCE is embodied in excitations transmitted from a strongly excited node of the item layer, such as SUBJECT in Fig. 2.11, through the synapses SS1, SS2, …, SS10, and many more, into the nodes NS1, NS2, … NS10, and many more, and so producing experience. This experience is the imagery.

Imagery is known to be experienced as copies of sensations previously experienced. This property of being copies is embodied in the synapses SS1, SS2, … SS10, …, being the same that have provided for the experience of perception of the object embodied in SUBJECT. In perception the relevant conductivity is the one that provides excitation in the direction from the nodes of the sense layer into a node of the item layer. In forming an image the relevant conductivity is in the opposite direction, shown by arrow heads in Fig. 2.11.

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As reported by James [II 51-60], the quality of imagery, as compared with the sensual experience of the same subject, varies from one person to another and from one of the five senses to another. These differences stem from individual difference in the plastic properties of the synapses shown in Fig. 2.11 as SS1, SS2, … SS10.

Some persons experience perfectly distinct visual imagery, with fine details and full colors. This is only possible if the image stems from one particular occasion when the image was sensed and perceived. In terms of Fig. 2.11, the first time the person perceives the subject embodied in SUBJECT the synapses contributing to the perception, SS1, SS2, … SS10, …, must have their conductivities in the direction of the arrows increased to saturation. Whenever later SUBJECT gets strongly excited, the nodes NS1, NS2, … NS10, …, will become excited to the same strength as when the subject was first perceived, and so the visual experience will the same as at the first perception of the subject.

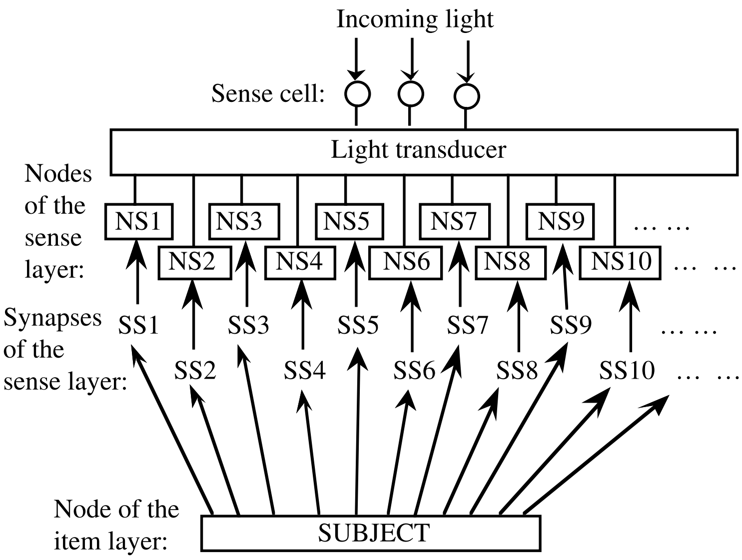


Fig. 2.11 Experience of visual imagery

Some people experience visual imagery which is vague and blurred. In such a person the conductivities of the synapses SS1, SS2, … SS10, will increase only by moderate amounts at each occasion when the image involved comes to be perceived. Moreover, the excitations of the nodes NS1, NS2, … NS10, …, will usually not have been quite the same at each occasion of perception of the subject. At one occasion the excited nodes may have included NS1, NS3, and NS4, and at another occasion they may have included NS2, NS4, and NS6, etc. For this reason the plastic conductivity states of the synapses SS1, SS2, … SS10, …, have not been formed at one particular occasion of perception, but have been built up gradually in a series of occasions of perception. Consequently these states correspond, not to one particular sensation of the object, but to a kind of composition of such sensations, in which the distinct features of the originally sensed images have been mixed together to form a blurred image, without any details that may have appeared only at some occasions of perception.

INTERNAL SENSUAL EXPERIENCE arises by the excitation of the sense cells by agents in the organism itself, such as light reflected from the skin of the hands, sound produced in the vocal chords, tasty substances secreted in the mouth, smelly substances secreted from the skin, and influences upon feeling sense cells located inside the body, arising from the excitations of muscles and glands. Such excitations are transmitted along the path shown in Fig. 2.9 as a thick arrow.

A specific example of embodiment of internal sensual experience is shown in Fig. 2.9 in the form of a path of excitation from node C, through the synapse ACQ-C, the node M-Samefeel, the synapses SAME…, the nodes M-same…, into the muscles and glands MusGl…. This path of excitation shows how any excitation of the node C will give rise to excitation of certain particular muscles and glands, in this case supposed to produce the experience of a specific feeling of *familiarity*, i.e. *being-the-same-as-has-been-experienced-before*. In other words, as a consequence of the conductivity of the synapse ACQ-C, the node C embodies an *acquaintance object.*

THOUGHT OBJECT CHANGES - THE SPECIOUS PRESENT. The thought object changes incessantly, the strength of excitation of some of the nodes increasing, of others decreasing. The changes of the thought object from one moment to the next have been described by James in connection with the explanation of the specious present, in the words [I 606]:

> 'If the present thought is of A B C D E F G, the next one will be of B C D E F G H, and the one after that of C D E F G H I—the lingerings of the past dropping successively away, and the incomings of the future making up the loss'.

This description only accounts for part of the items of the thought object, those that are driven by what shall be called the intellectual mechanism.

The changes are driven by two different kinds of mechanisms, one that caters for the change of one part of the nodes and another one catering for the rest. Roughly speaking, the intellectual mechanism takes care of the attention to intellectual matters, while the muscular mechanism serves the voluntary movements of the body. At any time one intellectual mechanism and several muscular mechanisms may be active. The mechanisms will normally be active side by side, and each will proceed largely at its own pace, with only slight interference from the others.

INTELLECTUAL CHANGES. The changes of the thought object from one moment to the next induced by the mechanism of intellectual attention are brought about partly by the changes of the excitations received on the sense cells, partly by the changes of the contributions to the excitation of nodes that happen as a consequence of the plastic properties of the attention and specious present synapses. These latter changes happen without external influence and may be said to drive the stream of thought forward.

As illustration, Fig. 2.12 shows the main features of the 'intellectual part' of the thought object as these features have been generated within a second or two from the object shown in Fig. 2.9. Fig. 2.12 shows only the neurons and synapses that directly contribute to the excitation of the node F, which in the new situation is the one most strongly excited, mainly through the attention synapse ATT-F. Node F has been assumed to have been excited already in the situation of Fig. 2.9 from several sources: (1) through the synapses SSS-F…, as the perception of a certain quality of sound, (2) through SSF-F, as influenced by a certain quality of feeling arising from the excitation of the node B and transmitted through the synapses BMM…, the nodes MM…, exciting certain glands, which in their turn influence feeling sense cells and nodes of the sense layer and the synapses SSF-F…, (3) through the synapses BF, CF, and KF, embodying associative links with the nodes B, C, and K

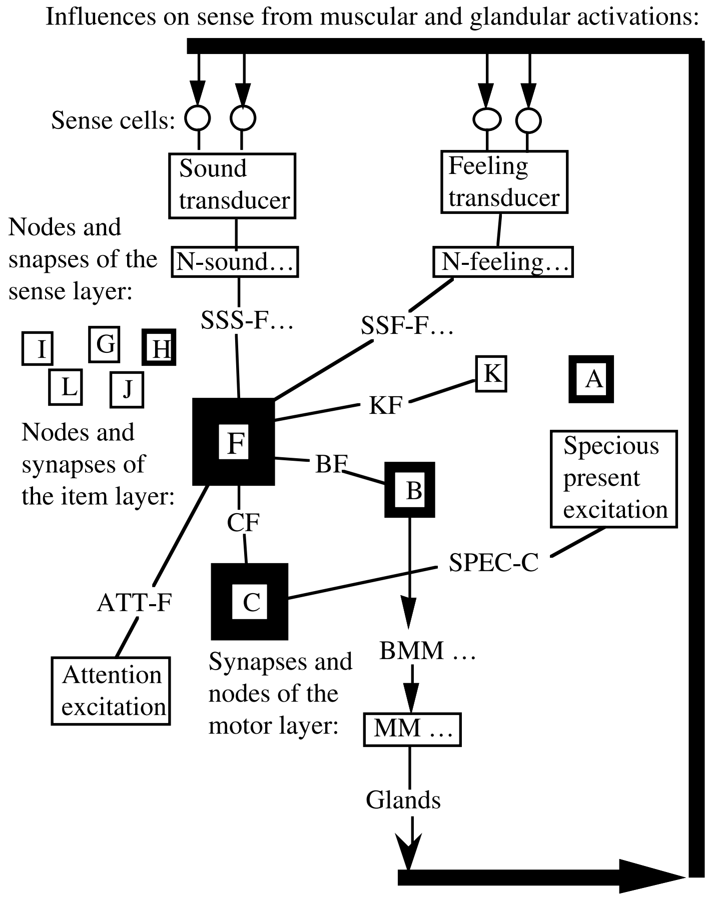


Fig. 2.12 Next moment of intellectual part of thought object

The most important change from Fig. 2.9 to Fig. 2.12 is that the strong attention excitation of node C in Fig. 2.9 has taken effect in increasing the excitation of node F, to the extent that its attention synapse ATT-F has become excited and so adds a great additional excitation into F. The important thing is to note how this strong excitation of F results from the summation of a number of contributions. This is the neural embodiment of the process described by James on page [I 585] in talking about association in voluntary thought and the 'hovering of the attention in the neighborhood of the desired object', illustrated by Fig. 2.6 above. The process is what James describes as *the 'transitive parts' of the stream of thought.*

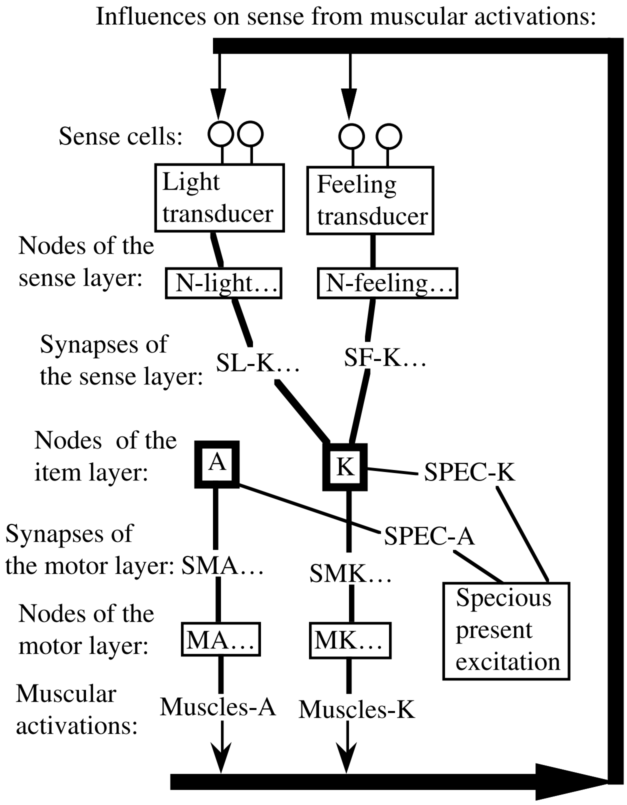


Fig. 2.13 One step in muscular control from A to K

MUSCULAR CHANGES. Fig. 2.13 shows the main features of the change brought about by the activity of one of the muscular mechanisms active in Fig. 2.9. The change is induced in the way described by James as quoted above in section 2.3: 'In action grown habitual, what instigates each new muscular contraction to take place in its appointed order is not a thought or perception, but the *sensation occasioned by the muscular contraction just finished.'* In Fig. 2.13 it is assumed that node A in the situation of Fig. 2.9 has excited Muscles-A through the synapses SMA… and the nodes MA…. The excitation of Muscles-A has given rise to an influence in the organism in the form of tensions and movements indicated by the thick black arrow. This influence in its turn has given rise to certain excitations of sense cells, that again are transmitted through the transducers into the nodes N-light… and N-feeling…, and from there through the conductive synapses SL-K… and SF-K…, resulting in enhanced excitation of node K. By this enhanced excitation of K the synapse SPEC-K will become excited, and will add a strong excitation into K. As a consequence the muscles Muscles-K will become excited, through the synapses SMK… and the nodes MK…. By this process one step of a chain of habitual actions has been accomplished.

As clear from this explanation the habit by which the activation of Muscles-A is followed by the activation of Muscles-K is embodied in the plastic states of the synapse sets SL-K…, SF-K…, and SMK….

2.19 The anatomy of the synapses

To prevent misunderstanding it must be said that the picture of synapses shown in Fig. 2.7 should be taken merely to indicate the place and function of the synapses in the neural network, not as indicating what synapses are in anatomical detail. Such detail undoubtedly differs for synapses of the five layers, and, for synapses of the sense layer, for synapses of the five senses. What the anatomical details are must be determined in microphysiological studies. Here only certain anatomical possibilities will be mentioned.

First, concerning synapses of the item layer. In view of the plastic properties of these synapses, conceivably such synapses are anatomically formed as filaments extending the full length between the two nodes they connect. Then the conductive state of the synapse might be embodied in the extent of different states of the filament matter along the filament, as suggested by the different patterns shown along the filament in Fig. 2.14.

Fig. 2.14 Item synapse in filament form

Second, concerning the synapses of the attention and specious present layers. These synapses are shown in the figures as two separate sets. However, conceivably each pair consisting of the attention synapse connected to one node of the item layer and the specious present synapse connected to the same node, such as ATT-A and SPEC-A in Fig. 2.8, anatomically are combined into a single unit which would serve the combined functions. If so the attention excitation source and the specious present source would be combined into one anatomical unit.

3. Node/synapse aggregates and their functions

3.1 The personal character of node/synapse aggregates

In explaining the activity of particular neural systems we shall make use of what was introduced above as *node/synapse aggregates*, saying that the activity at a particular moment includes the excitation of a certain number such aggregates. A description in such terms aims at relating the neural excitation of the node/synapse aggregates to the description of the behavior and experience of people in terms of psychological characteristics.

Description in such terms meets two difficulties, however. First, the node/synapse aggregates of any individual are characteristics of that individual as they have been established as states of synapses at a particular moment of that individual's life, as a result of the education of the person's neural system, and so strictly speaking any description of the function of such an aggregate is valid only for that individual at that moment.

As the second difficulty, the function of any node/synapse aggregate at any moment is coupled to all the rest of the individual's nervous system, which is indispensable to its function. The overall function of a nervous system can only very crudely be described as the concerted activity of a number of separate functions.

For these reasons what will be described in this section can be no more than some of the features of the function of some node/synapse aggregates that are similar to such aggregates that plausibly are found in the neural systems of many people. Five kinds of aggregates will be described: response habit aggregates, subject aggregates, quality aggregates, urge aggregates, and action aggregates.

3.2 Response habit aggregates and nodes: the embodiment of personal modes and styles

The individual's personal modes, styles, manners, and attitudes, are embodied in certain synapse/node aggregates, the *response habit aggregates,* each with one *node,* of which there are in the neural system of any particular individual in total perhaps 100, perhaps 1000. A prominent function of these aggregates is to influence the responses of the person by transmitting preperception and preactivation excitations into other nodes.

Typically, for the duration of each particular *situation* in which the person finds himself or herself, for example in a familiar place, together with familiar people, talking about familiar subjects, in terms of familiar words from a familiar language, the nodes of a certain selection of the response habit aggregates, perhaps 5 or 10, will be held excited.

Like all other synapse/node aggregates, response habit aggregates are distinct only by the states of their connected synapses, not neurophysiologically. The response habit aggregates that have been formed in any individual at any time are personal, a result of the continued education of that person's nervous system up to that time. How many there are, and what they are, is an entirely individual matter.

Response habit aggregates shall here be described in terms of (1) their manner of functioning, (2) the response kinds involved, and (3) concrete examples.

MANNER OF FUNCTIONING. A response habit aggregate functions neurally in two ways that happen at the same time: (1) the way the aggregate is held excited for the duration of a situation, and (2) the way the aggregate influences the excitation of other nodes while it is itself excited.

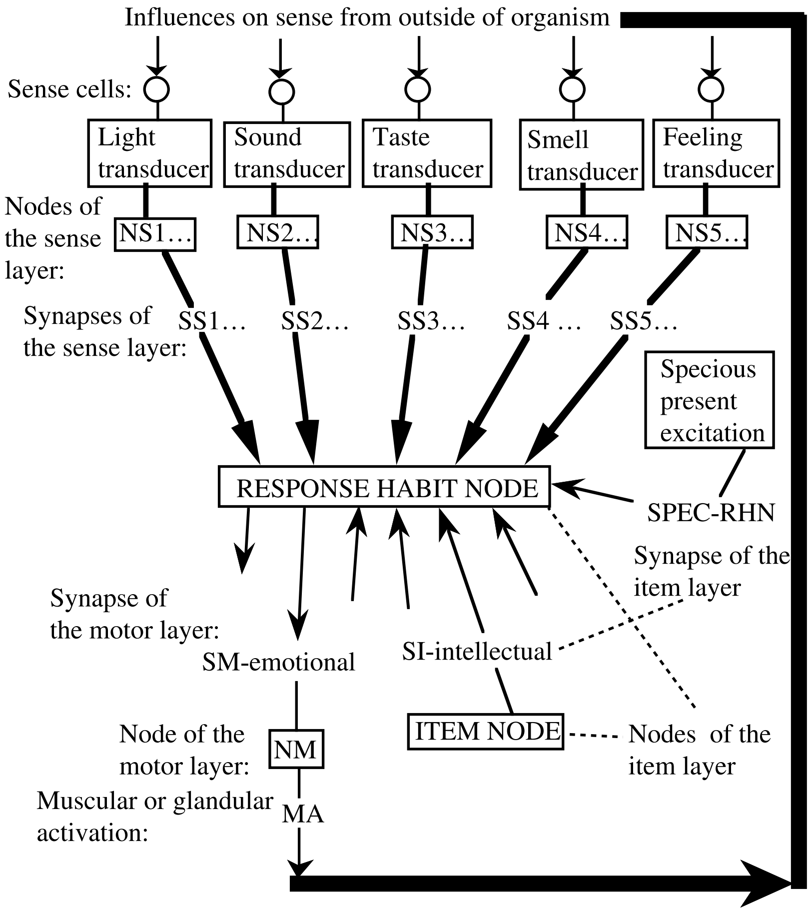


Fig. 3.1 Excitations of node of response habit aggregate

Fig. 3.1 shows representative paths by which the aggregate RESPONSE HABIT NODE may be held excited. Most commonly, in a particular response habit aggregate only some of these paths will be effective. One kind of path is shown as the synapse sets SS1…, SS2…, SS3…, SS4…, and SS5…, that have been put into a conductive state, as part of the education of the nervous system. They are representative in the sense that there typically will be many, perhaps thousands of, other synapses in the same position in the network. Likewise the node sets NS1…, NS2…, NS3…, NS4…, and NS5…, are representative.

Excitations of RESPONSE HABIT NODE through such synapse sets as SS1…, SS2…, SS3…, SS4…, and SS5…, happen in the same way as perception of such items as things. Such excitation of a response habit aggregate differs from such perception by involving a wider range of sensual impressions. For example, the excitation of the response habit aggregate of a location, a particular room say, has its source in all the sensual impressions received by the person from that location, of all kinds, from all directions. By contrast, the perception of a thing in the location has its source only in the sensations excited by that thing.

The sensual features of the situation that through the sense cells and nodes and synapses of the sense layer contribute to the excitation of a response habit aggregate will usually change from moment to moment, and may also be interrupted for short times, for example by the person closing the eyes. For this reason, at any particular moment normally only a fraction of the corresponding nodes of the sense layer will contribute to the excitation of RESPONSE HABIT NODE, that fraction perhaps changing from moment to moment. In any case, after it has been initiated the excitation will be maintained for the duration of the specious present by way of the synapse SPEC-RHN.

A second kind of excitation of a response habit aggregate is shown in Fig. 3.1 by the path from ITEM NODE through the synapse SI-intellectual. By this path the excitation of ITEM NODE will contribute to the excitation of RESPONSE HABIT NODE. This is the path of intellectual excitation.

A third kind of excitation of RESPONSE HABIT NODE is shown by the synapse SM-emotional, the node NM, the muscle MA, bodily influence, the Feeling transducer, the nodes NS5…, and the synapses SS5…. Excitation along this path will contribute when the excitation of RESPONSE HABIT NODE by the excitation of the muscle or gland MA excites a feeling.

The effects of the excitation of RESPONSE HABIT NODE are shown in Fig. 3.2. One of these effects is to transmit excitations through conductive synapses, such as S-preperception-p, to nodes, such as SUBJECT NODE-p, with which they are associated. This, by summation of excitations that may arrive from nodes of the sense layer through synapse sets such as SS6-p…, SS7-p…, SS8-p…, SS9-p…, and SS10-p…, will influence the way a node such as SUBJECT NODE-p responds to sensations—in other words, the perceptions taking place at the moment. Thus the excitation of RESPONSE HABIT NODE produces *preperception* excitation of SUBJECT NODE-p.

As a second effect of the excitation of RESPONSE HABIT NODE, this excitation may through a synapse S-preactivation-q excite a node, such as ACTION NODE-q, that through the synapses SM-C-q… and the nodes NM1… excites certain muscles, MA1…. This will be added to other excitations transmitted into ACTION NODE-q and will in that way function as a *preactivation* of the muscular action activated by that node.

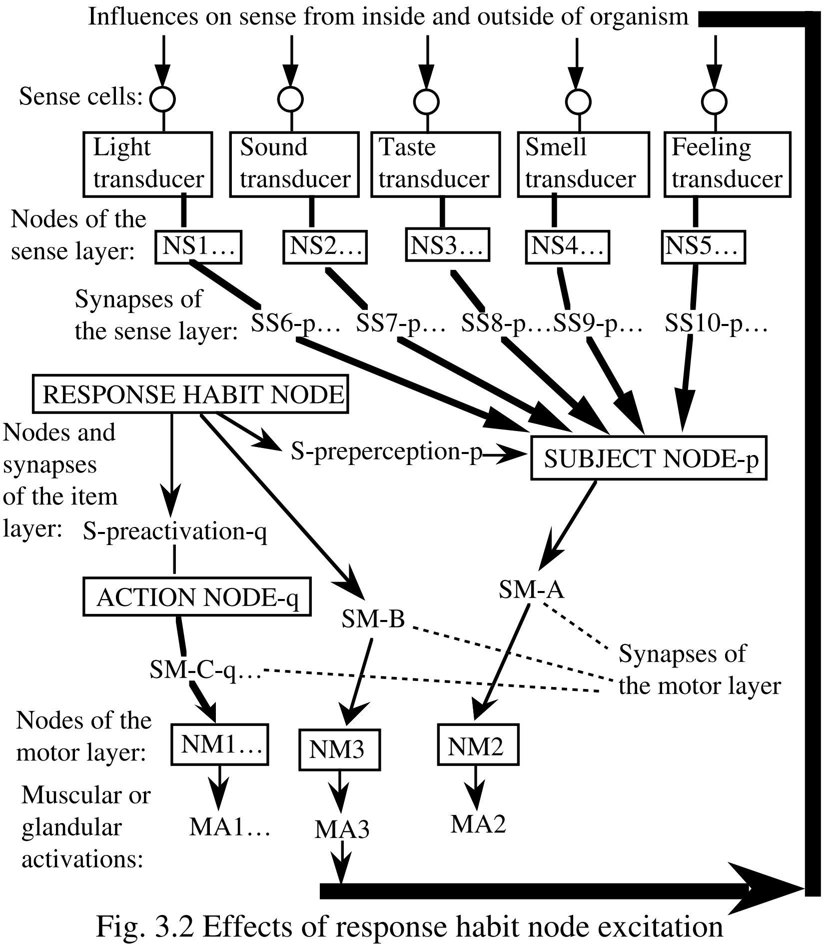


Fig. 3.2 Effects of response habit node excitation

Furthermore, the weak excitation of SUBJECT NODE-p from RESPONSE HABIT NODE through S-preperception-p may sometimes give rise to experience, as described by James [1, I 439]: '… so completely does the expectant attention consist in premonitory imagination that … it may mimic the intensity of reality, or at any rate produce reality's motor effects.' This premonitory imagination comes about by the same mechanism as other imagination, thus in Fig. 3.2 by excitations from SUBJECT NODE-p transmitted in the opposite direction of the arrows into

SS6-p, SS7-p, SS8-p, SS9-p, and SS10-p, and so into NS1, NS2, NS3, NS4, and NS5, and thereby giving rise to experience. The motor effects are produced by excitation from SUBJECT NODE-p through a synapse SM-A into node NM2 and muscle MA2.

Besides catering for preperception and preactivation, some response habit aggregates excite particular feelings. In Fig. 3.2 such excitation takes place along the path SM-B, NM3, MA3, muscular and/or glandular activations, sense cells, into NS5.

Preperception of the same subject nodes and preactivation of the same action nodes will often be produced by several different response habit aggregates. When several response habit aggregates are excited at the same time their several preperception and preactivation excitations will be combined in the subject nodes and action nodes by summation.

RESPONSE KINDS. So as to clarify the function of response habit aggregates in more detail, the various kinds of personal responses and the way they depend on the mental state of the person and on the situation in which the person finds himself or herself, shall be described.

The kinds of responses to be considered are: (1) *perceptions,* (2) *voluntary muscular activity,* (3) *feelings,* and (4) *formations and changes of associative links.* Both for perceptions and voluntary muscular activity an important circumstance of the mental state is the person's momentary *attention.*

(1,2) *Perceptions* and *voluntary muscular activations* are described by James as quoted in section 2.1 above. It should be noted at this point that perception as described by James includes any responses in the form of such understanding that a person achieves as a result of having sensations, either of such sounds that are generated in human speech, or of the sights of such signs that are used to record speech in script and print. James's discussion of responses therefore includes all that may be called language understanding. Similarly, voluntary muscular activations include the activity of speech.

The dependence of perception and voluntary muscular activations on the momentary situation and mental state of the person is explained by James when he writes that the attentive process is a matter of [I 434]: '*The anticipatory preparation from within of the ideational centres concerned with the object to which the attention is paid.*' In this pronouncement James has very accurately anticipated the explanation in the synapse-state theory of the way perception and muscular responses are influenced by response habit aggregates. Indeed, such nodes that are excited from the response habit, in Fig. 3.2 nodes SUBJECT NODE-p and ACTION NODE-q, are precisely some of *the ideational centres* of which James writes. And the excitations transmitted from RESPONSE HABIT NODE through S-preperception-p and S-preactivation-q into SUBJECT NODE-p and ACTION NODE-q are precisely *the anticipatory preparation from within* which by being added to other excitations into these nodes help to bring about that their attention synapses will be excited.

(3) Some response habit aggregates excite particular *feelings*. As already said, such excitation is shown in Fig. 3.2 to take place along the path SM-B, NM3, MA3, muscular and/or glandular activations, sense cells, into NS5.

(4) *Formations and changes of associative links* are matters of changes of the conductivities of synapses, both of those that are part of the response habit aggregate itself, shown in Fig. 3.1, and those that get excited in consequence of the excitation of the response habit aggregate, shown in Fig. 3.2.

These changes of the conductivities of synapses are long term effects that happen as a consequence of the plasticity of the synapses. By this plasticity the conductivity of any synapse excited at a particular occasion of excitation of the response habit aggregate will have been formed partly as it was increased in all previous occasions of such excitations, partly by the decay of conductivity taking place between excitations.

Owing to the complexity of the pattern of synaptic links involved in any excitation of a response habit aggregate, accounting for the change of the conductivity of any particular one of the synapses involved is practically impossible. However, several overall trends of the conductivity changes and of the corresponding changes in behavior and experience follow in a fairly obvious way:

(4.1) Owing to the plasticity of the synapses SS1…, SS2…, SS3…, SS4…, SS5…, and SI-intellectual, of Fig. 3.1, the perceptional and activational responses evoked by the excitation of the response habit aggregate will be stronger when the excitations happen frequently, and will become weaker when they happen rarely. If for a very long time the response habit aggregate is never excited the synapses will gradually lose their conductivity, and the person will then cease to respond in accordance with the response habit aggregate. In terms of behavior and experience, the person's perceptional and activational responses related to the matters activating the response habit aggregate will become more lively when the person is frequently concerned with them, and will wane and eventually die out when the person ignores them for a long period.

(4.2) Owing to the plasticity of the synapses SS1…, SS2…, SS3…, SS4…, and SS5…, that pattern of sensual impressions that excites the response habit aggregate will adjust itself to the patterns actually experienced. It will invariably be so that the set of sensations that contribute to the excitation of the response habit aggregate will change from one moment to the next and from one occasion of excitation to another. Thus the conductivity of each the synapses SS1…, SS2…, SS3…, SS4…, and SS5…, will be formed individually for that synapse as a consequence of its contribution to the excitation of the response habit aggregate at all previous moments. Those of the synapses that have been contributing at many moments and occasions will have become more strongly conductive. These synapses will determine what may be said to be the most typical features of the sensuous characteristics embodied in the response habit aggregate. Owing to the plasticity of the synapses in their reaction to the person's changing mental activity, these features will tend to change over time so as to follow any changes of the strengths of the actual sensations received.

In other words, in terms of the person's experience, what may be called the dominating sensual features of the situation exciting the response habit aggregate will tend to get adjusted according to the sensual impressions actually experienced at each period of the person's life.

(4.3) Owing to the plasticity of such synapses as S-preperception-p and S-preactivation-q of Fig. 3.2 the strength of the perceptional and activational responses will change according to both the frequency of the excitations of the response habit aggregate and the frequency of the accompanying excitations of such nodes as ACTION NODE-q and SUBJECT NODE-p. If one particular SUBJECT NODE-p, SUBJECT NODE-r say, has frequently been strongly excited from its attention synapse, S-preactivation-r will have become highly conductive. This will have the effect that any strong excitation of SUBJECT NODE-r, from any source, will be added to the excitation of RESPONSE HABIT NODE. In other words, SUBJECT NODE-r has the effect of ITEM NODE of Fig. 3.1.

The effect of a high conductivity of a particular S-preactivation-q, S-preactivation-s say, will be that the excitation of RESPONSE HABIT NODE will be transmitted strongly into ACTION NODE-s.

(4.4) The conductivity of the synapses SM-emotional will wax or wane according to the frequency and strength of excitation of RESPONSE HABIT NODE. Thus the strength of any emotional responses accompanying the particular set of responses will change according to the frequency of the person's having experienced them.

Table 1 James's summary of the empirical life of Self

	MATERIAL	SOCIAL	SPIRITUAL
SELF-SEEKING	Bodily Appetites and Instincts Love of Adornment, Foppery, Acquisitiveness, Constructiveness Love of Home, etc.	Desire to please, be noticed, admired, etc. Sociability, Emulation, Envy, Love, Pursuit of Honor, Ambition, etc.	Intellectual, Moral and Religious Aspiration, Conscientiousness
SELF-ESTIMATION	Personal Vanity, Modesty, etc. Pride of Wealth, Fear of Poverty	Social and Family Pride, Vainglory, Snobbery, Humility, Shame, etc.	Sense of Moral or Mental Superiority, Purity, etc. Sense of Inferiority or of Guilt

3.3 Examples of response habit aggregates

SELF AND PERSONALITY. As one important function, certain response habit aggregates embody all that can be called the Self of the individual. The psychology of Self can be gleaned from James's chapter 'The Consciousness of Self' [I 291-401]. As a summary James presents Table 1 [I 329].

So as to extract the kind of personal characteristics that are common to all the personal features displayed in the table, consider, for example, love of foppery. Foppery is explained in the dictionary as 'the clothes, manners, actions, etc., of a fop', and a fop by the dictionary is 'a man who is excessively vain and concerned about his manners and appearances'. By these explanations a fop is a person who will *respond* in certain definite ways, in his thoughts, feelings, and actions, including speech, to certain sense impressions. Clearly the fop's responses will be called forth only in certain kinds of situation.

A consideration of the other items in James's table will make it clear that this characterization of what it is to be a fop as being a matter of responses, is valid equally for all of them. The differences between the items in the table concern the sense impressions being responded to, the kind and quality of the responses, and the situations in which the responses are called forth.

In other words, a person's Self is a matter of the person's habitual responses to certain sense impressions in certain situations. From this it should be clear that the person's Self is embodied in a certain number of response habit aggregates.

It should be clear also that since the responses that concern any particular personal style, manner, or attitude, will become effective only when the person is exposed to certain particular sense impressions and only in certain particular situations, a person may have the habits of any number of styles, manners, and attitudes, at the same time.

A *hypocrite* by the dictionary is a person guilty of hypocrisy, which is explained as 'simulation of virtue or goodness; dissimulation, pretence.' The embodiment of hypocrisy is to have certain response habit aggregates that support certain kinds of responses and other response habit aggregates that support responses that are contradictory to them.

MOODS. *Mood* is explained in the dictionary as '1. a state or quality of feeling at a particular time. 2. a distinctive emotional quality or character. 3. a prevailing emotional tone or general attitude. 4. frame of mind. Synonyms: 1. temper, humor, disposition, inclination.'

The person's being in a particular particular mood may be understood as the excitation of a particular response habit aggregate with the following properties, explained in terms of Fig. 3.1:

(1) The aggregate centered upon RESPONSE HABIT NODE is partly self-excited by such a path as the synapse SM-emotional through the node NM, exciting certain muscles and/or glands MA that by their excitation of nodes NS5… generate a certain quality of feeling, which again through the synapses SS5… contributes to the excitation of RESPONSE HABIT NODE.

(2) There are certain subject nodes, such as ITEM NODE, which when they are excited, perhaps by their attention synapses, contribute to the excitation of RESPONSE HABIT NODE. Such subject nodes are excited by the particular feelings that also excite RESPONSE HABIT NODE. This has the effect that when the person thinks of the subject embodied in ITEM NODE, thereby exciting that

node, this excitation contributes to the excitation of RESPONSE HABIT NODE. In other words, there will be certain subjects that when thought of call forth the feelings of the mood, embodying intellectual excitation of RESPONSE HABIT NODE

The mood will prevail as long as these paths continue to be active. The attention will tend to drift between such subject nodes that support the excitation of the mood.

The person's responses may be so strong that the person is unable to avoid exciting the subject nodes that support the excitation of the mood—the person is stuck in a particular mood.

The way to escape from a painful mood is to seek strong excitations of other nodes, so as to avoid the excitation of the self-exciting paths. Thence the well-known remedies: seek new impressions and environments, travel.

There may be one response habit aggregate which is excited by so many different sensations that it stays excited at all times. The effect of such an aggregate may be to activate certain muscles. If these muscles are in the face of the person, for example around the lips, their constant contraction will modify the tissue, for example forming wrinkles, which will then be directly visible in that face as some characteristic expression, whether it is of merriment, disdain, or bitterness. By this neural mechanism some features of a person's dominant mood may become directly visible in the person's face.

LANGUAGES. Part of what may be called a person's knowledge or possession of languages is embodied in response habit aggregates. There will be separate response habit aggregates that are excited in various situations of (1) language understanding, (2) language production, (3) script, and (4) spoken form of language words and phrases. In terms of Fig.s 3.1 and 3.2, the effective synapses in each case are as shown in Table 2.

Table 2 Effective synapses in language understanding

	Fig. 3.1	Fig. 3.2
Understanding script	SS1…	S-preperception-p
Understanding speech	SS2…	S-preperception-p
Writing	SI-intellectual	S-preactivation-q
Speech in conversation	SS2…	S-preactivation-q
Lecturing	SI-intellectual	S-preactivation-q

In situations of language understanding, preperception excitation is transmitted into all those subject nodes that embody the person's habitual understanding in the situation of written or spoken words and phrases.

In writing situations, preactivation excitation is transmitted into all those action aggregates that embody the muscular activity of writing all such words and phrases that the person has been writing habitually in the situation.

In situations of conversational speech and in lecturing, preactivation excitation is transmitted into all those action aggregates that embody the muscular activity of speaking all such words and phrases that the person has been speaking habitually in the situation.

PERSONS. Each individual person and each group of persons that the individual has regular contact with will give rise to the formation of a separate response habit aggregate. This aggregate will be excited mostly from sensations of such visual and auditive influences that stem from the appearance and tone of voice of the other person or persons, i.e. in terms of Fig. 3.1, through the synapses SS1… and SS2…. The effect of the excitation of the response habit aggregate will be to transmit (1) excitation of activations of muscles and glands that produce certain feelings, by the paths shown in Fig. 3.2 as SM-B, NM3, MA3, muscles and glands, Feeling transducer, into NS5, (2) preperception excitations into such subject nodes that embody the subjects that have been brought up regularly in the conversations with the person or persons, i.e. in Fig. 3.2 by such synapses as S-preperception-p, and (3) preactivation excitations into such action aggregates that embody the verbal phrases that the person has commonly used in conversations with the other person or persons, i.e. in Fig. 3.2 by the synapses S-preactivation-q.

LOCATIONS. Each person will have response habit aggregates embodying the person's familiarity with a number of locations and physical environments. Each such response habit aggregate will become excited by the sights, sounds, and smells, of a particular location. As the effect of excitation, the response habit aggregate will transmit preperception excitations into each subject node embodying something that the person is familiar with in the location.

BODILY BALANCE. Each of the states of bodily balance practised by the person, such as standing upright, sitting on a chair, or riding a bicycle, will be supported by a complicated node/synapse aggregate. As an example Fig. 3.3 shows the aggregate maintaining upright balance. The aggregate includes a reponse habit aggregate centered on the reponse habit node UPRIGHT BALANCE. In situations when the person wishes to maintain upright balance, UPRIGHT BALANCE will be excited from nodes of the item layer that are excited in the thought object. As an example NIq is shown, exciting UPRIGHT BALANCE through SI-4. UPRIGHT BALANCE will be held excited for the duration of the situation through the specious present synapse, SPEC-UB. The effect of this excitation will be preactivations of certain balance movement nodes, BALANCE MOVEMENT-1, BALANCE MOVEMENT-2, … BALANCE MOVEMENT-i, through the synapses SI-1, SI-2, …, SI-i. Whenever one of these nodes gets strongly excited, so effecting muscular excitation, that node will transmit excitation back into UPRIGHT BALANCE through the same synapses, contributing to keeping it excited.

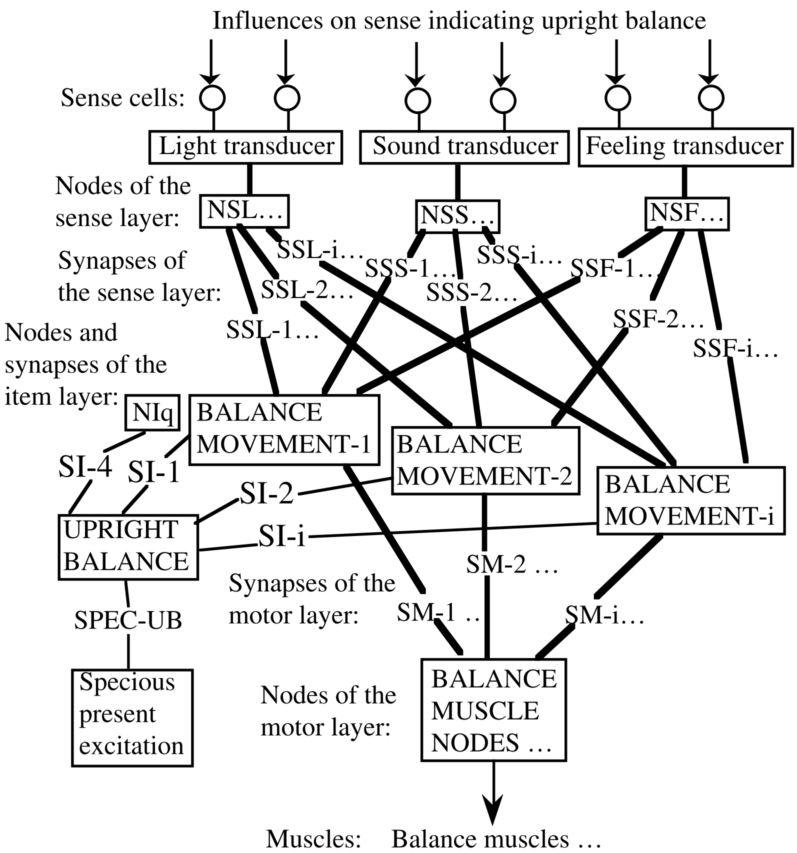


Fig. 3.3 The node/synapse aggregate for upright balance

The muscular activations that serve to keep the body of the person in a stable position against the influence of gravity are excited through the balance movement nodes, BALANCE MOVEMENT-1, BALANCE MOVEMENT-2, … BALANCE MOVEMENT-i. Each balance movement node transfers certain sense cell excitations into certain nodes of the motor layer, thus transferring the sensations of imbalance into corrective muscular contractions.

The sensations contributing to maintaining the upright balance are of a great variety. Visual sensations received from things in our environment when we have our eyes open contribute through the synapse sets SSL-1…, SSL-2…,…, SSL-i…. Sounds emitted or reflected from things may contribute through the synapse sets SSL-1…, SSL-2…,…, SSL-i…. Mostly the strongest contributions come through the synapse sets SSF-1…, SSF-2…,…, SSF-i… from feeling sense cells. The dominating sensations derive from the reaction of our body to gravity, thus the pressures in our feet and legs that result from the weight of our body. Additional sensations are generated in the balance centres in our ears. Other contributing feelings may come from our fingers and arms when we hold on to a firm support in our surroundings. In any case, the nervous excitements that through the synapses and the balance movement nodes arrive into the muscles will be formed by summation of those contributions that from moment to moment come into the nodes BALANCE MOVEMENT-1, BALANCE MOVEMENT-2, ... BALANCE MOVEMENT-i.

The corrective muscular contractions excited depend on the sensations. When the imbalance is detected by feelings in our hands the corrective action will include activations of the muscles in our arms. This flexibility of the neural balance system is clearly understandable from the synapse-state description of the nervous system.

The development of the neural balance nodes and synapses is an individual matter. Certain activities, such as dancing, will require development of the neural balance aggregate into a more elaborate form, with several response habit nodes. Such movement characters as military bearing are matters of the neural balance aggregates.

ACTIVITIES. Each kind of activity that the person is regularly engaged in will be supported by one or several reponse habit aggregates. Activities in this context cover both any kind of profession and craft and such that are undertaken as recreation. The excitation of an activity reponse habit aggregate comes usually from visual and auditive sensations, in Fig. 3.1 through SS1... and SS2..., as well as from intellectual sources, through SI-intellectual. The effect of the excitation will be preperceptions of all such subjects that have been habitually brought up for the person's attention in the activity, as well as preactivations of all such bodily movements that have been trained by the person while being engaged in the activity.

The training for a profession is to a large extent a matter of the education of certain response habit aggregates of the nervous system.

The effects of response habit aggregates of locations and activities on perceptions and actions explain the two phenomena of inattention, discussed by James [I 455f] as reported in section 2.1 above. The first phenomenon is the way persistent impressions on sense, such as continued strong noises or the ticking of a clock, are ignored while they continue, but give rise to a special feeling when they stop. A persistent impression on one of the senses which has been experienced regularly will give rise to the formation of a response habit aggregate, which will be excited whenever the impression is there. This response habit aggregate while excited will give rise to the experience of a specific feeling. When the impression ceases the excitation of the response habit aggregate will cease when the specious present has passed, and the feeling will no longer be experienced, which is experienced as a sort of void. The attention will be attracted to the persistent impression when it starts, but will soon fade from it, in the way of any attention, by the plasticity of the attention synapse.

The second phenomenon is the way a person's doing continued movements of unmeaning kinds supports the person's attention to a difficult subject. This arises by the attentional excitation of the subject nodes being supported by the preperception excitation from a specific response habit aggregate, which is kept excited by the continued movement influencing the feeling aggregates of the sense layer, NS5… in Fig. 3.1.

DREAMING. Night dreaming is a matter of the excitation of a particular response habit node. During dreamless sleep no response habit node is excited, and as long as no strong impressions arrive in the sense cells the nodes of the sense layer are excited only weakly and so very little is experienced by the person. There may, however, be a response habit node, DREAM, that is connected by conductive synapses only to nodes of the item layer, but from a large number of them, and that therefore may happen to become strongly excited from its attention synapse even during sleep. When thus strongly excited, DREAM in reverse will excite the nodes of the item layer connected by conductive synapses with it and will thereby give rise to the experience of such imagery that is associated with those nodes. The experience of dreaming is further described in section 7.1 below.

3.4 Subject aggregates: the embodiment of what one may think of

What one may think of is explained by James (1890) in his discussion of what he denotes *conception*. For clarity James's word 'conception' will here be replaced by *acquainting*. With this replacement James writes [I 459]:

> CHAPTER XII - ACQUAINTING (CONCEPTION) - THE SENSE OF SAMENESS. In Chapter VIII, p. I 221, the distinction was drawn between two kinds of knowledge of things, bare acquaintance with them and knowledge about them. The possibility of two such knowledges depends on a fundamental psychical peculiarity which may be entitled '*the principle of constancy of the mind's meanings*', and which may be thus expressed: '*The same matters can be thought of in successive portions of the mental stream, and some of these portions can know that they mean the same matters which the other portions meant*'. One might put it otherwise by saying that '*the mind can always intend, and know when it intends, to think of the Same*'. … [I 461]
>
> ACQUAINTING DEFINED. *The function by which we thus identify a numerically distinct and permanent subject of discourse is called* ACQUAINTING; and the thoughts which are its vehicles are called *acquaintance objects*. … The word 'acquainting' is unambiguous. It properly denotes neither the mental state nor what the mental state signifies, but the relation between the two, namely, the *function* of the mental state in signifying that particular thing. It is plain that one and the same mental state can be the vehicle of many acquaintings, can mean a particular thing, and a great deal more besides. If it has such a multiple acquainting function, it may be called an act of compound acquainting.
>
> We may acquaint realities supposed to be extra-mental, as steam-engine; fictions, as mermaid; or mere *entia rationis,* like difference or nonentity. But whatever we do acquaint, our acquainting is of that and nothing else—nothing else, that is, *instead* of that, though it may be of much else *in addition* to that. Each act of acquainting results from our attention singling out some one part of the mass of matter for thought which the world presents, and holding fast to it, without confusion. … [I 462]

> Each acquainting thus eternally remains what it is, and never can become another. The mind may change its states, and its meanings, at different times; may drop one acquainting and take up another, but the dropped acquainting can in no intelligible sense be said to *change into* its successor. The paper, a moment ago white, I may now see to have been scorched black. But my acquainting 'white' does not change into my acquainting 'black'. … Thus, amid the flux of opinions and of physical things, the world of acquaintings, or things intended to be thought about, stands stiff and immutable, like Plato's Realm of Ideas.
>
> Some acquaintings are of things, some of events, some of qualities. Any fact, be it thing, event, or quality, may be acquainted sufficiently for purposes of identification, if only it be singled out and marked so as to separate it from other things. Simply calling it 'this' or 'that' will suffice. … [I 463]
>
> Most of the objects of our thought, however, are to some degree represented as well as merely pointed out. Either they are things and events perceived or imagined, or they are qualities apprehended in a positive way. Even where we have no intuitive acquaintance with the nature of a thing, if we know any of the relations of it at all, anything *about* it, that is enough to individualize and distinguish it from all the other things which we might mean. Many of our topics of discourse are thus *problematic*, or defined by their relations only. … [I 464]

Acquaintance objects are embodied in *subject aggregates*. Each such aggregate has one node, which may be called a *subject node*. The subject node is connected by conductive synapses to usually a large number of other subject nodes that embody such subjects that are associated with it and forming, when the subject node is strongly excited, the embodiment of the *fringe* of it. An example is shown in Fig. 3.4. This figure shows part of a subject aggregate centered on the subject node AUDREY HEPBURN. In the figure a very small selection of the subject nodes that typically in some person's neural system may be connected to the node AUDREY HEPBURN are shown: FICTIONAL CHARACTER: NATASHA, MOVIE FILM: WAR AND PEACE, MOVIE FILM: ROMAN HOLIDAY, ACTRESS, BEAUTY, FEMALE HUMAN.

Many subject aggregates have synaptic connections to other nodes than subject nodes: (1) Connections to nodes of the sense layer. In Fig. 3.4 such connections to AUDREY HEPBURN are shown as SL-AH… and SS-AH…. Such connections cater for *perception*, that is the way the subject node may become excited from impressions on the senses. In the present example the node AUDREY HEPBURN may become excited by visual sense impressions of the sight of the person Audrey Hepburn as it may be obtained from pictures, or of the sight of the name 'Audrey Hepburn' in the form of script. The node may also be excited by aural sense impressions of the sound of Audrey Hepburn's voice as it may be heard in sound recordings, or of the spoken sound of her name. Depending on the individual power of *imagination* of the person, these synapses may also enable the person to imagine the sight and voice of Audrey Hepburn and her name. (2) Connections to nodes of the motor layer, shown in Fig. 3.4 as SM-AH…. By such connections the transmission through the path NM1…, MA1…, bodily influence of muscular and/or glandular activations, Feeling transducer, NS3, may give rise to the *experience of certain feelings* whenever the node AUDREY HEPBURN is excited. (3) A connection shown as SI-sayAH to an action node: 'Action node, say "Audrey Hepburn"'*. This action node, when strongly excited, will start the muscular activity going into *the person's saying 'Audrey Hepburn'*. The excitation from AUDREY HEPBURN through SI-sayAH will function as a preactivation of this muscular activity.

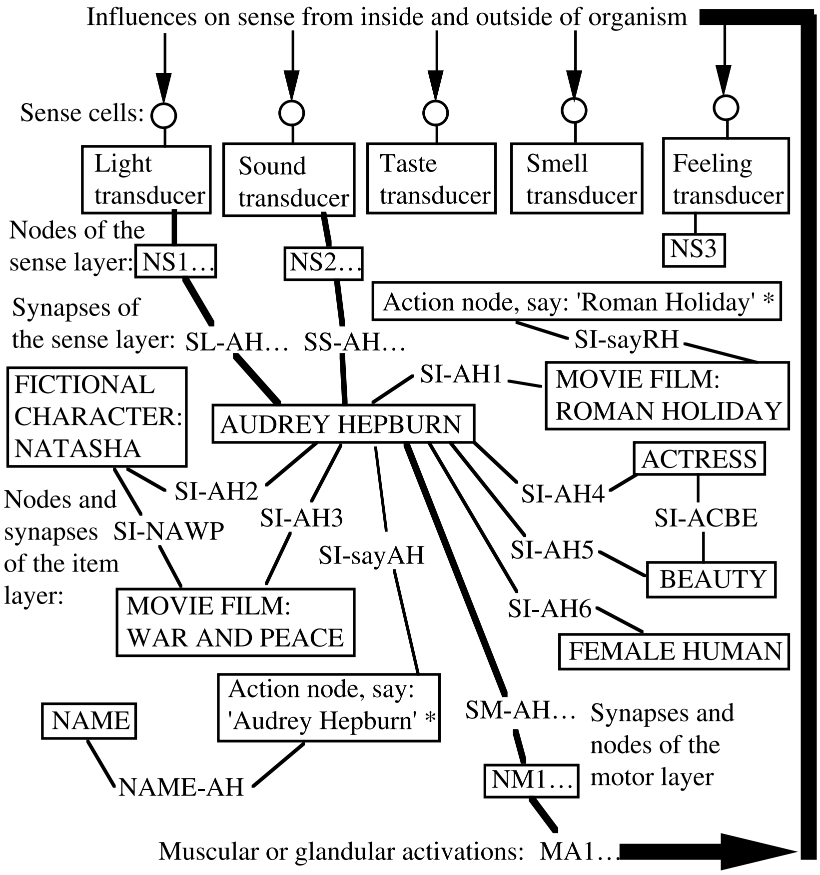


Fig. 3.4 Subject aggregate: AUDREY HEPBURN

Fig. 3.4 gives concrete illustration of what James describes when talking about association in voluntary thought, as quoted in section 2.1 in connection with Fig. 2.6. Suppose the person of Fig. 3.4 is asked: 'Do you remember the beautiful actress who played Natasha in War and Peace? What is her name?' Then it may very well happen that the person answers: 'Yes, I remember her. She also did the princess in Roman Holiday. But I don't recall her name.'

A certain part of what happens in the person's neural system during these remarks is this. While hearing the first question, certain of the nodes of the person's neural system become excited from the aural sense cells and their attention and specious present synapses (not shown in the figure), first BEAUTY, then ACTRESS, then FICTIONAL CHARACTER: NATASHA, then MOVIE FILM: WAR AND PEACE, finally NAME. Hearing the words 'What is her …?' puts the stream of thought of the person into a transitive state, embodied in a rapid exchange of excitations among the five nodes through the synapses connecting them: SI-AH5, SI-ACBE, SI-AH4, SI-AH2, SI-NAWP, and SI-AH3. Further nodes (not shown in the figure) that are excited by other words spoken will take part in this exchange. The excitations will additionally receive contributions from such response habit aggregates that are excited in the situation, not shown in Fig. 3.4, typically a response habit aggregate for the person spoken to. Other contributions may arrive from sense cells, through synapses of the sense layer, depending on the influences arriving from the environment.

As a result of these exchanges the combined excitations arriving into the node AUDREY HEPBURN by their summation will excite that node strongly, so as to excite its attention synapse. It must now be assumed that the synapse SI-sayAH has insufficient conductivity to bring about also a strong excitation of 'Action node, say "Audrey Hepburn"'*, even when the preactivation from NAME through NAME-AH is added to it. However, it must be assumed that the excitation through SI-AH1 excites MOVIE FILM: ROMAN HOLIDAY sufficiently to arouse its attention synapse. This excitation is then transferred through SI-sayRH into 'Action node: say "Roman Holiday"'* and so will make the phrase 'Roman Holiday' to be spoken by the person.

The pattern of Fig. 3.4 explains the very common situation, that one can think of a person who is well known to oneself, and yet cannot at the moment recall the person's name. This is a matter of the conductivities of the synapses shown in the figure. When the person thinks of the actress Audrey Hepburn, this is a matter of the excitation of such nodes as AUDREY HEPBURN, ACTRESS, BEAUTY, MOVIE FILM: ROMAN HOLIDAY, NATASHA, and MOVIE FILM: WAR AND PEACE. 'Thinking of Audrey Hepburn' is a matter of having the attention pass rapidly back and forth among these and other connected nodes. This thinking process will steadily increase the conductivities of the synapses connecting the nodes being excited, such as SI-AH1, SI-AH2, SI-AH3, SI-AH4, SI-AH5, SI-AH6, SI-ACBE, and SI-NAWP. But the synapse SI-sayAH will in this process remain unchanged. This synapse will only become excited and thereby have its conductivity increased when 'Action node, say: "Audrey Hepburn"'* is excited, that is when the person actually pronounces the name Audrey Hepburn. Compared with the frequency of excitation of the other synapses in the picture, this usually in practice is a rare event.

Fig. 3.5 shows other subject nodes that may serve to explain a technique for helping to recall a name which is sometimes effective. The technique consists in asking yourself in turn: Does the name spell with ‘A’? Does the name spell with ‘B’? etc. through the alphabet. The effectiveness of this technique depends on the person’s neural system having already a set of subject nodes: ‘First letter is A’, ‘First letter is B’, … ‘First letter is Z’, that are connected by conductive synapses to such action aggregates that embody speech actions. ‘First letter is A’ is connected to all action nodes that when excited activate the muscular activity of speaking a phrase having A as the first letter, thus as shown in the figure to action nodes for speaking ‘Audrey Hepburn’ and ‘Australia’. Similarly for the other nodes of the alphabet. By these nodes the thought ‘Is the first letter of the name A?’ will excite the node ‘First letter is A’ which will transmit preactivation excitations into the corresponding action nodes. These excitations will by summation combine with other preactivations of the action nodes and may thereby raise the excitation of one of these to the attention level, whereby the actual saying of the name will take place in the muscles.

So if you want to be able to recall the name of a particular person at any time, train yourself by thinking many times of that person, and every time say the person’s name aloud. It is not enough just to think of the name, you must have your muscles say it.

This explanation makes it clear that the difficulty of recalling names will be a common one to such persons who are given much to silent pondering rather than to talking.

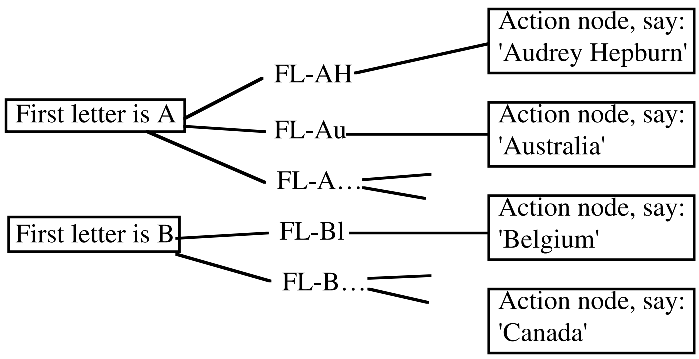


Fig. 3.5 First letter nodes

The subject aggregates are the carriers of pondering. Such activity will be the more varied and lead to more unusual insights the more subject aggregates the person has formed and the more associative connections they have.

3.5 Quality aggregates: the embodiment of how we feel about things

Quality aggregates embody our feelings about things. An example, HEAVY-WEIGHTY, is shown in Fig. 3.6. In this figure, AN stands for action node, SN for subject node, and RHN for response habit node. HEAVY-WEIGHTY will receive excitations under several different circumstances in the following way:

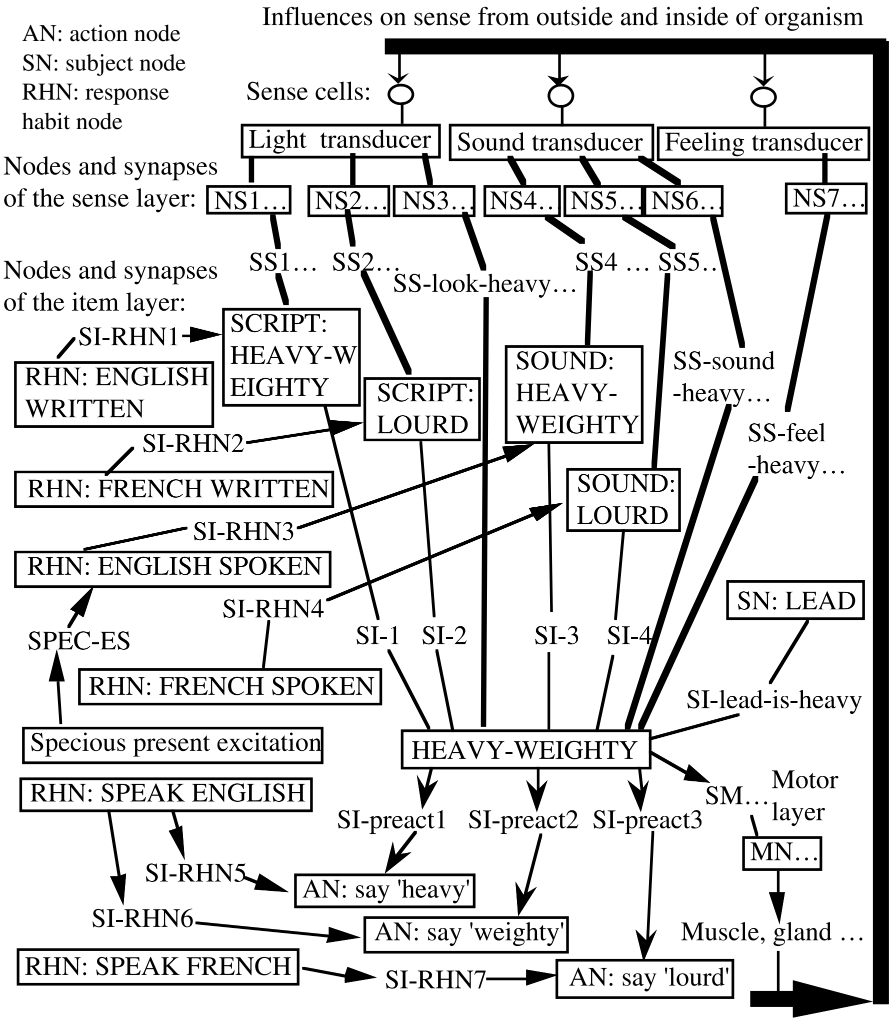


Fig. 3.6 The quality aggregate HEAVY-WEIGHTY

1) When something heavy comes to be sensed by the person, by any sense. Such excitations will be received from such nodes of the sense layer that get stimulated by sensations of things that look, sound, or feel, heavy: NS3…, NS6…, and NS7…,

through the synapses SS-look-heavy…, SS-sound-heavy…, and SS-feel-heavy….

2) When the words ‘heavy’ and ‘weighty’ are heard by the person in an English-speaking situation, or the word ‘lourd’ is heard by the person in a French-speaking situation. In such a situation excitations from such nodes of the sense layer as NS1…, NS2…, NS4…, and NS5…, that get stimulated from the sense cells by the sight or sound of a written or spoken word as, in English, ‘heavy’ and ‘weighty’, and in French, ‘lourd’, get summed together in such nodes as SCRIPT: HEAVY-WEIGHTY, SCRIPT: LOURD, SOUND: HEAVY-WEIGHTY, and SOUND: LOURD. From these nodes excitations get transmitted into HEAVY-WEIGHTY through the synapses SI-1, SI-2, SI-3, and SI-4. The transmissions of the word excitations through the four nodes get influenced by the preperception excitations coming from the four response habit nodes: RHN: ENGLISH WRITTEN, RHN: FRENCH WRITTEN, RHN: ENGLISH SPOKEN, and RHN: FRENCH SPOKEN. For example, in an English speaking situation, the node RHN: ENGLISH SPOKEN will be kept excited from its specious present synapse, SPEC-ES, and will contribute preexcitation into SOUND: HEAVY-WEIGHTY through the SI-RHN3 synapse.

3) Something heavy is thought about by the person. Whatever is thought about will have the node embodying it excited from some source. Whatever is known to the person to be heavy will have the node embodying it connected through a conductive synapse to the node HEAVY-WEIGHTY. In the figure the node SN: LEAD is shown to contribute to the excitation of HEAVY-WEIGHTY through the synapse SI-lead-is-heavy.

The effects of the excitation of the node HEAVY-WEIGHTY for the functions of knowing and feeling are as follows:

1) A specific feeling is produced, by the activation of certain particular muscles and/or glands through the path SM…, MN…, muscle/gland, bodily influence, Feeling transducer, NS7….

2) The node HEAVY-WEIGHTY will transmit preactivation excitations into such action nodes as ‘AN: say “heavy”’, ‘AN: say “weighty”’, and ‘AN: say “lourd”’. Depending on the situation these nodes also receive preaction excitations from the response habit nodes RHN: SPEAK ENGLISH and RHN: SPEAK FRENCH. The action nodes will activate the speech muscles when they receive additional excitations from nodes not shown in the figure. Thus when the excitation of other nodes activates the speech activity associated with the subject about which the ‘heavy’-‘weighty’ character is known, then the phrase spoken will be ‘heavy’ or ‘weighty’ in an English speech context and ‘lourd’ in a French speech context.

Sexual arousal is a complicated pattern of feelings and responses. It will typically be embodied in a quality aggregate as shown in Fig. 3.7. The structure comprises the nodes SEXUAL FEELING and SEXUAL AROUSAL. Of these two nodes the first one caters mostly for the influence of the sexual feeling in the stream of thought, while the second node caters for the muscular and glandular excitations that through sense cells produce the experience of the feeling. The two nodes embody what may be called two aspects of the sexual feeling, the one being the influence of the feeling on other activities of the stream of thought, including perception and speech, the other being the manifestation of the feeling as an experience.

Sexual feelings develop in each individual from an instinct. The instinct is embodied in a reflex excitation via neurons connected directly from certain nodes of the sense layer to nodes of the motor layer, NM…, shown in Fig. 3.7 as Reflex path, the excitation continuing by the path Muscles, gland…, bodily influence, sense cells, Feeling transducer, into the nodes NS5… where the excitation gives rise to a particular feeling experience.

In the individual with an educated neural system the excitation of NS5… that gives rise to the experience of the feeling may at the same time via synapses such as a SSA5… excite the SEXUAL AROUSAL node of the item layer. This node will again via SM1… excite nodes such as NM… and thereby certain muscles and glands, that in their turn will excite certain feeling sense cells and thereby nodes of the sense layer such as NS5… This circular chain of excitations is prominent in masturbation. Since the chain is circular there will, to some extent, be a steady maintenance of the experience of the sexual feeling, once it has begun. If it has no other sources the excitation of the circular chain will continue until it fades out by the exhaustion of the muscles that are part of it.

But the node SEXUAL AROUSAL will be excited also by certain sense impressions, other that those coming through NS5…, from nodes such as NS1… to NS4… through the synapses SSA1… to SSA4… Those from the light transducer may derive from certain sights of human faces and bodies, those from the sound transducer may derive from sounds of certain human voices, tones of voice, and sounds, those from the smell transducer may derive from certain odours of human bodies. Such excitations will by summation in the node SEXUAL AROUSAL contribute to starting and maintaining the circular chain of excitations and thus to maintaining the experience of sexual arousal produced by the excitation of nodes such as NS5….

The node SEXUAL FEELING may receive a preperception excitation from SEXUAL AROUSAL through SI-preperc, but it receives its main excitation from the sense layer, through the synapses SSF1… and SSF2…, when influenced by the sight and sound of certain printed and spoken words. In addition it will receive excitation from other nodes of the item layer such as SUBJECT X.

The effect of the excitation of SEXUAL FEELING is to supply preactivation excitation to action aggregates, for example through SI-preact1 to such a node as ‘AN: say ‘vagina”, that have to be excited in order to express matters related to the sexual feeling in speech and writing. Such preactivation excitation will also to some extent be supplied by SEXUAL AROUSAL, for example as preactivation through SI-preact2 to such a node as ‘AN: say ‘cunt”. In this way the speech vocabulary of the person will be influenced by the momentary strengths of excitations of SEXUAL FEELING and SEXUAL AROUSAL.

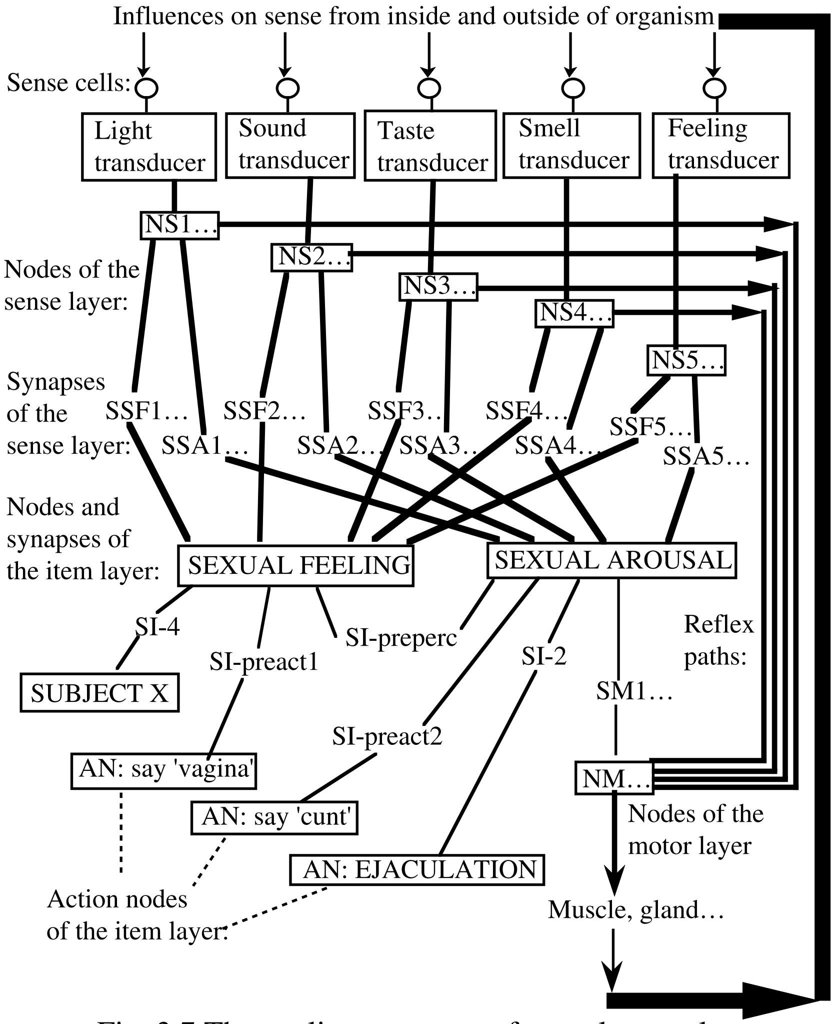


Fig. 3.7 The quality aggregate of sexual arousal

The two nodes of the quality aggregate, SEXUAL FEELING and SEXUAL AROUSAL, act mutually as preperceptions to each other, through SI-preperc. Which of these two nodes will be more strongly excited is a matter of the momentary situation of the person.

When the muscles that influence the sense cells giving rise to a particular feeling can be activated at will, the experience of the feeling can be called forth by such voluntary activation. This would be called forth by any excitation of the nodes NM… in Fig. 3.7.

3.6 Urge aggregates: the embodiment of the urge to take action

Most muscular actions take place as chains of part-actions, as described below in section 3.7. The excitation of the first part-action of a chain usually depends on the summation of excitations from several sources of various kinds, including usually several response habit nodes, that by their combination determine what the action shall be. Additionally there will often be contributions that just embody the urge that an action of a certain general kind shall be taken. Such contributions are provided by the nodes of urge aggregates. Such nodes will be called *urge nodes*.

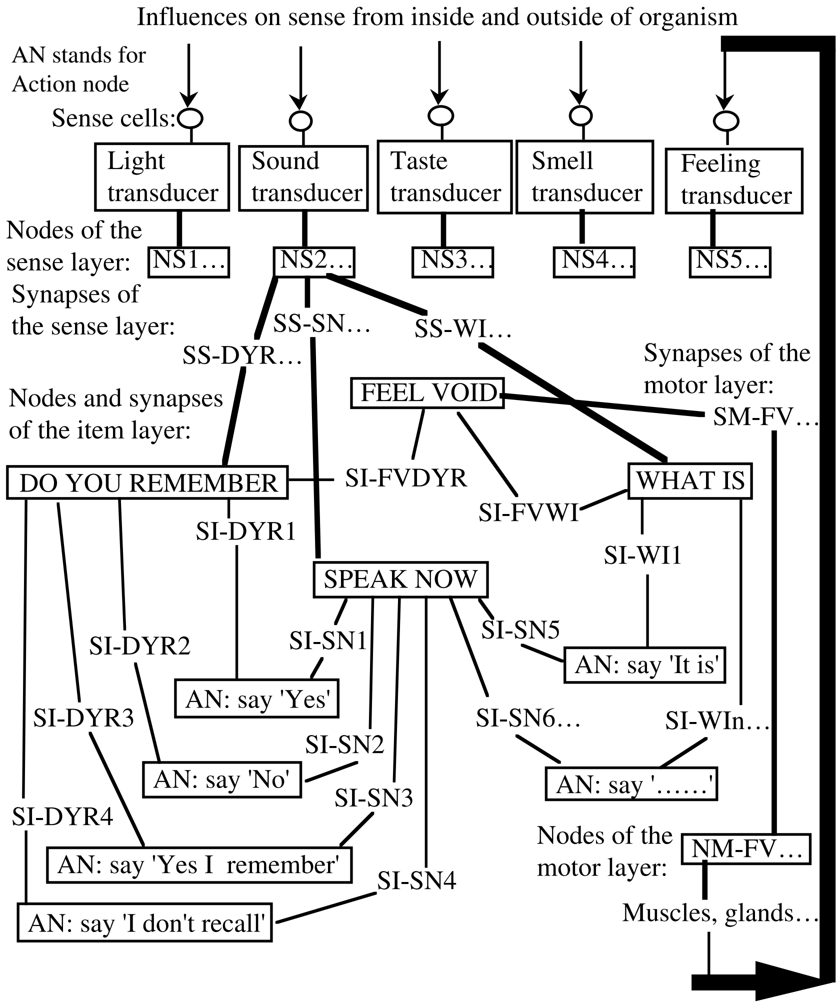


Fig. 3.8 Question answering urge aggregates and the aching void

As examples Fig. 3.8 shows some urge nodes that when excited initiate actions of answering spoken questions. The excitations shown in this figure should be taken to happen at the same time as those shown in Fig. 3.4, as the neural embodiment of the events involved in the person's answering the question: 'Do you remember the beautiful actress who played Natasha in War and Peace? What is her name?' The question contains the spoken invitations 'Do you remember …', and 'What is …'. As shown in Fig. 3.8 the sound sensations of such invitations will through the synapses SS-DYR… and SS-WI… excite particular urge nodes, DO YOU REMEMBER and WHAT IS. In its turn DO YOU REMEMBER will transmit preactivation excitations through the synapses SI-DYR1, SI-DYR2, SI-DYR3, and SI-DYR4, into the action nodes 'AN: say "Yes"', 'AN: say "No"', 'AN: say "Yes I remember"', and 'AN: say "I don't recall"'. WHAT IS will transmit preactivation excitations through the synapses SI-WI1 and SI-WIn…, into the action node 'AN: say "It is"' and others of the form 'AN: say "……"'.

The spoken question ends in an inquiring phrase consisting of the phrase 'What is her name?' spoken in a certain tone of voice followed by silence. In the listener this inquiring phrase will through the synapses SS-SN… excite the urge node SPEAK NOW. This node will in turn excite any action node that may be the first one of an answer, thus through the synapses SI-SN1, SI-SN2, SI-SN3, SI-SN4, SI-SN5, and SI-SN6…, the actions nodes 'AN: say "Yes"', 'AN: say "No"', 'AN: say "Yes I remember"', 'AN: say "I don't recall"', 'AN: say "It is"', and 'AN: say "……"'.

The excitation of the urge nodes DO YOU REMEMBER and WHAT IS will through the synapses SI-FVDYR and SI-FVWI excite the node FEEL VOID, which in its turn, through the path SM-FV…, NM-FV…, muscles/glands, bodily influence, feeling sense cells, Feeling transducer, will excite certain nodes NS5… and thereby produce the experience of a peculiar feeling, what James [I 584] calls the feeling of *aching void*. This feeling will prevail as long as the attention keeps the urge nodes excited. This will continue as long as the attention is directed from one to the other of the subject nodes shown in Fig.s 3.4 and 3.8. This process ceases when the attention is directed into one of the action nodes and the action of speech is initiated. That speech action node will then be activated that in the previous process of attention excitations of the nodes has received the greatest sum of preactivations. Some of these preactivations may have originated in response habit nodes not shown in Fig.s 3.4 and 3.8.

Other muscular actions than speech will be urged by any variety of sensations and feelings. A person feeling hot and sweaty may thereby be urged to undertake the actions of pulling off his sweater. A sitting gentleman seeing a lady entering the room, or feeling a vague tiredness in his back, may thereby be urged to rise from his seat. The action taken will in any case result from the combination of the possible actions in the situation, as embodied in the summation of preactivations of certain action nodes from the response habit nodes that are excited in the situation, and further excitations, stemming from sensations, that are transferred into the action nodes. That action node will become effective which in this process receives the highest sum of excitations.

3.7 Action aggregates: the embodiment of muscular actions

Action aggregates embody the muscular activity of voluntary movements of the body. Typical examples are the movements of arm and fingers performed when lifting a cup to the lips for drinking and the movements in lips, tongue, throat, and abdomen, when speaking a word or phrase. Such movements happen as habitual chains of sub-movements, as described by James as quoted in section 2.4 in connection with Fig. 2.3.

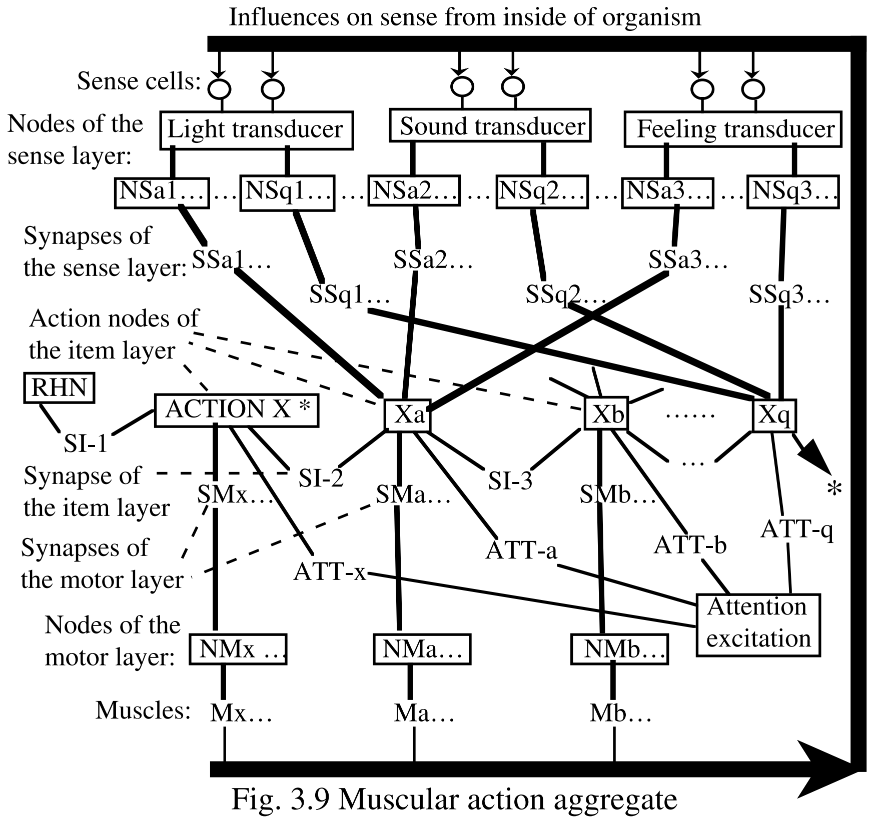


Fig. 3.9 Muscular action aggregate

The neural embodiment of a chain of muscular actions is shown in Fig. 3.9. In this figure synapse and node designations such as SMx… and NMx… are used as abbreviations to indicate that the pattern includes an indefinite number of other synapses and nodes in a similar position within the structure.

The pattern of connections of Fig. 3.9 is most easily explained by an account of the way the excitations within the pattern develop after the first node of the aggregate has been excited, which are further illustrated in Fig. 3.10. The action aggregate is activated by excitation of the node ACTION X*, which will be supported in strength through the ATT-x synapse. This excitation is shown in Fig. 3.10 at Time 1. By way of the synapses SMx… and nodes NMx… it will activate the muscles of the first action, Mx…. The movements that result from these activations will excite a number of sense cells, and thereby the nodes NSa1…, NSa2…, and NSa3…. These nodes will further excite the synapses SSa1…, SSa2…, and SSa3…, and thereby the action node Xa as shown in Fig. 3.10 at Time 2. This, when supported in strength from ATT-a, in its turn will excite the synapses SMa…, the nodes NMa…, and the muscles Ma…. And so the activation of muscles will continue through any aggregate of action nodes Xb… as long as the connecting synapses have conductivities patterned upon those described above. The movements resulting from this chain of actions will finally excite sense cells exciting the nodes NSq1…, NSq2…, and NSq3…, and the synapses SSq1…, SSq2…, and SSq3…, and so the node Xq, which will then get supporting excitation through ATT-q. In Fig. 3.10 this is the situation at Time 4.

Excitation strength of nodes shown by the lengths of letter strings
Contributions: S: preactivation in this situation; A: attention excitation

Node	Time 1	Time 2	Time 3	Time 4
ACTION X *	SSSAAAAA	SSS	SSS	SSS
Xa	S	SAAAAA	S	S
Xb	S	S	SAAAAA	S
Xq	S	S	S	SAAAAA

Fig. 3.10 Crude snapshots of four situations in the activation of an action aggregate, showing the strengths of excitation of four nodes

The execution of an action aggregate may be supported in the situation by supplementary excitations of the relevant nodes from one or more response habit nodes, of which RHN is shown, and by internal excitations along the aggregate by such synapses as SI-2 and SI-3.

The end of the execution of an action aggregate will lead to the excitation from certain sense cells of the node shown as Xq, which is not an action node. Such a node will usually be tied by synaptic links, shown as *, to certain other nodes that thereby receive a certain excitation when the actions of the aggregate have been done.

For notational simplicity action nodes will in other figures be shown only as the first node of the aggregate, like ACTION X * in Fig. 3.9. When this abbreviated notation is employed the neurons emerging from the last node of the aggregate, Xq, will be shown in the figures as emerging from the symbol * of the name of the first node, as shown in Fig. 3.11.

Fig. 3.11 Action aggregate in abbreviated notation

4. The neural embodiment of speech

4.1 Speech as a crucial issue of neural embodiment

Accounting for speech is a crucial issue to any theory of the neural embodiment of mental life, for two reasons:

(1) Speech is produced by activations of muscles in lips, tongue, jaws, throat, and abdomen. Each utterance spoken by a person is the result of a complicated pattern of such activations. Every one of these muscular activations must have been produced by neural excitations, and will produce an audible effect which is evidence of the neural activity which has produced it. Speech is the most detailed manifestation of the neural activity of the person that is directly accessible to observation.

(2) Owing to the highly developed habits of perception of human speech sounds had by most people, the details of speech sounds can readily be registered by many listeners and so be subjected to detailed analysis.

To this it should be added that what is required as the empirical support of accounts of the neural embodiment of the speech activity, are samples of speech as it is produced spontaneously by some person in real time in a concrete situation and context which is well understood by the analyst.

It should be noted that the present view of the problem of the neural embodiment of speech rejects the prevailing views of linguistics, as exposed by, for example, Chomsky, who says (Chomsky, 1971):

> … a *generative grammar* … is a system of rules that relate signals to semantic interpretations of these signals. It is *descriptively adequate* to the extent that this pairing corresponds to the competence of the idealized speaker-hearer. The idealization is (in particular) that in the study of grammar we abstract away from the many other factors (e.g. memory limitations, distractions, changes of intention in the course of speaking, etc.) that interact with the underlying competence to produce actual performance.

As clear from this, Chomsky's generative grammar is concerned, not with genuine speech, but with some sort of idealized speech. In the present view such ideas are misguided and have to be disregarded.

4.2 Representations of speech

The account of the neural embodiment of the speech production process to be developed here will be based upon empirical data in the form of several samples of speech as it has been produced spontaneously by several different persons who speak about generally well understood subjects in a public context. However, the use of such data meets the difficulty that since each action of production of speech is a unique manifestation of the mental state of the speaking person, strictly speaking any concrete sample of speech can only be studied at the one and only moment when it is produced. A detailed analysis of the outcome of the action, in particular the stream of verbal sound produced in the action, must be based on representations (descriptions) of the outcome of the speech activity.

The representations of speech samples that will be used here are, first of all, high quality video recordings of the speech activity, as visible in the face of the speaker and audible in the speaker's voice sounds. The video recordings give evidence of the neural process underlying the speech, since, as well known in laryngology, the speech activity is a matter of a complicated sequence of muscular activations in the speaker's organism, including a series of complicated muscular activations in the speaker's speech organs. These muscular activations set up vibrations in the vocal chords that have transferred vibrations into the surrounding air. In a video recording these vibrations have by electronic means been recorded and the records have been copied. With the aid of such recordings it is possible at any time to reproduce with great fidelity the stream of speech sounds produced in the samples, as well as to represent in picture form the facial expression of the speaker as it was during the speech activity.

However, video recordings are not sufficient. For the purposes of a detailed analysis of the speech sounds the video recordings have to be supplemented with representations of the speech sound in the form of typescripts.

With respect to the typescript form, there is a choice between a purely phonetic notation of the speech sounds and a notation that makes use of the well established alphabetic representations of the speech sounds as taken to be elements of a human language. For the present purpose the second of these alternatives must be adopted. What has to be presented in the typescript for the purpose of finding the neural process underlying the speech is not primarily the speech sounds as such, but the speech sounds as a person having the perception habits of the language spoken perceives them. Such a person will immediately perceive the speech sounds to consist of a sequence of mostly words and phrases of the language.

This raises the question, how and by whom should a transcription of the recorded sound into typescript be made? One might say that ideally the transcription should be made by the speaker. However, in practice such a procedure would be found to be problematic. If one confronts a speaker with an exact typescript rendering of what he or she has spoken at some occasion, the speaker will tend to correct the typescript, removing such features of the text that are only appropriate in a spoken message, so as to make the typescript conform rather to a style that is appropriate to a written message. Such corrections would remove many of the features of the text that are evidence of the neural process by which the spoken message has been produced, and would thus defeat the purpose of the present investigation.

If the transcription is done by another person than the speaker, the success of it will be entirely dependent upon the extent to which the linguistic perception habits of the transcriber match the speech habits of the speaker. How far this is the case will be directly evident to the transcriber, simply by the extent he or she is able to perceive the speech sounds as language phrases that make sense in the context.

The typescript representations of the speech samples shown below have been produced by me, your present writer. They have required me to listen to the electronic records of the original speech sounds several times while recording in writing what I have heard. I have found that most of the stream of sounds produced by the speakers, although extremely complicated, by my perception habits can be immediately perceived to be composed of English words and phrases. However, in the transcriptions I have had to add ways of notation not ordinarily used in written English, particularly for hesitations and pauses in the speech. In a few places I have failed to perceive a language phrase in the speech sound. These places I have marked -?-.

4.3 Typescript representations of samples of spontaneous speech

The samples of speech represented below appear as spoken comments included as Special Features, *From page to screen* and *Making of Pride & Prejudice*, in a published DVD edition of a television adaptation of Jane Austen's novel *Pride and Prejudice* produced by BBC in London in 1995. They have been spoken by persons who all work with speech at the highest artistic level. As will be discussed below the comments are significant in the present context not only as samples of genuine speech but also by what they say about speech.

Comment 1 is made by Andrew Davies, who as screenwriter adapted the dialogues of Jane Austen's novel to what was actually spoken by the actors in the television adaptation. In transcription from the spoken form Andrew Davies says:

> [*From...* 16:10-16:54] Jane Austen's dialogue is — is — is absolutely wonderful to work with because she does write very distinct speech patterns for all the characters — Darcy is — very economical with his words — and very very powerful never wastes a word — and he speaks generally in short sentences — ah — Elizabeth is — is — is — is very light and — and lithe and quick of remark — and articulate— ah — Mrs Bennet says a great deal to not much purpose — Mr Collins is a compendium of clichés — ah — Mr Bennet — hardly ever speaks anything except when he has got his tongue in his cheek — almost every remark is ironic — and — and so you have got lovely things to work with —

Comment 2 is made by Sue Birtwistle, producer on the television adaptation, in transcription from the spoken form:

> [*From...* 3:48-4:20] Andrew Davies and I were very clear at the beginning that we wanted to get to really reflect what we feel is the spirit of Jane Austen's Pride and Prejudice — now it's a very lively book — it's a very witty book —

it's a great romantic — love story — and — and it's quite hard headed — Jane Austen I think is — quite hard headed — she understands the reality — of being — a woman — at that time — so we wanted all of that to — to come out as an adaptation — … [*From…* 22:06-22:24] certainly when I was first producing it — whenever I went out and people asked what I was doing and I said Pride and Prejudice — they said who is your Elizabeth — who is your Darcy — ahm — and if you would suggest possible names they would say oh no no — you can't possibly have that person or — you absolutely have to use this actor — he is Darcy — it was pretty frightening — … [*Making…* 17:51-18:07] — I particularly wanted Colin Firth to — to play Darcy — ahm — and some people said it was an odd — an odd choice and I think Colin himself thought it was an odd choice and — ah he in fact said no at the beginning and I — absolutely had to insist that he — think again — and he -?- him to take the part and he is said to realize that anybody else to take the part he would be immensely jealous — because the part had taken over him — ahm — … [*From…* 27:46-28:09] — I think it is simply — the best — eh — love story — ah — that I know — I read it — I've read it now hundreds of times but every single time — I wait to see if Elizabeth and Darcy are going to get together — hm — I still dispense my disbelief until until that moment and I long for them — hm — to work out —

Comment 3 is made by Simon Langton, director on the television adaptation, in transcription from the spoken form:

[*Making…* 12:18-12:48] Well casting — it's a truism to say casting — is important — it — probably is the most important thing — or aspect — of the whole — production process — ah — particularly — eh — for a book — that is so well known — because — unlike — other novels which have been adapted and successfully done — Pride and Prejudice is I think I am right in saying is one of the most widely read — eh — classical novels in the English language —… [*From…* 13:49-14:14] — if Elizabeth Bennet comes on or if Mr Bennet comes on — and it's ahr — it's not how I imagined — Mr Bennet then — then — you have to work very very hard to get over that hurdle — in order to get people back into it into it so it's it's — doubly enhanced in a sense that you have to get people who are acceptable — as these characters — especially for instance — the Bennet family — …[*From…* 24:50-25:25] We know what the end is like — it's a kind of inevitability and once the inevitability happens — you lose narrative — thrust — you lose — some of the need — to see it through — so one must hold it back hold it back restrain restrain — right until the last minute — — ah — — the beauty of the love — between Darcy and — — — and Elizabeth is that it is held back — almost to the last moment — they are too proud and prejudicial if you like to — to express that earlier on — …[*From…* 25:30-25:42] — editing of course is — is extraordinarily important and you can change the whole — eh — focus of a scene eh simply by staying on one shot one second longer than another — eh — I mean I will give you an example of simply holding on looks —

Comment 4 is made by Alison Steadman who acted the part of Mrs. Bennet, in transcription from the spoken form:

> [*Making...* 16:04-16:13, 16:32-17:01] As an actress I'm constantly on the lookout for — fun roles — things that can be interesting and give me plenty of scope to be creative — when I was offered this part — ahm — I hadn't read — the book — so I first of all read the book — and then — eh — read the script — and of course as soon as I read it — I could hear — the voice of Mrs. Bennet — she just — comes off the page — so beautifully written — the character is all there — it's all there as a box of chocolates you know — it's just ready to dive into — and I just couldn't — couldn't resist — ...[*From...* 14:34-15:00, 15:24-16:10] — the character was easy — but the language is — very difficult because of course — we speak in a completely different way — we keep wanting to put — modern phrases in — and every one who has been involved with the production — all the actors have said that — they found the dialogue extremely difficult to learn — you think you know it — then when you come to run it you find -?- coming on saying now that's wrong — this is wrong — ticking off all these words — at first it was just a nightmare — I will never get — on top of this — I will never get the hang of it — I thought I was the only one but everyone had the same problem — but once you do get over that — once you get into the rhythm — and the speech patterns that they used — then it all begins to — to make sense —

Comment 5 is on the character of Darcy, spoken by Colin Firth who acted Darcy, in transcription from the spoken form:

> [*From...* 19:12-19:32] I think there is a problem of his — of his attractiveness — eh — I think there is very little about him which — eh — which is appealing — eh — he is utterly — hm — and unreasonably dismissive of almost everybody he — he meets — ahm — you know it's up to other people whether they find that fascinating about him or not — ... [*From...* 20:26-20:52] I don't think she would have developed the prejudice against him — quite as — violently had had not — had not her pride been hurt — ahm — in fact Jennifer who who plays Elizabeth found this in her playing of it that — eh — she is quite prepared to be amused by Darcy's arrogance — ahm — even when her mother is slighted — but when she herself gets slighted — it becomes a sort of obsession I think —

Comment 6 is a critical review of the finished adaptation, spoken by P. D. James, in transcription from the spoken form:

> [*From...* 1:26-2:24] I imagine that Jane Austen — a great genius — hm — writing at the early nineteenth century — and I myself — a fabricator of mysteries here in the late twentieth — would agree about the principles really which should govern -?- of our work — and I think first there should be respect for the work itself — and the story should be told more or less as it is written — if the story has to be — greatly changed then — — s-s-s-sesignificantly

altered — huge additions — huge deletions — then why perform it at all — I think we both agree that as far as possible — the writer's dialogue should be used and spoken by the person who speaks it in the book — — it should never be necessary to invent new characters — it may sometimes be necessary to drop existing ones — because it is a popular book — nearly everyone knows the opening — ... [*From...* 6:36-7:10] I am only really upset by additional scenes if necessary scenes are cut out to make way for them — and one of the great virtues of this adaptation because of the length — — of the serial — we do get virtually the whole of the book — it's very very little cutting — not anything that's important — and — and therefore I am quite happy — hm — for Andrew Davies — perhaps in a slightly self-indulgent way — eh — to show us Lydia scamper about in her underclothes — (chuckle)

4.4 Core-phrases as the elements of speech

According to the synapse-state theory, speech is produced by excitations of action aggregates of the kind described in section 3.7, each utterance being produced by a series of such excitations in sequence. Each action aggregate involved in speech when excited will produce the speaking of what shall be called a *core-phrase*. In this way core-phrases must be considered to be the elements from which any utterance of speech is formed.

The excitation of an action aggregate gives rise to the execution of a sequence of bodily movements that release each other automatically. The central role of such action aggregates in the pronunciation of core-phrases should be clear already from personal experience that may be had by anyone. For example, anyone who is used to it can observe that when pronouncing the name Audrey Hepburn he or she will perform four sub-movements corresponding to the sounds Au-drey-Hepb-urn, these sub-movements following each other in rapid sequence, automatically. That these sub-movements are embodied in a single action aggregate may be demonstrated by trying to do the four sub-movements in an unfamiliar order, for example as urn-Hepb-drey-Au. Then it will be found that one can only do this more slowly, by giving separate attention to each of the four sub-movements in turn.

The primary evidence in the speech samples in section 4.3 of the formation of the speech from core-phrases is the occurrence of immediate repetitions of speaking of phrases. As one example, in comment 3 such repetitions come twice in immediate sequence: 'so one must hold it back hold it back restrain restrain', involving two core-phrases: 'hold it back' and 'restrain'. In judging this evidence it should be kept in mind, first, that, as may be observed by anyone, pronouncing the phrase 'hold it back' requires a very complicated muscular activity, involving a number of muscles in abdomen, throat, tongue, jaws, and lips, that must be activated in a strict order.

Second, the transcription of the speech from the spoken form to the typescript form 'hold it back hold it back', has involved the perception by the transcriber of the speech sounds as consisting, not of one phrase, but of the same phrase, 'hold it back', spoken twice. This perception depends on very complicated sequences of sense impressions, but impressions that have followed each other in immediate sequence, within one or two seconds, thus presenting the best possible situation for comparing them. The perception habits are such that many thousands of different sound sequences would be clearly distinguished, as being different language phrases. The perception that the two phrases in 'hold it back hold it back' are the same is the strongest possible evidence that their spoken sound must have been produced neurally, in the speaker's nervous system, not by one continued sequence of neural excitations, but by the excitation of a shorter sequence, twice repeated. It follows irresistibly that the speaking of the phrase is embodied neurally in two excitations of the same action aggregate for speaking the core-phrase 'hold it back'.

Evidence of core-phrases in the form of repeated phrases is found in all six comments, as follows: in comment 1: 'and very very powerful', in comment 2: 'I still dispense my disbelief until until', in comment 3: 'in order to get people back into it into it so it's it's', in comment 4: 'and I just couldn't — couldn't resist', in comment 5: 'violently had had not', in comment 6: '— and — and therefore'.

Other evidence of the embodiment of core-phrases in action aggregates are such passages as, in comment 1: 'is — is — is absolutely', 'is — is — is — is very light', 'and — and lithe', 'and — and so', in comment 2: 'and — and it's quite hard headed', 'to — to come out', 'to — to play Darcy', 'an odd — an odd choice', in comment 3: 'to — to express', 'is — is extraordinarily', in comment 4: 'couldn't — couldn't resist', in comment 5: 'of his — of his attractiveness', 'which — eh — which is appealing', 'he — he meets', 'had not — had not her pride', in comment 6: 'and — and therefore'.

The activity patterns here are that after speaking the first part phrase or phrases of a core-phrase having several part phrases, such as, in the first example, 'is absolutely', the muscular activity of the action aggregate is diverted into continuing the muscular activity of another action aggregate that has the same first part phrases but a different continuation, in this example 'is'. Let us call this activity pattern *core-phrase diversion.*

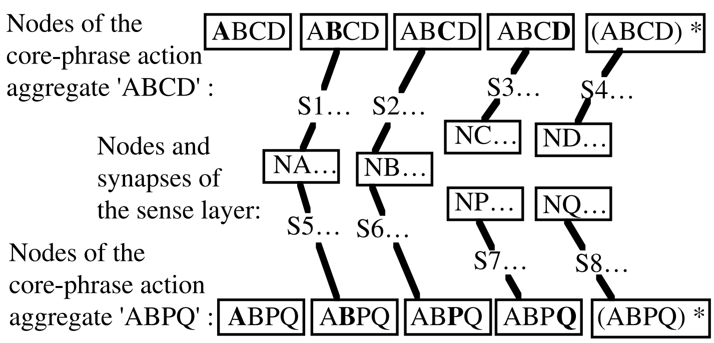


Fig. 4.1 Core-phrase diversion from ABCD into ABPQ

Core-phrase diversion is readily explainable in terms of the activation of core-phrase action aggregates, as shown in Fig. 4.1. The figure shows the nodes that will be excited successively when the core-phrase aggregates **A**BCD and **A**BPQ are excited. They are core-phrase aggregates for speaking core-phrases having four part phrases denoted, respectively, A, B, C, and D, and A, B, P, and Q, the two first, A and B, being the same. Each node shows in bold type the particular part phrase spoken when the node is excited. The terminating nodes are shown as (ABCD)* and (ABPQ)*. The successive excitations of the nodes stem from nodes of the sense layer that are excited by the speaking of the part phrases. Thus nodes NA… get excited as an effect of the muscular activity of speaking the part phrase denoted A. These excitations are transferred into the nodes of the following part phrases A**B**CD and A**B**PQ by the synapses S1… and S5… .

Now assume that so as to effect the speaking of the core-phrase having four part phrases denoted A, B, C, and D, the action node **A**BCD is strongly excited from nodes of the thought object. This will excite the muscles that will produce the verbal sound of the first part phrase of the core-phrase, the part phrase denoted A. This muscular activity will be sensed and so will produce excitations of the nodes NA… of the sense layer. These excitations will through the synapses S1… excite the node of the second part phrase of speaking ABCD, A**B**CD. But since the core-phrase ABPQ begins with the same part phrase A, the excitations of the nodes NA… of the sense layer will also through the synapses S5… excite the node of the second part phrase of speaking ABPQ, A**B**PQ. These simultaneous excitations of the nodes A**B**CD and A**B**PQ will give rise to excitation of the attention synapse of one of them, and so to the muscular activity of speaking the part phrase denoted B. This muscular activity will be sensed and so will produce excitations of the nodes NB… of the sense layer. These excitations will be transferred through S2… into AB**C**D and through S6… into AB**P**Q. This is then the crucial moment when one of the two nodes will be selected for further attention excitation. Which one is thus selected depends on the preexcitations the nodes have already received, and thus on a variety of circumstances of the neural state. And so it may very well happen that although the speaking was initiated by excitation of the node **A**BCD, the part phrases spoken in fact will be those denoted A, B, P, Q, the activity being terminated by excitation of (ABPQ)*.

Yet another kind of evidence of the way the speaking of core-phrases is embodied in action aggregates is in comment 6, the pronunciation written in the transcription as '— s-s-s-sesignificantly'. This represents the action, visible in the video picture of the speaker's face, of a rapid sequence of several soundless articulation movements 's', then a softly voiced sound 'se', and finally the full chain, at full voice, of saying 'significantly'. This shows how the full chain of movements of a core-phrase comes to be excited only when the first sub-phrase is excited strongly. In terms of Fig. 3.9, if the activations of the muscles Mx… are weak, the influence through the body into the sense cells and the nodes NSa3… will be too weak to excite the node Xa, and the pronunciation of the chain of subphrases will not take place. More details of how this pattern of excitations came about in comment 6 are given below in section 4.6.

As conclusion of this section, the ability to produce speech is embodied in the person's nervous system in the form of a large number of core-phrase action aggregates. In other words, a large part of what may be called 'language habits' are embodied in the core-phrase action aggregates in the person's nervous system. The core-phrase action aggregates are personal. Each person will by education of the nervous system have acquired an arsenal of action aggregates for speaking core-phrases.

4.5 The selection of the next core-phrase to be spoken

In this section what will be described is how the sequence of core-phrase action aggregates embodying the production of a full utterance comes to be selected and activated as a neural process. It is obvious from the speech samples that the selection of the next core-phrase to be spoken depends on several circumstances of the mental state that come to be combined when the selection happens. One circumstance is the situation of speaking, being influential inter alia in the selection, when the speaker is able to speak several languages, of a particular speech language vocabulary of core-phrases. Another circumstance is the subject of the speech. This circumstance will further the selection of certain particular core-phrases that are associated with that subject. A third circumstance is the core-phrase just spoken. This in many cases will further the selection of the immediately following core-phrase among those that have habitually been followers.

These considerations show that the final selection of the next core-phrase cannot happen until right at the moment when the previous core-phrase has been spoken. While the muscular activity of the speaking of each core-phrase involves only a limited part of the nervous system, the process that leads to the choice of the core-phrases that together form an utterance will normally involve a large number of neural components in a complicated pattern of mutual excitations that embody the thought object, a pattern that depends on the entire nervous system, with its 10 billion synapses in each their individual state of conductivity, in addition to the neural impulses that stem from sense impressions. Accounting for this choice in full detail is practically impossible. What will be shown in the present section is how all the features of the choice may be understood entirely in terms of the synapse-state description of the nervous system.

The core components of a person's neural system that contribute to speech are core-phrase action aggregates, each of which when strongly excited will give rise to the muscular activations producing the pronouncement of a speech core-phrase. Of such core-phrase action aggregates there will be one for each core-phrase the person has learned to pronounce, and so there will be many thousands of them. Fig. 4.2 shows typical synaptic connections of six core-phrase action aggregates, using the abbreviated notation shown in Fig. 3.11: AN: say 'Subject X'*, AN: say 'X'*, AN: say 'Subject Y'*, AN: say 'Phrase A'*, AN: say 'Phrase B'*, and AN: say 'eh'*. The core-phrase action aggregate AN: say 'eh'* is one of those that embody hesitations in the speech activity. Typical in each person's nervous system there is one that embodies a short pause without voice activity and a few others that embody the person's pause voice sounds such as 'ah' or 'eh'.

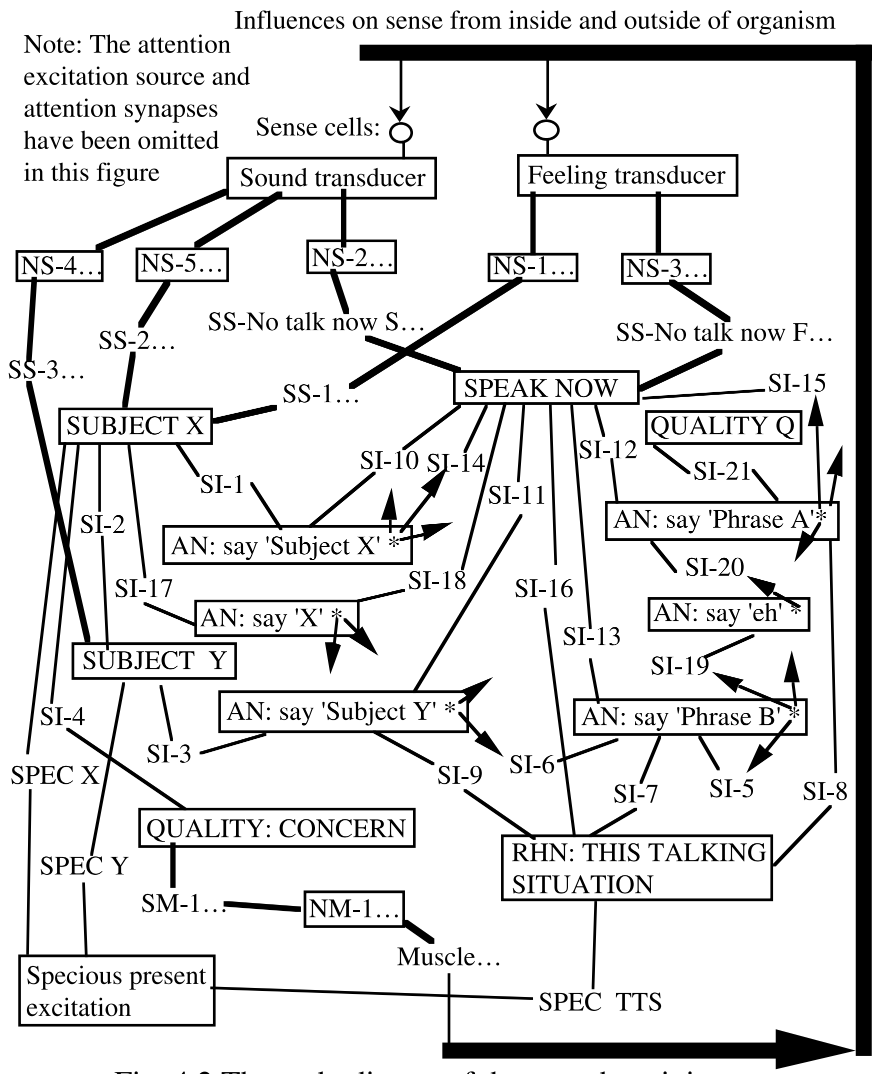


Fig. 4.2 The embodiment of the speech activity

It must be kept in mind that each of the core-phrase action nodes shown in Fig. 4.2 stands for a full node/synapse aggregate as shown in Fig. 3.9. This means that weak excitations of such an aggregate will excite only the first node of the aggregate, shown in Fig. 3.9 as ACTION X *, without effecting the muscular contractions. The muscular contractions will normally only take place as a result of a strong excitation of the action node. The strong excitation will normally be formed by summation in the core-phrase action node of preactivation excitations from a number of sources, being transferred at the same time.

Core-phrase aggregates: / Moments in speech	Elizabeth	is	—	is very light	and	and lithe	and quick of remark
1. Beginning 'Elizabeth'	RSMA	RR	RRS	RM	RR	RM	RMZ
2. Ending 'Elizabeth'	RSNMP	RR	RRSN	RMPF	RR	RMP	RMP
3. Beginning 'is very light'	RS	RR	RRS	RMAA	RR	RM	RMZ
4. Ending 'is'	RSF	RR	RRSFF	RM	RR	RM	RMZ
5. Beginning '—'	RS	RR	RRSAA	RM	RR	RM	RMZ
6. Ending '—'	RSNF	RR	RRSNF	RMF	RR	RM	RMZ
7. Beginning 'is very light'	RS	RR	RRS	RMAA	RR	RM	RMZ
8. Ending 'is'	RSF	RR	RRSFF	RM	RR	RM	RMZ
9. Beginning '—'	RS	RR	RRSAA	RM	RR	RM	RMZ
10. Ending '—'	RSNF	RR	RRSNF	RMF	RR	RMF	RMZF
11. Beginning 'is very light'	RS	RR	RRS	RMAA	RR	RM	RMZ
12. Ending 'is'	RSF	RR	RRSFF	RM	RR	RM	RMZ
13. Beginning '—'	RS	RR	RRSAA	RM	RR	RM	RMZ
14. Ending '—'	RSNF	RR	RRSNF	RMF	RR	RMF	RMZF
15. Beginning 'is very light'	RS	RR	RRS	RMMAA	RR	RM	RM
16. Ending 'is very light'	RSN	RR	RRSNF	R	RR	RMMF	RMF
17. Beginning 'and lithe'	RS	RR	RRS	R	RR	RMMAA	RM

The total excitations, formed by summation into core-phrase action nodes, are given by the length of letter strings. Contributions to excitations:

(1) R From RHN: THIS TALKING SITUATION
(2) S Contribution from SPEAK NOW
(3) M From nodes embodying the subjects and qualities thought of at the moment
(4) Z From nodes embodying strongly felt subjects
(5) P Excitation by aural perception of the core-phrase the person speaks at the moment
(6.1) F From core-phrase immediately previously spoken, into habitual followers
(6.2) N Contribution from termination through SPEAK NOW
A Attention excitation

Fig. 4.3. Crude measures of contributions to excitations of core-phrase action aggregates at 17 moments during the speaking of 'Elizabeth is — is — is — is very light and — and lithe and quick of remark'

Fig. 4.3 shows the preactivations and their sources of the core-phrases spoken in the first part of the passage 'Elizabeth is — is — is — is very light and — and lithe and quick of remark' in comment 1. The preactivations are shown as they are at 17 moments during the speaking of the core-phrases. The amounts of these preactivations are shown in a crude way, the total excitation of an aggregate at one moment being shown as the number of letters in a string of capital letters, with each of the letters identifying the source of a contribution to the excitation. Thus for example the string RRSN is meant to show a total excitation of 4 units of some kind, with two contributions from source R, one contribution from source S, and one contributions from source N. These indications of excitations can only be roughly suggestive since the strengths of the excitations that are transferred in any nervous system can only be known approximately. They will change incessantly, depending as they do on such excitations that derive from sensations and on the conductivities of synapses that always change with time in a plastic manner.

Fig. 4.3 shows only the preactivations and their sources of seven core-phrase action aggregates at the moments when these aggregates give rise to speech. Many more core-phrase action aggregates will receive preactivations from the same sources at these moments, not only every one of those embodying the remaining core-phrases of comment 1: 'and articulate — ah — Mrs Bennet says a great deal to not much purpose — Mr Collins is a compendium of clichés — ah — Mr Bennet — hardly ever speaks anything except when he has got his tongue in his cheek' etc., but all such that embody core-phrases that have in the past been spoken by the speaker in the same context, that is probably many thousands.

At any time the core-phrase action aggregates held in the nervous system will become preactivated in varying and changing amounts from a number of different sources. As long as the sums of these preactivations remain small no muscular activations of speech will happen. Speech will start coming forth when the total excitation transferred into one of the core-phrase action aggregates exceeds a certain amount, and will continue as long as core-phrase action aggregates continue to be strongly excited, one after the other, in close sequence. What is spoken is a matter of which core-phrase action aggregates are activated in this sequence, and so is a matter entirely of which core-phrase action aggregate becomes most strongly excited at each moment when the previous one in the sequence has terminated its activation. Thus the sequence of the core-phrases spoken is entirely a matter of the preactivations of the core-phrase action aggregates that embody them, as these preactivations change from moment to moment.

The sources of the preactivations of the core-phrase action aggregates act selectively on only some of the aggregates in a way which is different for the sources, the excitations from the various sources being summed in each of the aggregates. The sources of the preactivations of the core-phrase action aggregates shown in Fig. 4.3 are described below.

(1) *Response habit nodes excited in the present kind of situation.* Every one of the core-phrase action aggregates that are shown in Fig. 4.2 by six samples: AN: say 'Subject X'*, AN: say 'X'*, AN: say 'Subject Y'*, AN: say 'Phrase A'*, AN: say 'Phrase B'*, and AN: say 'eh'*, are such that have commonly been used by the person in the kind of talking situation that prevails, probably a large number of times. Such aggregates will become preactivated by the excitation of the response habit node RHN: THIS TALKING SITUATION, which is kept excited for the duration of the specious present of the utterance through the synapse SPEC TTS.

The strength of this preactivation for each aggregate depends on the conductivity of the connecting synapse, SI-8 for AN: say ‘Phrase A’*, SI-7 for AN: say ‘Phrase B’*, SI-9 for AN: say ‘Subject Y’*, and synapses not shown for AN: say ‘Subject X’*, AN: say ‘X’*, and AN: say ‘eh’*, and so depends on how frequently each core-phrase has been used in a similar situation, that is a situation in which the node RHN: THIS TALKING SITUATION has been excited, in the past.

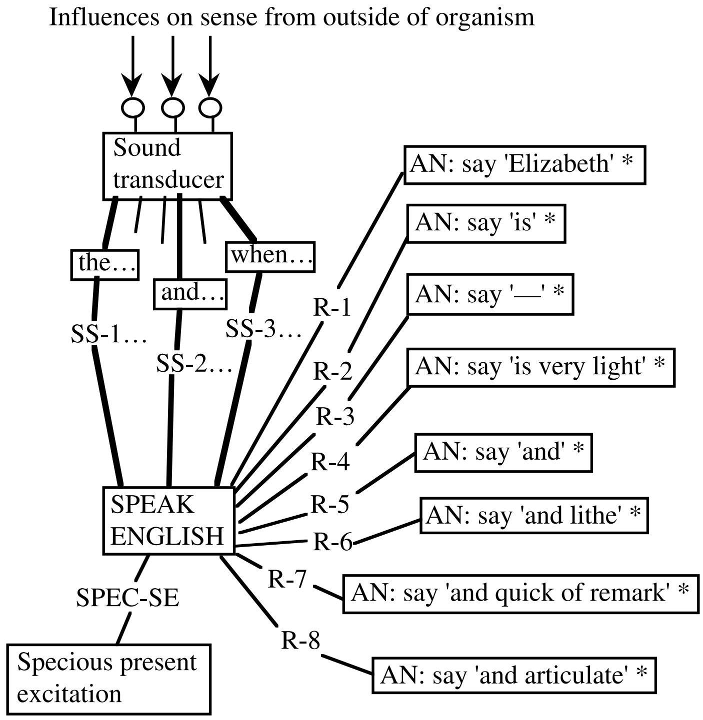


Fig. 4.4 Contributions to core-phrase action node preactivations from the response habit node SPEAK ENGLISH

The preactivations of this kind that contribute to the speech of the concrete situation of Fig. 4.3 are described in Fig. 4.4. Here the response habit node SPEAK ENGLISH is shown to be excited from the sounds of English words through nodes of the sense layer and the synapse groups SS-1…, SS-2…, and SS-3…, that transmit excitations into SPEAK ENGLISH when the person hears the sounds of the words ‘the’, ‘and’, ‘when’, and thousands of others that are recognized by the person to be English words. This will have the effect that whenever the person is exposed to the sound of English speech SPEAK ENGLISH will become excited. This excitation in turn is transmitted as preactivation into all the person's action aggregates of English core-phrases, including those that are shown in Fig. 4.3. In this figure preactivations from response habit nodes are shown by the letter R. The amount of preexcitation depends on the conductivity of the synapses shown in Fig. 4.4 as R-1, R-2, …, R-8. The conductivity will be greater for such words that have frequently been spoken by the person. In Fig. 4.3 a greater excitation, shown by two letters R, is shown for the aggregates of the very common core-phrases 'is', '—', and 'and'.

(2) *Urge nodes transmitting preactivations into first core-phrases of pronouncements.* Certain urge nodes embody the start of spoken utterances. Fig. 4.2 shows the urge node SPEAK NOW. It is preexcited from several sources: (1) The deliberate intent of speaking, including specific feelings of urgency, as embodied in excitation of quality nodes in the thought object. (2) Excitation through SI-16 from RHN: THIS TALKING SITUATION. (3) From nodes of the sense layer that get excited when silence is sensed by the sound transducer and no voice activation muscles are sensed by the Feeling transducer, transmitted by the synapses 'SS-No talk now S…' and 'SS-No talk now F…'. (4) From the termination of such core-phrase action aggregates that embody core-phrases that habitually have been terminating pronouncements. Fig. 4.2 shows the synapses SI-14 and SI-15 transmitting excitations at the termination of speaking the core-phrases Subject X and Phrase A, that is when the active speaking of the core-phrases is terminated.

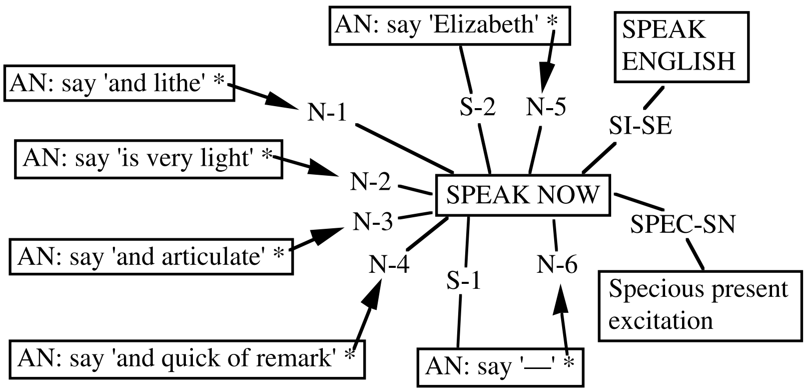


Fig. 4.5 Paths of preactivation into the urge node SPEAK NOW

The preactivations from the urge node SPEAK NOW that contribute to the speech of the concrete situation of Fig. 4.3 are described in Fig. 4.5. SPEAK NOW is excited at all the moments through SI-SE and SPEC-SN. These excitations, as they are transferred through S-1 and S-2, are described in Fig. 4.3 by the letter S. SPEAK NOW is further excited at moment 2 through N-5 and at moments 6, 10, and 14, through N-6, and at moment 16 through N-2. As transferred through S-1 and S-2 these excitations are shown in Fig. 4.3 by the letter N.

(3) *Subject and quality nodes embodying the subjects and qualities thought of and experienced at the moment,* that is *embodying subjects and qualities the person is considering for his utterance.* As illustration Fig. 4.2 shows the nodes SUBJECT X, SUBJECT Y, and QUALITY Q. These are shown to transmit excitations through SI-1, SI-2, SI-17, and SI-21, into the core-phrase action aggregates AN: say 'Subject X'*, AN: say 'X'*, AN: say 'Subject Y'*, and AN: say 'Phrase A'*. Assumed to have been excited as parts of the person's thought object in the immediate past, the node SUBJECT X will remain excited for the duration of the specious present through the synapse SPEC X. It is shown to be directly connected by the synapse SI-1 to the action aggregate AN: say 'Subject X'*, and by the synapse SI-17 to the action aggregate AN: say 'X'*, both of which will thus also receive preactivation, and may in addition have been excited by their ATT-synapses, and so may have had their SPEC-synapses (not shown in the figure) excited. Altogether the core-phrase action aggregates of the core-phrases that are associated with the person's items of thinking in the immediate past of the actual utterance will have contributions to their excitations, of various degrees of strength, from their SPEC-synapses, corresponding to the way they have been given attention by the person in the minutes prior to the utterance and while the utterance is being spoken.

As concrete illustration, Fig. 4.6 shows the subject and quality nodes CHARACTER: ELIZABETH, SPEECH, QUALITY: SPEED, and QUALITY: CHARACTER, transferring preactivations through a number of synapses into the core-phrase action aggregates AN: say 'Elizabeth'*, AN: say 'is very light'*, AN: say 'and lithe'*, and AN: say 'and quick of remark'*. Only a few of the many conductive synaptic connections are shown in the figure. While the speaking of the core-phrases is in progress the person's thinking of the subjects and qualities will be embodied in ever changing excitations of the corresponding nodes. By the synaptic connections these excitations will contribute changing preactivations into the core-phrase action aggregates. In Fig. 4.3 preactivations from this kind of source into each core-phrase action aggregate are shown as the letter M. At moments 15, 16, and 17, the preactivation from this kind of source into AN: say 'very light'* is shown to have increased, so bringing about the speaking of the corresponding core-phrase at moment 17.

(4) *Nodes embodying feelings associated with the subjects and qualities thought of and experienced at the moment.* In Fig. 4.2 SUBJECT X is shown connected to the quality node QUALITY: CONCERN by the synapse SI-4. QUALITY: CONCERN upon being excited will excite the chain SM-1…, NM-1…, muscle…, bodily influence, sense cells, Feeling transducer, NS-1…, SS-1…, into SUBJECT X. In this way, in addition to generating the experience of the feeling of concern in NS-1…, exciting the node QUALITY: CONCERN will add excitation into SUBJECT X, as well as into AN: say 'Subject X'* and AN: say 'X'*. By this mechanism such core-phrases that are associated with subjects to which strong feeling are associated will receive special excitation and thereby tend to occur more prominently in the utterance spoken.

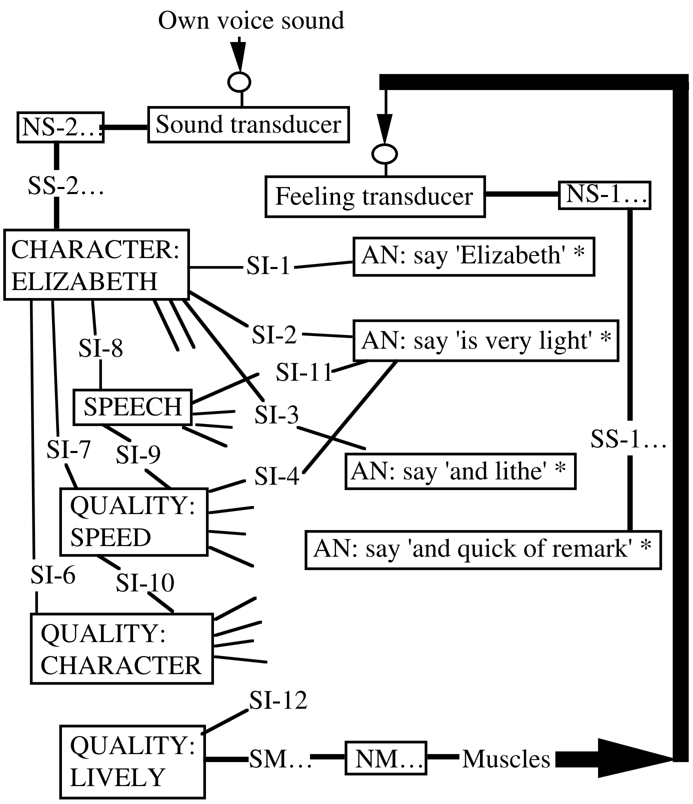


Fig. 4.6 Contributions to core-phrase action node preactivations from the thought object

In the sample comment 1 it is clear by the context that the speaker has feelings of liveliness associated with such such core-phrases as ‘Elizabeth’. As shown in Fig. 4.6 the quality of liveliness is embodied in a node: QUALITY: LIVELY. When this gets excited from CHARACTER: ELIZABETH it will transmit the excitation through the path SM…, NM…, muscles, bodily influence, Feeling transducer, into the nodes NS-1…, producing an experience of feeling of liveliness. The excitation may be transferred further through the synapses SS-1… and so contribute preactivation to the core-phrase action aggregate AN: say ‘quick of remark’*. In Fig. 4.3 this preactivation is shown as Z, present during the moments 1 to 14 and ceasing thereafter.

(5) *Excitation by aural perception of the core-phrase the person speaks at the moment.* Such contributions to the excitations of the action aggregates come at the time of the actual activation of such aggregates as AN: say 'Subject X'*, AN: say 'X'*, AN: say 'Subject Y'*, AN: say 'Phrase A'*, and AN: say 'Phrase B'*, in Fig. 4.2. The activation of any such aggregate will bring forth the process of perception by hearing of the sound produced in the speech organs when the action aggregate is activated. Some of these connections are shown in Fig. 4.2 as NS-4…, SS-3…, and NS-5…, SS-2…. By such an added excitation to a subject node such as SUBJECT X, other subject nodes connected to it, such as SUBJECT Y, will receive additional excitation, and so any action aggregate connected to that, such as AN: say 'Subject Y'*, will tend more to come forth to activation. By this mechanism the associative connection between subject nodes will tend to bring forth a connection between their connected core-phrases in the utterance produced.

The effect is shown in Fig. 4.6, in the transmission of the own voice sound through the sound transducer, NS-2…, and SS-2…, into CHARACTER: ELIZABETH. From there the excitation will be distributed into the five core-phrase actions aggregates shown. In the situations of Fig. 4.3 such preactivations will happen at moment 2. They are shown by the letter P.

Another example of the effect is seen in comment 6, the passage 'if the story has to be — greatly changed then — — s-s-s-sesignificantly altered'. Here the speaking of 'then', picked up by hearing, gives rise to a disturbance of the thinking process and thereby to a distorted speaking of the core-phrase 'significantly'. The process in described in more detail in section 4.6 below.

Aural perception of one's own voice will also be effective in correcting the distortion of the speaking of a core-phrase that results from core-phrase diversion, described in section 4.2 above.

It should be noted that the excitation transmitted by this process happens while the core-phrase is being spoken, and so will come into effect immediately at that time. This means that if the core-phrase to be activated for speaking next is one preactivated by this mechanism, it will be spoken without delay. In the comments such an an effect is seen wherever descriptive pronouncement consisting of a number of core-phrases come in uninterrupted succession, without pauses between them.

(6) *Excitations generated at the termination of speaking of a core-phrase.* Still further excitation to core-phrase action aggregates is given at each moment when the muscular activities of speaking one core-phrase come to an end. This is the moment when the next core-phrase to be spoken is selected by the mechanism of attention, as the one of all the action aggregates having at this moment the greatest overall excitation. At this moment two different groups of excitations are transmitted.

(6.1) *Excitation of habitual followers of the core-phrase at the termination of the speaking of it.* One group of such excitations is released from the node shown in Fig. 3.9 as Xq upon reacting to the muscular activation of the last action just completed.

These are the excitations which are represented in the figures as emerging from the asterisk of the action aggregate designations. These excitations will be transmitted into each action aggregate that in the past has been given excitation in immediate sequence of the one just coming to the end of execution, such action aggregates being connected to it by conductive synapses. In Fig. 4.2 such transmission is indicated by the synapse SI-6 marking AN: say 'Phrase B'* to be a follower in execution to AN: say 'Subject Y'*.

A core-phrase may be the follower in execution to itself. In Fig. 4.2 this is shown for AN: say 'Phrase B'*, through synapse SI-5. In comment 3 it appears to have been effective when the core-phrases 'hold it back' and 'restrain' follow themselves.

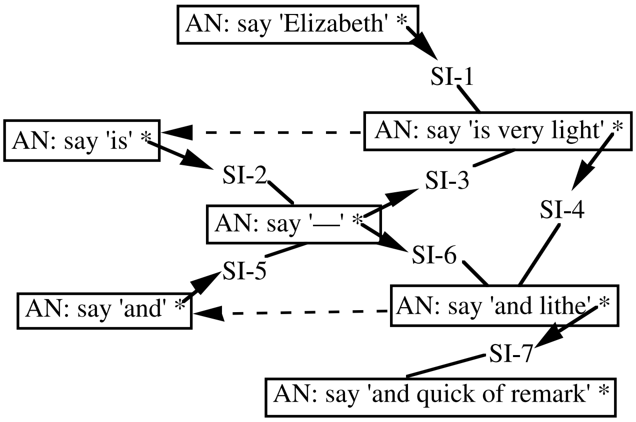


Fig. 4.7 Preactivation contributions from core-phrase action nodes into their immediate followers and from core-phrase diversions

Fig. 4.7 shows the follower synaptic connections that have contributed to the excitations shown in Fig. 4.3. In Fig. 4.3 preactivations of followers are shown by the letter F. Such preactivations occur only at the moments of ending the speaking of a core-phrase. It may be noted that as a consequence of the switch from excitation of AN: say 'is very light'* into excitation of AN: say 'is'* that in section 4.4 above was described as core-phrase diversion, AN: say 'is'* is not excited as a follower but only as a side track from the excitation of AN: say 'is very light'*. Such excitations are indicated by dashed arrows in Fig. 4.7. In Fig. 4.3 they appear in the way 'Beginning "is very light"' at moments 3, 7, and 11, is followed at moments 4, 8, and 12, not by 'Ending "is very light"' but by 'Ending "is"'.

(6.2) *Excitation of urge nodes transmtting preactivations into first core-phrases of pronouncements*. Such excitations were described in subsection (2) above. In Fig. 4.3 preactivations through urge nodes into follower core-phrase action aggregates are shown by the letter N.

The progress of speech is further influenced by the SPEC-synapses. At the moment of the activation of each core-phrase action aggregate, in addition to being excited from its ATT-synapse it will excite its SPEC-synapse. This will retain its contribution to the excitation of the core-phrase action aggregate, waning, for the duration of the specious present.

It should be noted that when the next core-phrase to be spoken is singled out as a consequence of the processes of the present subsection (6), the actual excitation of the core-phrase happens later than if the process of subsection (5) is effective. This is visible in comment 6 in the delays before such core-phrases as 'and I think' and 'it should'.

In summary of section 4.5, the core-phrases spoken in an utterance come to be selected from the person's established vocabulary of core-phrases in a process combining habits related to:

(1) Core-phrases habitually spoken in the actual situation.

(2) Core-phrases habitually being the first in pronouncements.

(3) Core-phrases habitually associated in the person's mind with the subjects and qualities that are in the person's stream of thought at the moment of the utterance.

(4) Core-phrases that habitually have been following each other in utterances spoken by the person.

4.6 Evidence of the next core-phrase selection

The description in section 4.5 of the way the selection of core-phrases takes place in speech finds further confirmation in the samples of speech presented in section 4.3 in several ways.

Some evidence concerning the way core-phrases come to be selected is provided by core-phrases in the form of hesitation in the stream of sound of the speech that in many places come to be inserted, filling the time between the completion of one core-phrase of proper speech and the beginning of the one following. Such core-phrases of hesitation appear as either pauses, or as hesitation sounds such as 'ah' or 'hm', or as short core-phrases such as 'the' or 'and' or 'in' or 'in a sense'. Hesitation core-phrases of one or several of these kinds appear in many places in every one of the six samples.

Such hesitations may be seen to be inserted at moments where there clearly have been several alternatives from which to choose the successor core-phrase. Such moments arise in two different ways. One way occurs at moments when a pronouncement of some matter has been completed. Then the choice is between the possible first core-phrases of the next pronouncement to be made.

Another way is at the choice between alternative core-phrases in the middle of a pronouncement. In these situations the choice is sometimes displayed explicitly, when the alternatives subsequently come to be spoken one by one. This pattern is found in every one of the six comments, twice in comment 1, first as '— Darcy … — ah — Elizabeth is … — ah— Mrs Bennet … — Mr Collins … — ah — Mr Bennet …' and then as 'is — is — is — is very light and — and lithe and quick of remark — and articulate'. In comment 2: '— now it's a very lively book — it's a very witty book — it's a great romantic — love story —'. Twice in comment 3: '—

probably is the most important thing — or aspect', '— you lose narrative — thrust — you lose — some of the need'. In comment 4: '— I will never get — on top of this — I will never get the hang of it'. In comment 5: 'eh — he is utterly — hm — and unreasonably'. In comment 6: ' — — s-s-sesignificantly altered — huge additions — huge deletions —'.

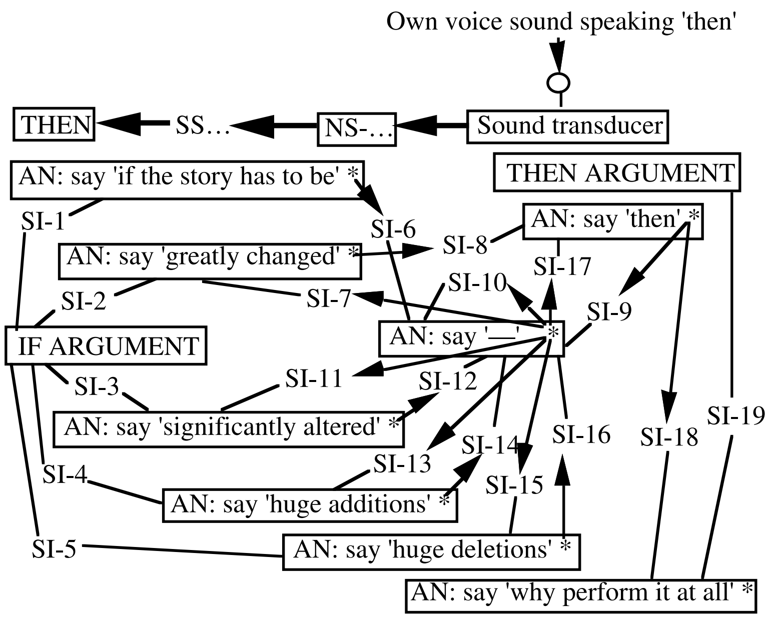
While the pause appears as hesitation core-phrase in all the comments, other hesitation core-phrases are personally distinct. Comment 1 shows such core-phrases as 'is', 'ah', and 'and', comment 2: 'and', 'ahm', comment 3: 'ah', 'then', 'eh', 'in a sense', 'if you like', 'I mean', comment 4: 'eh', 'to', comment 5: 'eh', 'hm', 'ahm', comment 6: 'and', 'hm'. In fact, the way hesitations are spoken, as much as the way all other core-phrases are spoken, is a matter of personal styles.

Again each person may have different styles that come to evidence in the speech, depending on the situation. In the present description such style differences are explained in terms of the preactivations of the core-phrase habit aggregates from response habit nodes.

Comment 3 in the long hesitation before speaking the name 'Elizabeth'—it lasts 2 seconds—gives an example of the phenomenon described in section 3.4, that the commentator finds it difficult to recall in speaking the name of a person who is obviously well known in the context. The difficulty would be caused by the low conductivity of just one single synapse in the commentators brain, in Fig. 4.6 the synapse SI-1.

Some of the neural components that contribute excitations while the speaking in comment 1 of 'Elizabeth is — is — is — is very light and — and lithe and quick of remark — and articulate' takes place were shown in Fig.s 4.4, 4.5, 4.6, and 4.7. Some of the excitations of core-phrase aggregates were shown in Fig. 4.3. As clear from these figures, what is in fact spoken in the utterance is a result of the person's attention being directed in rapid succession to such items as Elizabeth, speech, quality of speech, and speed of speech, and the way the node excitations embodying this thinking will add excitation contributions into the core-phrase action aggregates shown in Fig. 4.4. The figures make it clear how what comes to be spoken depends on the momentary conductivities of a large number of synapses. Thus the initial repetition of 'is — is — is — is very light' depends directly on the conductivities of SI-2, SI-3, and SI-5 in Fig. 4.7. But indirectly the repetition depends also on the conductivities of SI-2 and SI-11 in Fig. 4.6, as well as on the excitations of the nodes QUALITY: CHARACTER and CHARACTER: ELIZABETH, and to a slighter degree on a large number of further neural components not shown in the figures. Thus while the speaking of each core-phrase, as it happens when the corresponding core-phrase action aggregate gets strongly excited, takes place by a neural process that may be repeated fairly accurately, the process leading to the selection of the sequence of core-phrases going into an utterance depends critically on minute differences in the excitations of the nodes.

Fig. 4.8 shows some details of the core-phrase selections that were at work when in comment 6 the passage ‘if the story has to be — greatly changed then — — s-s-s-sesignificantly altered …’ was spoken. This passage is valuable evidence since it is spoken fairly slowly and clearly while displaying some curious speech patterns. In Fig. 4.8 the thinking going on while the passage is spoken is represented crudely merely by the excitations of the nodes IF ARGUMENT and THEN ARGUMENT. By the thinking going on, IF ARGUMENT will be strongly excited while the first part of the passage is spoken, THEN ARGUMENT while the second part is spoken.



4.8 Effective excitation paths in speaking 'if the story has to be — greatly changed then — — s-s-s-sesignificantly altered — huge additions — huge deletions — then why perform it at all'

What has happened may be understood as follows. First, as an effect of strong excitations from IF ARGUMENT the aggregate AN: say ‘if the story has to be’* is excited, leading to the speaking of ‘if the story has to be’. This excitation has been followed by the excitation, through SI-6, of the aggregate AN: say ‘—’*, resulting in a speech pause. Continued excitation from IF ARGUMENT has excited the aggregate AN: say ‘greatly changed’*, leading to the speaking of ‘greatly changed’. This speech action has terminated in the immediately following excitation, through SI-8, of the aggregate AN: say ‘then’*, and thus of the immediate speaking of the word ‘then’. This reaction, which is curious in the situation which is still dominated by the strong excitation of IF ARGUMENT, will have been brought about by an unusually high conductivity of the synapse SI-8, which must have been the result of the speaker having frequently spoken the two core-phrases in sequence: '… greatly changed then'.

The sound of the speaking of 'then' has been picked up by hearing and perceived as the word 'then', thus exciting the node THEN. This excitation has momentarily disturbed the thinking activity, thus weakening the excitation of IF ARGUMENT and leading first to a strong, double excitation of AN: say '—'*, and then to a weak excitation of AN: say 'significantly altered'*. Because of its weakness the first excitation of the first node of the node/synapse aggregate has been insufficient to bring about the speaking of the full core-phrase and thus leads to several rapidly repeated excitations, recorded as s-s-s-se, before the full core-phrase node/synapse aggregate comes to be excited.

Other evidence that the selection of the next core-phrase in speech depends on a large number of items of the thought object in a subtle interplay are curious passages such as, in comment 3: 'in order to get people back into it into it so it's it's — doubly enhanced in a sense that you have to get people who are acceptable — as these characters'.

The way the selection of the core-phrases spoken depends critically on minute differences in the person's mental state may be confirmed empirically by asking people to repeat such utterances that they have just spoken. Then it will be found that in most situations people find accurate repetition of their own utterances impossible, even after a delay of only a few seconds.

The speaking of the five alternatives in comment 1: '— Darcy … — ah — Elizabeth is … — ah — Mrs Bennet … — Mr Collins … — ah — Mr Bennet …', raises the question how it is that each alternative comes to be spoken just once, and not so that one of them comes to be spoken several times. This finds its explanation in the fact that even while the speaking of an utterance is in progress, in particular during each hesitation, other thinking which is relevant to the selection and activation of core-phrases of speech while not directly active in the activity, will take place. Thus during the hesitations preceding the speaking of each of the five core-phrases there will be thinking amounting to the person saying in silent soliloquy, first: 'Now I have to talk about all the characters', and later 'Now I have already talked about Darcy', etc. Such thinking is embodied in the excitations of the momentary thought object. These excitations will enter into the excitations of the core-phrase action aggregates side by side with the excitation from the sources described in section 4.3.

In certain places the comments contain long sequences of core-phrases, spoken without any hesitations, such as in comment 1: 'is absolutely wonderful to work with because she does write very distinct speech patterns for all the characters', in comment 2: 'Andrew Davies and I were very clear at the beginning that we wanted to get to really reflect what we feel is the spirit of Jane Austen's Pride and Prejudice', in comment 4: 'I thought I was the only one but everyone had the same problem', in comment 6: 'the writer's dialogue should be used and spoken by the person who speaks it in the book'. Some such long uninterrupted sequences of core-phrases come about where in the situation and context just a series of strongly preactivated core-phrases have come forth, with no competing alternative core-phrases. This clearly will often be a matter of the extent to which the speaker has prepared in advance in his or her mind what to say in the utterance. Such preparation will be embodied in preactivations of the core-phrase action aggregates lasting for the time of the specious present. This seems to be what has been the case in comment 2, where the long sequence is the very first one in the comment, presumably prepared in the mind of the speaker immediately before speaking the comment.

With respect to long uninterrupted sequences of core-phrases comment 6 is different from the others. While comments 1 to 5 are spoken by persons who have been concerned with the matters spoken of by their having contributed by their activity to these matters, comment 6 is a reasoned assessment of the final outcome of these activities, spoken by a person who as a writer is professionally engaged in finding verbal formulations to her thoughts. This explains that comment 6 on the whole is made up of longer unbroken sequences of core-phrases than the other comments.

All the comments display rapid repeated speaking of short core-phrases, for example in comment 1: 'is — is — is', 'very very', in comment 2: 'and — and', 'to — to', in comment 3: 'hold it back hold it back', 'restrain restrain', in comment 4: 'couldn't — couldn't', in comment 5: 'of his — of his', 'which — eh — which', 'he — he', in comment 6: 'very very', 'and — and'. Generally this comes about as follows: The speaking of any core-phrase occurs when the sum of the excitations transmitted into the corresponding action aggregate is large. During the rapid speaking of the core-phrase most of these excitation contributions may have become only slightly altered. If the core-phrase has been habitually repeated an additional contribution comes from the node/synapse aggregate of the core-phrase itself at the moment the speaking of the core-phrase comes to the end. These excitations may well be sufficient to set the action going anew.

4.7 Speech versus language perception

What is said in comment 4 of the speech samples in section 4.3 on the difficulty the actors had in learning the speech patterns written by Jane Austen gives significant evidence that the core-phrases that a person will readily produce as speech are completely independent of what language spoken by other persons, or what language in written form, that person will be able to perceive and understand. The comment explains the extreme difficulty of learning to speak in performance such core-phrases from Jane Austen's book that the same person when reading the book will perceive vividly, saying that in certain core-phrases 'the voice of Mrs. Bennet — she just — comes off the page'. The comment confirms that the core-phrases a person will be able to speak readily are only such that the person has practised in actually speaking them many times. What practising achieves is a matter of, as the comment says: 'once you get into the rhythm — and the speech patterns that they used'.

In terms of Fig. 2.8 the matter is clear: perceptual understanding of language, whether in spoken or written form, is a matter of the conductivity of certain synapses of the sense layer. Production of speech is primarily a matter of the core-phrase action aggregates and so depends on the conductivity of quite different synapses of both the sense and the motor layers.

In other words, the common talk of a specific 'language ability' that supposedly humans, but not brutes, possess has no ground in the way various language functions are embodied. This was clearly realized by William James who writes [I 56]: 'There is no "centre of Speech" in the brain any more than there is a faculty of Speech in the mind. The entire brain, more or less, is at work in a man who uses language.'

5. The education of the neural system

5.1 Education as the fixing of habits in synapse states

The education of the neural system is embodied in changes of the states of conductivity of the synapses. These changes consist first in the increase of conductivity of some of the synapses from being very low, by which some of these synapses come to belong to particular node/synapse aggregates. Later the conductivity of the synapses may increase further as a result of training. Decay of education happens when the conductivity of a synapse decreases during periods when the synapse is not excited.

The education of the neural system is preconditioned by the formation in the organism of the neurons, synapses, and nodes, of which the nervous system is composed. The education will start as soon as some of the neural organs have been formed and will proceed in parallel with the formation of more organs. In this process instinctive actions contribute in several ways.

5.2 The embodiment of instinctive actions

Instincts are explained by James (1890) [II 383]:

> CHAPTER XXIV - INSTINCT … *The actions we call instinctive all conform to the general reflex type;* they are called forth by determinate sensory stimuli in contact with the animal's body, or at a distance in his environment.

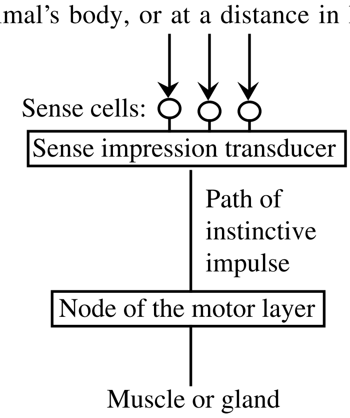


Fig. 5.1 Embodiment of instinctive reaction

The embodiment of an instinctive reaction is shown in Fig. 5.1. It consists of a direct neural path from a sense impression transducer into a node of the motor layer.

Often the instinctive muscular activation produced by a particular sense impression will have the effect that the sense impression itself is thereby changed. For example, the painful sensation in a finger of touching a hot object releases an instinctive impulse of a muscle in the arm, drawing the finger away from the object. Thereby the painful sensation in the finger will cease.

In the neural control of the eyes there are instinctive reactions such that when a spot in the peripheral part of the retina becomes strongly illuminated the muscles will rotate the eyeball to as to bring the strongly illuminated spot into the yellow spot. Since the yellow spot is more sensitive than other parts of the retina, the sensual impression will thereby become stronger.

5.3 The formation and education of protoaggregates

Some central issues of the psychology of the earliest mental states of the very young organism have been stated by William James (1890) when he writes [I 483]:

> CHAPTER XIII - DISCRIMINATION AND COMPARISON …[I 487] Experience, from the very first, presents us with concreted objects, vaguely continuous with the rest of the world which envelops them in space and time, and potentially divisible into inward elements and parts. These objects we break asunder and reunite. … The noticing of any *part* whatever of our object is an act of discrimination. … Where the parts of an object have already been discerned, and each made the object of a special discriminative act, we can with difficulty feel the object again in its pristine unity; and so prominent may our consciousness of its composition be, that we may hardly believe that it ever could have appeared undivided. But this is an erroneous view, the undeniable fact being that *any number of impressions, from any number of sensory sources, falling simultaneously on a mind* WHICH HAS NOT YET EXPERIENCED THEM SEPARATELY, *will fuse into a single undivided object for that mind.* … The baby, assailed by eyes, ears, nose, skin, and entrails at once, feels it all as one great blooming, buzzing confusion;

The education of the neural system will start immediately upon the first development in the foetus of nodes, neurons, and synapses. When influenced by changing impressions upon the senses, these neural components will form certain node/synapse aggregates that shall be called *protoaggregates*.

The formation of a protoaggregate will be explained in terms of Fig. 5.2. In this explanation it is assumed that sensitivity to certain sense impressions has developed in the foetus.

The protoaggregate centered on the node **PROTO 1** is first established after the full development in the organism of some of the components shown in bold type in the figure: **sense cell**, **Sense impression transducer, NS-1…, SS-1…, PROTO 1, ATT-1, SPEC-1, Attention excitation**, and **Specious present excitation**. The establishment of the protoaggregate happens when specific impressions on sense arrive in the **Sense impression transducer** in sufficient strength and duration so as to penetrate the initial low conductivity of the synapse set **SS-1…**, so bringing about sufficient excitation of **PROTO 1** to excite its attention and specious present synapses **ATT-1** and **SPEC-1**. For this to happen the foetus must at some moment be exposed to sense impressions of a certain strength.

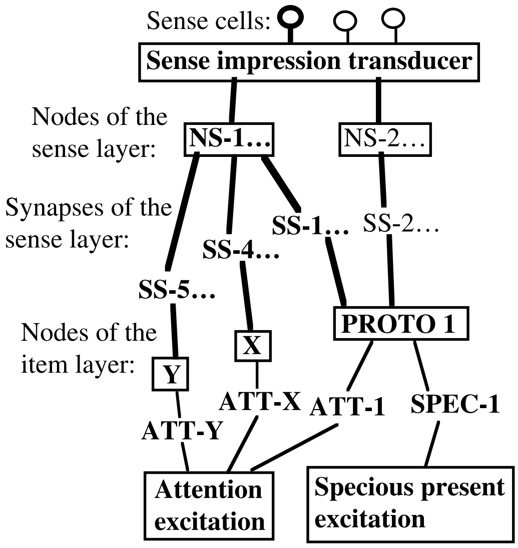


Fig. 5.2 Formation of protoaggregate

For example, a protoaggregate will likely be established in many newborn babies from the impressions received from their mother during the first few minutes after delivery. Plausibly that protoaggregate will be formed primarily from a strong impression of smell. It may then immediately embrace also impressions of sight, sound, and touch.

The first excitation of **PROTO 1** will immediately lead to increase of the conductivities of the synapse set **SS-1...** in a plastic manner. This increase will continue while **PROTO 1** is kept excited from **SPEC-1**, that is during the specious present.

As shown in Fig. 5.2 there may be other nodes, such as **X** and **Y**, that together with their connecting synapse sets **SS-4...** and **SS-5...** have been fully developed in the organism at the moment considered. Either of these nodes might have become educated as the node of the protoaggregate, rather than **PROTO 1.** The selection depends on slight differences in the the initial low conductivities of the synapse sets **SS-1...**, **SS-4...**, and **SS-5...**, specifically that **SS-1...** happens to have larger initial conductivities than either **SS-4...** or **SS-5...**. As a consequence **PROTO 1** becomes more excited than either **X** or **Y** at the moment shown, and so it is **ATT-1** rather than **ATT-X** or **ATT-Y** that gets excited. When this happens **SS-1...**, but not **SS-4...** or **SS-5...**, become more conductive, and **PROTO 1** is thereby established as the node of the protoaggregate, not **X** or **Y**.

The strength of the excitations coming from the nodes of the sense layer and the way they relate to the impressions on the sense cells is a matter of the transducers. This holds in particular for the relative strengths of excitations coming from the various senses.

After having first been established as the node of a protoaggregate, **PROTO 1** will again become excited at later occasions when sense impressions that are in some sense similar to those that gave rise to the initial strong excitation of **NS-1…** are received in the organism. Owing to the increased conductivities of the synapse set **SS-1…** these sense impressions will excite **PROTO 1** even if they are not so strong as those needed to establish the protoaggregate. The similarity of sense impressions in question here is a matter of the plastic changes of the conductivities of the synapses of the protoaggregate. Indeed, each occasion when **PROTO 1** is excited will give rise to plastic increase of the conductivity of any synapse that connects into **PROTO 1** from a node of the sense layer which is excited from sense at that moment. This excitation may be of any of the senses. Fig. 5.2 shows the synapse set SS-2… excited from NS-2…. The conductivities of the synapse sets **SS-1…** and SS-2… will develop individually in each synapse depending upon what impressions on the senses are received together during the moments when **PROTO 1** is excited.

It follows that precisely what set of sense impressions will cause **PROTO 1** to become excited will be entirely dependent on *the person's recurrent exposure to certain sense impressions that are received at the same time*. As a consequence of the plastic changes of the conductivities of the synapses of the node/synapse aggregate, what sense impressions contribute to exciting **PROTO 1** will change from one exposure to another and may continue to develop over a lifetime.

A new protoaggregate will become established whenever the individual is exposed to a strong sense impression that does not excite an already formed protoaggregate so as to excite its attention synapse. Such a strong sense impression may arrive in any of the senses.

In an individual with normal eyesight many, probably most, protoaggregates are formed from visual impressions. This is so because from the moment the newborn child first opens the eyes, visual impressions are richer and more varied than impressions from the other senses. This will be supported by the way instinctive impulses make the eye muscles turn the eyeball so as to make strong visual impressions fall into the yellow spot, as described in section 5.2 above. The sensitivity of the yellow spot is very high and so will tend to produce excitations into the nodes of the sense layer that are strong enough overcome the initial low conductivities of the synapses of the sense layer. Thus by instinct the visual sense provides for a more active selection of strong impressions than the other senses. Typically a person is able, within the duration of a few seconds, to receive visual impressions from a whole panorama and to select impressions from—that is, turn the attention to—a large number of different things in it.

This feature of vision is so prominent that it tends to distort the understanding of what attention is, to the effect that attention is taken to denote a feature of perception of visual impressions. This is displayed in Bundesen et al. (2005). The title of this paper, as well as the titles of papers by 16 other authors from the years 1981 to 2003 referred to in its references, all contain the phrase 'visual attention'. The way this notion distorts the understanding is evident from the fact that although the paper is titled 'A neural theory of visual attention' it argues merely in the terms of what is called 'a formal, computational theory' called TVA. No neural embodiments are given, neither of TVA, nor of visual perception, nor of attention.

As conclusion of this subsection, in the normal individual a large number of protoaggregates will be formed in the early years of life, primarily from strong visual impressions. As part of the education of the neural system the protoaggregates will gradually become specialized, some of them into response habit aggregates. Others will specialize into subject and quality aggregates. Each protoaggregate upon becoming established will immediately become tied by a conductive synapse to those response habit aggregates that are excited at the moment. Later the excitation of such response habit aggregates will transmit preexcitations into the node of the protoaggregate.

5.4 Embodiment of the discrimination of parts and qualities

The education of nervous system as far as the reaction to sensuous impressions is concerned is a matter of the discrimination of wholes and their parts and qualities. The discrimination of parts of wholes is embodied in mutual relations of the protoaggregates embodying the wholes and the parts. As said by James, quoted above, [I 487]: '*any number of impressions, from any number of sensory sources, falling simultaneously on a mind* WHICH HAS NOT YET EXPERIENCED THEM SEPARATELY, *will fuse into a single undivided object for that mind. …*'.

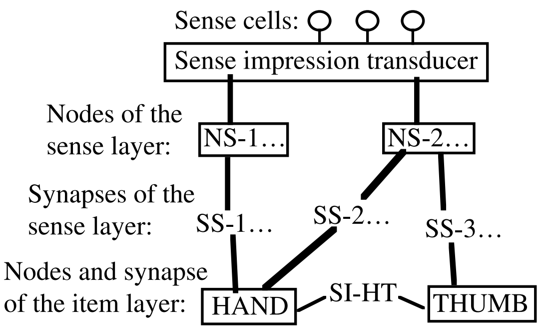


Fig. 5.3 Embodiment of thumb as part of hand

Fig. 5.3 shows the embodiment of the relation of a thumb being a part of a hand. Here it is assumed that the protoaggregate centered on HAND has first been formed from impressions transmitted through the nodes NS-1… and NS-2…, and so far the impressions from the hand and the thumb fuse into HAND. Later strong excitations of NS-2… have formed the separate protoaggregate centered on THUMB. From then on the impressions of the hand and thumb transmitted through NS-1… and NS-2… may excite HAND and THUMB simultaneously. When this happens the synapse SI-HT will become conductive, embodying the association of the sensuous objects hand and thumb.

The process of discrimination of parts illustrated in Fig. 5.3 works in the same way for impressions from mixed senses. Over a period of years in the individual’s life it will bring about establishing a large number of protoaggregates that get specialized into subject aggregates and quality aggregates. As a typical example, Fig. 5.4 shows the node/synapse aggregates that might result from the individual’s sense impressions of roses, their color and smell, and from visual and aural sense impressions of script and speech about roses and their color. As a result of the conductivities of the synapse sets shown in the figure the three nodes RED, ROSE, and SMELL OF ROSE, will become excited to various strengths when the smell of roses is sensed, when visual impressions of the color red and/or the shape of roses are received, when the sounds of the spoken words ‘red’, ‘rose’, and ‘smell’ are heard, and when visual impressions are had of the script form of the words ‘red’, ‘rose’, and ‘smell’.

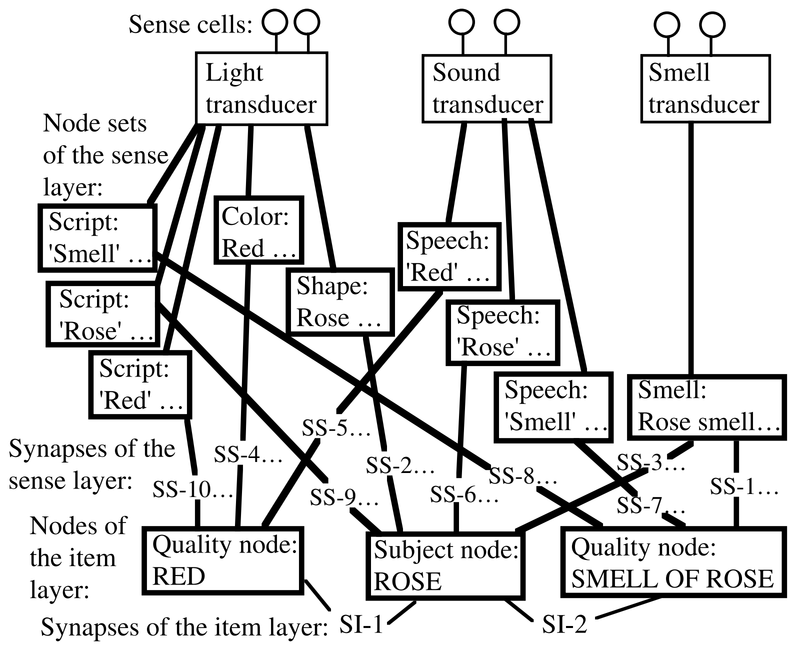


Fig. 5.4 Embodiment of rose subject and qualities

The conductivities of the synapse sets shown in Fig. 5.4 will have been first formed gradually as the education of the neural system proceeded during the early years of the individual’s life. Assuming that the smell was the first impression of roses to attract the individual’s attention, the synapse set SS-1… was the first one to become conductive. When later the sight of a rose, with the shape and color, was experienced together with smell, the synapse sets SS-2…, SS-3…, and SS-4…

became conductive. At this stage the item synapses SI-1 and SI-2 established the association of the subject and the qualities. At a later stage, when the baby heard the mother's talk of red roses and their smell, the synapse sets SS-5…, SS-6…, and SS-7… became conductive. At a still later stage, when the child learned to read, the synapse sets SS-8…, SS-9…, and SS-10… became conductive.

The synaptic connections described here are those that provide for *perceptions* of sensed objects.

5.5 The embodiment of voluntary acts

In the newborn child there are only instinctive acts. Voluntary acts develop in the child as a result of the child's experience of instinctive acts.

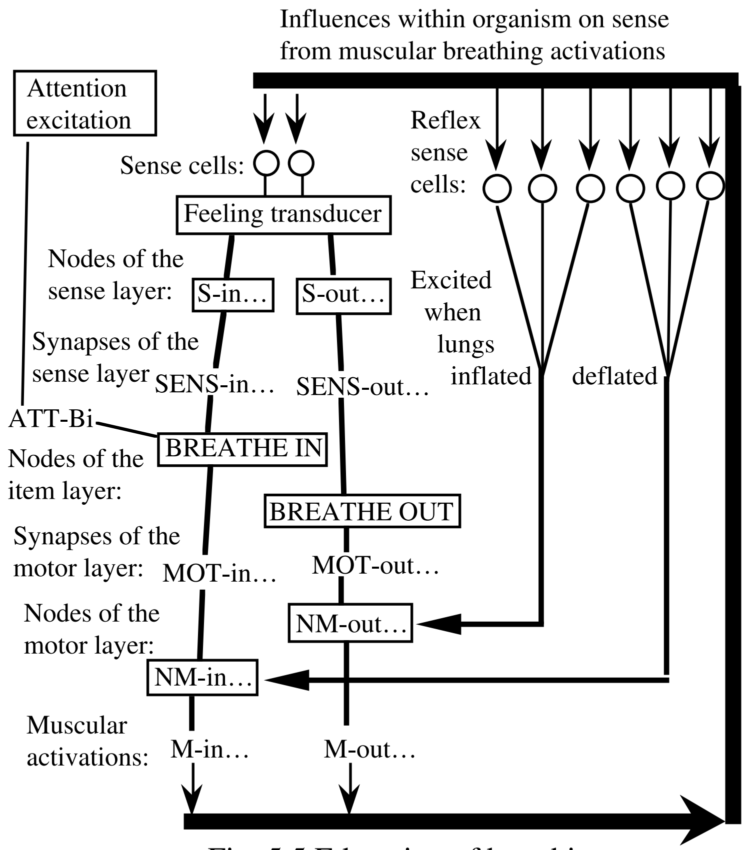


Fig. 5.5 Education of breathing

The first instinctive act to be performed in the newborn baby is that of breathing. For survival this must happen within the first few minutes after the umbilical cord has been severed. When instinctive breathing has been going on for some time the act develops into a semi-reflex act. Fig. 5.5 shows the synapse-state description of this act. It depends on the following parts of the nervous system:

1) Muscles and motor layer nodes that activate the breathing, the muscles M-in… and the nodes NM-in… for breathing in, and the muscles M-out… and the nodes NM-out… for breathing out.

2) A number of sense cells located around the lungs. Some of these, shown as *reflex sense cells*, are connected through neurons directly to nodes of the motor layer. Some of the reflex sense cells, including those shown that are connected to the nodes NM-out… that excite muscles that give rise to breathing out, get excited when the lungs are inflated. Others, including those shown that are connected to the nodes NM-in… that excite muscles that give rise to breathing in, get excited when the lungs are deflated. Other sense cells located around the lungs are connected through the Feeling transducer to nodes of the sense layer, such that when the lungs are inflated the nodes S-out… will become excited and when the lungs are deflated the nodes S-in… will become excited.

3) Two nodes of the item layer, BREATHE IN and BREATHE OUT.

4) A number of synapses of the motor layer, of which some are shown as MOT-in… and MOT-out….

5) A number of synapses of the sense layer, of which some are shown as SENS-in… and SENS-out….

The action of breathing is initiated in the newborn infant by the impulses coming from the reflex sense cells. In the very first instant after birth the lungs of the infant are deflated. This state gives rise to impulses from some of the reflex sense cells. These impulses will excite such nodes as NM-in…, which in turn will excite the muscles M-in… that will make the lungs get inflated.

As soon as this change in the tissue around the lungs gets under way the impulses from the corresponding reflex sense cells will decrease. At the same time impulses from reflex sense cells that are excited when the lungs are inflated will increase. When these impulses have increased to a certain level they will excite the nodes NM-out…, which in turn will excite the muscles M-out… that will make the lungs get deflated.

And so merely by the activity of the reflex sense cells the activity of breathing in and out will continue indefinitely, as a reflex activity.

When this activity is under way additional impulses supporting the lung work will become established by way of the nodes in the item layer, probably within the first few minutes or hours of the life of the infant, whereby the instinctive reflex act of breathing becomes semi-reflex.

This extension of the activity takes place as follows. Consider a moment when the lungs have become deflated by the excitations from the reflex cells of the nodes NM-out…. At this moment other reflex cells will excite the nodes NM-in…, initiating the action of the breathing in the muscles M-in….

At the same time the nodes S-in… will be excited from certain sense cells. In the first instance these excitations will be conducted only to synapses, such as SENS-in…, that have the same low conductivity as all other synapses at the time of birth, and so the large number of nodes of the item layer will receive only weak excitations from their synapses. Even so it must be assumed that the excitations coming through to them differ to some extent from one item node to the other, owing to small anatomical differences in the tissues. In addition, all nodes are at all times subject to random excitations coming from external influences on the organism that get distributed throughout the nervous system. These excitations will get added to those from the SENS-synapses. It must be assumed that by these combined, partly random excitations of all the large number of nodes of the item layer, one of these nodes at some moment will become excited sufficiently to excite its ATT synapse. When this happens that particular node will, once for all, be singled out so as to carry thereafter the function of breathing in. In the figure this is the node BREATHE IN, which at this moment is also excited by ATT-Bi. At this moment the synapses SENS-in… will receive excitations from both their neurons simultaneously. By their plasticity these synapses will then be changed from having their initial low conductivity into becoming more conductive, thereby establishing the node BREATHE IN permanently.

At the same time the synapses MOT-in… will receive excitations from both their neurons simultaneously, and by their plasticity will become conductive.

When this has taken place, impulse paths in parallel with the reflex paths have been established, shown as the path S-in… - SENS-in… - BREATHE IN - MOT-in… - NM-in…. These paths will become excited during every breathing-in action. They differ from the reflex paths by being dependent in the strength of the excitation that they transmit, not only on the excitations received from the sense cells but also on the strength of excitation of the node BREATHE IN. This node may receive excitations from other nodes, depending on the states of certain synapses. In this way the breathing activity will be influenced by the momentary mental state of the person. In other words, breathing has become a semi-reflex action.

The node BREATHE IN is the embodiment of what James calls the idea of the movement of breathing in.

The node BREATHE OUT and the synapses SENS-out… and MOT-out… will become established in a like manner as the corresponding neural components of BREATHE IN.

The very first breathing-in action has to overcome the stickiness of the internal lung surfaces. For this the impulses coming from the reflex sense cells may be insufficient. This explains that a momentary additional impulse into the neural system, such as may originate in the midwifely smack in the bottom of the baby, may be necessary.

5.6 Education from the imitation instinct

The word imitation is used by William James to denote an instinct. In this sense it denotes a variety of patterns of human action and behavior, some of them very elaborate, the common feature being that the imitating person performs an action after having perceived a somewhat similar action performed by another person. Imitation is not the process of learning to perform an action, but the performance of an action already learned. Learning may come in when the imitation is responded to by another person, perhaps in the form of a repetition of the initial action.

As an example of imitation in a simple form, observed as performed by an infant, consider *protrusion of the lips*. James in describing instincts says [II 404]:

> '*Smiling* at being noticed, fondled, or smiled at by others. It seems very doubtful whether young infants have any instinctive fear of a terrible or scowling face. I have been unable to make my own children, under a year old, change their expression when I changed mine; at most they manifested attention or curiosity. Preyer instances a *protrusion of the lips,* which, he says, may be so great as to remind one of that in the chimpanzee, as an instinctive expression of concentrated attention in the human infant.'

Later James mentions [II 408] that 'Professor Preyer speaks of his child imitating the protrusion of the father's lips in its fifteenth week.'

At first sight Professor Preyer's observation of his child's imitation of the protrusion of the father's lips seems to contradict James's observations of his own children. However, Professor Preyer's observation makes sense if it assumed that his child's imitation has been preceded, at earlier occasions, by the child's observing the father's imitation of his child.

In other words, the sequence of events appears to have been the following: At a first stage Professor Preyer's child develops a habit to protrude the lips in response to certain sensations, in other words, in the child what James [II 488] calls the *idea of the movement of protrusion of the lips* is formed. In a second stage, when this habit has been establish in the child Professor Preyer in playing with the child observes and imitates the child's original instinctive protrusion of the lips. The child perceives the father's protrusion and so develops the habit of associating the father's protrusion with his own. In a third stage, when this associative habit has been established in the child, the child will react on perceiving the father's protrusion by protruding his own, that is by imitating the father's protrusion.

This development may be described in terms of synapse states as shown in Fig. 5.6. The first stage of the development is embodied in:

1) A number of lip muscle activations: MA-pl…, and the nodes of the motor layer driving them: M-pl….

2) A number of reflex sense cells in the face that excite the nodes M-pl… as a reflex action.

3) A number of nodes in the sense layer that become excited from feeling sense cells when the muscles in the lips are activated: SF…

4) the node I-PROTRUDE-LIPS of the item layer.

5) the states of a number of synapses of the sense layer: SS-F…, and
6) the states of a number of synapses of the motor layer: SM….

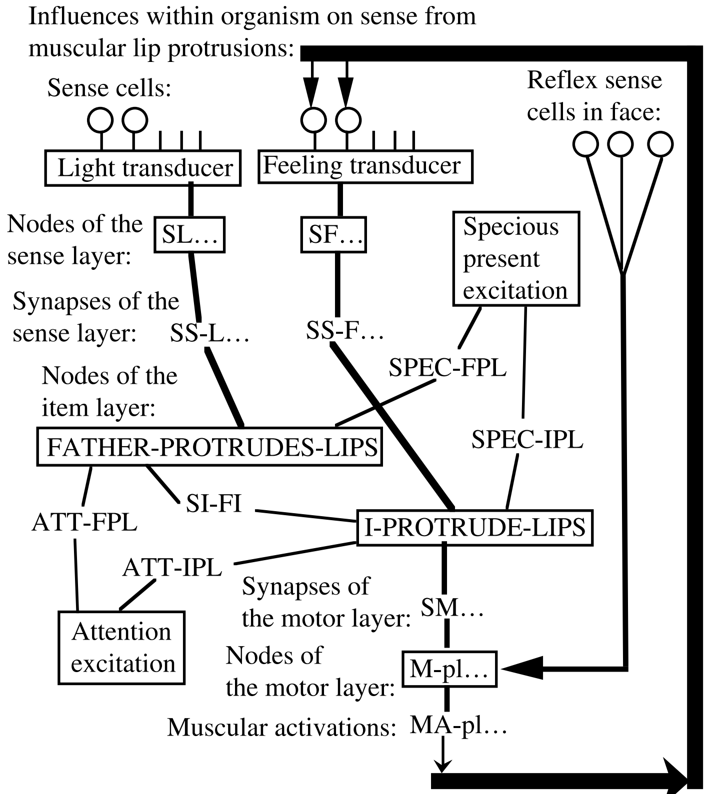


Fig. 5.6 Imitating father's protrusion of lips

The formation of the embodiment in the node I-PROTRUDE-LIPS of the *idea of the movement of protrusion of the lips* is a matter of putting certain relevant synapses into certain states. This formation results from the excitation of certain sense cells in the face that are connected to such nodes in the motor layer as M-pl…. by reflex arcs. When these sense cells activate the connected muscles, MA-pl…, additional sense cells in the lips will excite such nodes in the sense layer as SF…. The excitation of these nodes is experienced as a feeling in the stream of thought, in the case of the muscles of the lips a peculiar kind of tickling feeling.

The singling out of the node I-PROTRUDE-LIPS among the thousands of similar nodes of the item layer, to embody the idea of the lip protrusion movement, happens like the formation of a protoaggregate at a moment when by pure chance that particular node receives a certain excess of excitations from its connected synapses, with particularly strong contributions from such synapses that connect to sense cells in the lips, such as SF…, this excess being sufficient to excite the attention synapse of the node, ATT-IPL. The moment this happens all synapses that transfer excitations into the node I-PROTRUDE-LIPS, in particular SF…, will receive excitations from both of their neurons simultaneously and so, by their plasticity, will become more conductive. Likewise the synapses of the motor layer that transfer excitations from the node I-PROTRUDE-LIPS into activations of the muscles of the lips, such as SM… will become more conductive.

Once the node I-PROTRUDE-LIPS has in this way become connected through conductive synapses to certain of the sense cells and muscles in the lips, each subsequent excitation of these same sense cells and muscles in the lips will cause excitation of the node, and if strong will excite the attention and specious present synapses of the node, which will give rise to a further strengthening of the conductivity of the connecting synapses. In such excitations further sense cells in the lips and further nodes of the sense layer may become excited and may make the synapses connecting to the node I-PROTRUDE-LIPS conductive. In other words, the activity of protrusion of the lips has become habitual, and as such will be developed by training. On the other hand, if the activity is not trained the conductivity of the synapses involved will gradually decrease and the habit will gradually decay. Thus the node I-PROTRUDE-LIPS has become a center of the excitations of the sense cells and muscles in the lips, such that an excitation of the node, from any source, will activate the muscles in the lips, and any excitation of the sense cells in the lips will excite the node. The node has become the embodiment of what James calls the *idea of the movement of protrusion of the lips*.

In the second stage the child will perceive the father's imitative protrusion of his lips. This development involves the following neural components shown in Fig. 5.6:

7) A number of nodes in the sense layer that become excited from sense cells when the child sees the father's protrusion of his lips: SL….

8) the node FATHER-PROTRUDES-LIPS of the item layer.

9) the states of a number of synapses of the sense layer: SL… , and

10) the state of the synapse SI-FI of the item layer.

The child's perception of his father's protrusion of his lips happens when the visual sensations of the protrusion, giving rise to excitation of certain nodes of the sense layer such as SL…, through the synapses SS-L… excite the node FATHER-PROTRUDES-LIPS sufficiently to excite the attention synapse, ATT-FPL. Whenever the father reacts in this way at a moment of the child's own protrusion of the lips, the node I-PROTRUDE-LIPS will also be excited, and consequently the synapse SI-FI will be opened and will have its conductivity increased. This opening of the synapses is the neural embodiment of the association of the two ideas *I-protrude-lips* and *Father-protrudes-lips* in the child's mind.

It should be added that undoubtedly there are excitations contributing to some of the excitations, such as that of the node FATHER-PROTRUDES-LIPS, additional to those shown in Fig. 5.6. At the moment of the perception of the father's protrusion of the lips the child will already have perceived the father's face, which will have excited a node, FATHER'S FACE, not shown in the figure. This node will excite FATHER-PROTRUDES-LIPS faintly, as parts of its fringe, through a synapse. Such faint excitation of a node may be said to embody a preperception in the child, influencing the perceptions that are actually taking place.

At the third stage, whenever the child senses the father protruding the lips there is a tendency that the excitation through such synapses as SS-L… will excite the node FATHER-PROTRUDES-LIPS sufficiently to excite also ATT-FPL. This excitation is conducted through SI-FI, so also to excite I-PROTRUDE-LIPS and ATT-IPL, and so will excite the muscles doing the protrusion of the child's lips. This happens as the child's imitative reaction to seeing the father protrude his lips.

As seen in this example, the imitation depends on the association of the idea of what another person does and the idea of the person's own action, embodied in the state of the synapse SI-FI. This association may be established in several ways. In the example of protrusion of lips it was established by the two action nodes being excited at the same time (within the same specious present). Another way of establishing the association is by the two actions having certain properties in common. This in mature individuals is the more usual way the association is established.

As shown by this example, the education of a habit by imitation is an individual matter. It depends upon a particular concrete experience in the person, in this example upon the formation of the node I-PROTRUDE-LIPS, which, as described above, is a matter of chance.

The education of habits by imitation is enormously important. The whole development of speech, that is establishing the core-phrase action aggregates described in section 4.4, is entirely a matter of such education. Likewise, as described by James [II 400-01], such education has a profound influence on each person's development of interests and passions.

5.7 Development of competing impulses into habits

As said by James [II 392]: '*Nature implants contrary impulses to act on many classes of things*, and leaves it to slight alterations in the conditions of the individual case to decide which impulse shall carry the day.' He gives as one example [II 395]: 'Animals, for example, awaken in a child the opposite impulses of fearing and fondling. But if a child, in his first attempts to pat a dog, gets snapped at or bitten, so that the impulse of fear is strongly aroused, it may be that for years to come no dog will excite in him the impulse to fondle again.'

In considering the development of habits from instinctive impulses it should noted that the development considered is concerned with the reaction to a sensed thing, such as a dog, that being composite may arouse a number of different impulses at the same time, and that the various impulses may be aroused by quite different properties of the thing, sensed by any of the five senses, such as the dog's growling sound that may be heard, on the one hand, and his fur as it appears to the sight, on the other.

The contrariness James talks about is a question of the resulting muscular activations. For example, the child's fondling of a dog must start by the stretching forward of the arm, while the reaction of fear is initiated by a withdrawal of the arm. These two muscular activations are indeed contrary to each other and any muscular activity that starts from one of them does inhibit the other one. Thus the development of habits from impulses is not a question of one impulse inhibiting another. Rather than being contrary to each other, the impulses to be considered are competing to be established as habits.

This development is described by a concrete example of a child's reaction to a dog in Fig. 5.7. The two reflex impulses of fondling and retracting in fear are embodied in the neurons, shown thick, between the node sets FURRY… and GROWL… of the sense layer and the nodes FONDLE and WITHDRAW ARM of the motor layer. By these neurons, whenever the child sees something furry such muscular activations that go into the fondling action, shown as M-F, will be excited. Similarly, whenever the child hears a certain kind of growling, such muscular activations that go into the action of withdrawing the arm, shown as M-W, will be excited

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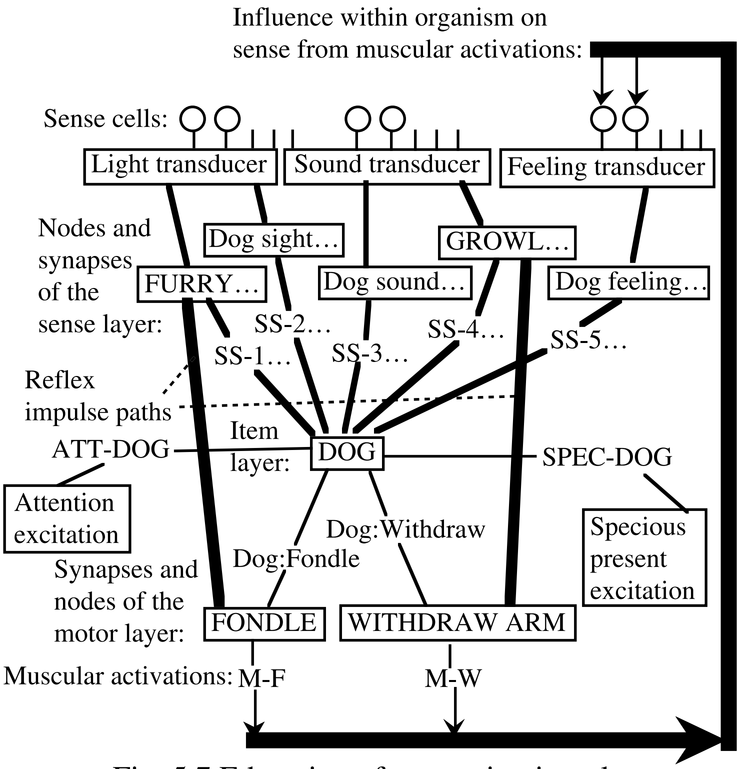

Fig. 5.7 Education of competing impulses

Any such muscular action will, at every moment when it gets activated, become accompanied with certain feelings, originating in sense cells in the tissue around the muscles, an influence suggested by the thick arrow in the figure.

The development of one of these two impulses into a habit of reaction to a dog has been preceded, at some time in the child's past, by the establishment of the subject node DOG. By this establishment a large number of synapses connecting such nodes of the sense layer that become excited when the child senses a dog, shown as SS-1…, SS-2…, SS-3…, SS-4…, and SS-5…, have become conductive. By the conductivity of these synapses, under some circumstances when the child senses a dog the node DOG will become excited (the child will have perception of the dog). As with all perception, the sense impressions that go into exciting it do not form a definite set. And so the child may have perceived the dog at many occasions without the excitations of either of the nodes FURRY or GROWL having been sufficiently strong to excite either of the nodes FONDLE or WITHDRAW ARM appreciably.

However, if it happens that the child perceives a fearfully growling dog, this perception of the dog, embodied in the excitation of the node DOG through the attention synapse ATT-DOG, will be accompanied by the instinctive withdrawal of the arm brought about by the excitation of the node WITHDRAW ARM from the node GROWL. When this happens the synapse Dog:Withdraw will become excited by both of its connecting neurons and so will be put into a conductive state. As a consequence of this any later perception of the dog, with the excitation of the node DOG, will arouse also the excitation of the node WITHDRAW ARM. And so the child's habit of withdrawing the arm in fear at the perception of any dog, even when this dog does not growl, has been established.

As seen from this example, *the choice between several competing impulses happens at the first occasion when one of the competing impulses is excited at the time of perception of the thing of which it is one of the properties.*

The mechanism of establishment of one out of several competing impulses into a habit described here will account for the establishment of each person's habits with respect to the activities of sexual activity, including such habits that characterize the sexual orientation of the person as being heterosexual, homosexual, or bisexual.

5.8 Education of action chains

In mature individuals voluntary acts are only rarely performed in isolation. Most commonly, voluntary acts are performed as series of acts that have been trained as such. This is how all ordinary activity of handling things and of moving about in walking, as well as the muscular activity in speaking, is performed. As described by William James and quoted in section 2.4 above in connection with Fig. 2.3, in the performance of such a series, each act of the series is activated by the sense impressions that are produced by the muscular activations of the previous act in the series.

Fig. 5.8 shows the way two voluntary actions, A and B, of such a series come to be coupled as a chain. Initially each of the two actions has been learned by imitation. This means that for each of them there is a node that when excited activates a muscular action, ACTION A through SM-A… and NM-A… into MA…, and ACTION B through SM-B… and NM-B… into MB….

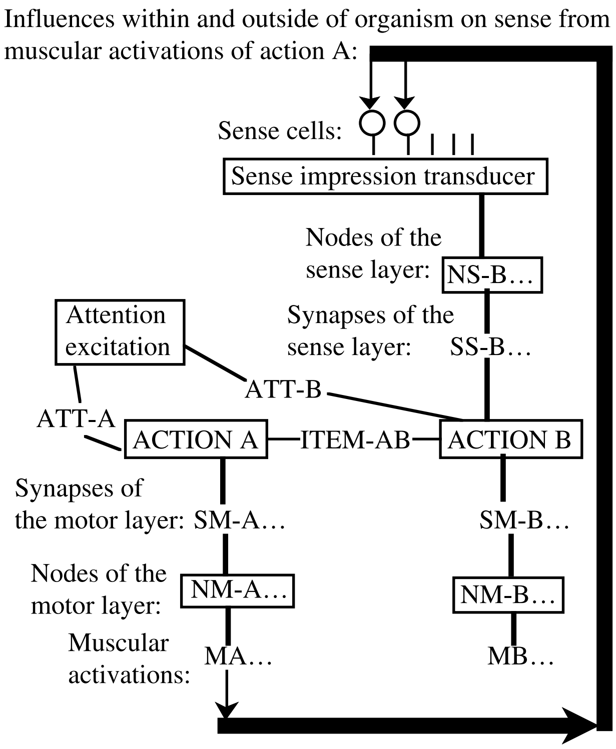

Fig. 5.8 Education of series of voluntary acts

While learning a series of acts the performer directs the attention to each act in order. In terms of Fig. 5.8 this means that such attention synapses as ATT-A and ATT-B excite their nodes.

Consider now that the two actions A and B are performed in immediate sequence by their nodes ACTION A and ACTION B being strongly excited from other nodes of the item layer not shown in the figure. As a consequence of the muscular activations MA… there will be a number of sensible effects within and around the organism. The motions of the organic parts will give rise to specific bodily feelings. The effects may include the production of sounds and changes that are visible by the light they emit. All these effects will excite the sense cells of the organism, as suggested by the thick arrow. By these excitations a number of nodes of the sense layer, NS-B…, will become excited. This excitation will happen at same moment as the excitation of the node ACTION B. Thereby the synapses SS-B… will receive excitations from both of their neurons at the same time, and so will become conductive. Additionally, owing to the simultaneous excitations of ACTION A and ACTION B the synapse ITEM-AB will become conductive. As the consequence, whenever action A is performed, ACTION B will receive excitation and so the action B will be performed.

At later occasions, every time the two actions are performed in immediate sequence the conductivities of the synapses SS-B… and ITEM-AB will change in a plastic manner, thereby embodying the training of the movement that is being done.

5.9 Influence of innate individual neural characteristics

As described above, the education of a person's neural system happens as a continued interplay between the plastic states of one or more synapses and some influence stemming from impressions on sense. Thus the influence on the education of the person from innate individual characteristics must come about from innate plastic characteristics of the synapses.

The plastic characteristics of individual persons' synapses seem not so far to have been investigated directly. However, certain indirect evidence indicates that there may be great differences between the characteristics of synapses in different persons. One striking evidence is the differences in the imagery experienced by various persons, described in section 2.12 above, with a particularly striking case, involving a radical change of visual imagination, described in section 7.4 below. This evidence indicates, first, that the plastic characteristics of *synapses of the sense layer* differ among persons. Second, that in their characteristics the synapses of the sense layer are different for the five senses.

Similarly each of the sets of other *synapses* in the neural system, those of the *item layer*, of the *attention layer*, of the *specious present layer*, and of the *motor layer*, undoubtedly have characteristics that are different in different persons.

It should be clear from the character of the innate differences that the most direct influence of such differences upon the education of the neural system will be a question of (1) the ease or speed with which the various education processes proceed, and (2) the quality of the habits the person is capable of acquiring.

The plastic characteristics of *synapses of the sense layer* will influence the interplay with sensations in the processes of education in complicated ways that are beyond description in general terms. Special cases are most easily understood when they are concerned with habits of accurate recall. For example, the person with the unusual visual imagination described in section 7.4 below had a quality of visual recall such that he was able to reproduce in his visual imagination every visual feature of the letters of his correspondence. This unusual feature of his neural system undoubtedly had a major influence upon the education of the person's fluent mastery of a number of languages and his manner of conducting his affairs.

The characteristics of other sets of synapses than the visual sense synapses undoubtedly are very important to the education and mature mental state of the person, but are mostly more difficult to ascertain. This holds in particular for the characteristics of the *feeling sense synapses*. These characteristics determine the general weight feelings of any kind have on the mental life in general and at all times, and on the education of habits in particular. But the concrete effect of this upon the person's education and mental life are too indirect to be described in general terms.

The characteristics of the *attention* and *specious present synapses* will have a more indirect influence upon the education of the nervous system. The characteristics of these sets of synapses influence the way nodes of the item layer are held excited at the same time, within the same thought object. They are primarily decisive in the way the stream of thought changes from moment to moment and how it is experienced by the person.

Secondarily the characteristics of these sets of synapses influence the *changes of the conduction states* of the synapses embodying the associations of the subjects and qualities embodied in the nodes. This influence is the education of the nervous system at the level of detail. This obviously is strongly influential in the way the education of the nervous system takes place, but in ways that are too complicated to trace in their details.

Plausibly some of the mental states that are classified as disorders, such as *autism*, come about as a result of the education of nervous systems having unusual characteristics of the attention and specious present synapses.

In summary, the innate neural characteristics influencing the education of a person's neural system stem from the innate plastic characteristics of at least nine different sets of synapses. This explains why the persistent attempts over a century to explain innate individual characteristics in terms of a single item denoted intelligence have been a failure.

6. Neural functional evidence

6.1 Neural functional evidence of the synapse-state theory

In the present chapter further evidence for the validity of the theory will be found in observations of the effect on the mental state of the organism of various cerebral affections. This will supplement the account given in chapter 4 of the way the synapse state theory accounts for the muscular activity of speech.

6.2 Literature sources of neural functional evidence

What is needed as supporting evidence of the synapse state theory are accurate descriptions of individual cases of the behavioral effect of particular well defined influences upon the neural functioning of the brain.

Clarity and detail is all important in the discussion of the neural functional evidence. By far most of the neural functional influences of concern arise from lesions of the brain caused by accidents or tumors. Precisely what part of the brain tissue is affected by such influences is clearly different from one case to the other. So as to disentangle the neural functions behind the various mental effects it is necessary to carry out a detailed analytical comparison of many individual cases, in particular so as to isolate cases in which only one single neural function is impaired.

For the descriptions and discussions of individual cases of brain lesions three literature sources have been examined: James (1890), Luria (1979), and *Encyclopedia of the Neurological Sciences, EncycNeuro* (2003).

James's book (1890) is descriptive throughout and presents a wealth of relevant detailed evidence as it was available in sources from the following authors: Ferrier, 1878; François-Franck; Goltz; J. Loeb; Paneth; Schaefer and Horsley; Nothnagel und Naunyn,1887; W. A. Hammond; A. Christiani, 1885; Schrader; Munk 1881, 1884, 1886, 1889; Luciani und Seppili; Luciani; Brown and Schaefer; Lannegrace, 1889; Flechsig, 1876; Exner; Seguin; Wilbrand, 1887; C. S. Freund, 1888; Bruns, 1888; Mauthner, 1881; Lissauer; Bernard, 1885; Ballet; 1886; Jas. Ross, 1887; Wernicke, 1874, 1881; Monakow; A. Starr, 1889. To this James adds analyses of the behavioral effects of superior clarity and detail, as will be discussed in sections 6.3-6.7 below.

An examination of Luria's book (1979) has found it useless in the present context, both by its inherent quality and in a comparison with James's book. More particularly Luria's book is wanting in the following respects:

(1) The descriptions of the behavioral evidence are scanty and unclear. They are presented, not as independent characteristics of human behavior, but only in the context of descriptions of complicated patterns of behavior and in terms that depend on unclear and problematic assumptions about mental life. One example is Luria's account of what he denoted 'disturbances of the speech initiative' or 'dynamic aphasia', which he describes in this way [Luria p. 266]:

> The first investigation of the patient may not reveal any speech disturbances. However, a more thorough analysis will show these disturbances quite clearly. They appear the moment when the patient has to go beyond the simple repetition of words and sentences or naming of things into an active, creative formation of the schema of an independent verbal statement.
>
> They repeat without difficulty the first fragment or passage of a story which is read aloud to them. But when asked to retell the whole story they experience great difficulties and declare that 'nothing comes into their heads'. The same defect may be observed in these patients when they are asked to tell the contents of a picture shown to them. In this case they name the individual details of the picture, and sometimes grasp its main theme, but turn out to be unable to transfer this contents into a connected, broad verbal statement.

This whole discussion depends entirely on the assumption that people's speech normally consists of 'active, creative formation of the schema of an independent verbal statement'. This assumption is without any empirical ground.

Another example is Luria's description of what he calls 'telegraphic style' [p. 268]:

> Thus one of these patients, when asked to tell how he was wounded at the front, says: 'Then … then … front … then … offensive … then … bullet … then … nothing … then … hospital … operation … then … talk … talk … talk …'. The cause of such disturbances of speech is a deep decay of earlier established grammatical stereotypes, that are basic to the broad, syntactically organized statement (Luria 1975, Achutina 1975)'.

This shows how Luria presents what he claims to display a disturbance of speech in terms of the way the patient reacts to the request to tell how he was wounded at the front. But what comes forth as speech from a person upon such a request must be the final outcome of a very complicated mental process, involving perception of the sounds of the spoken request as well as recall of a large number of past experiences and activation of a number of muscles that produce the patient's speech sounds. Luria's suggestion that a particular character of the patient's response, what Luria calls 'telegraphic style', should indicate a particular defect somewhere in this very complicated pattern of nervous activities, and his attendant claim that 'telegraphic style' should be taken to be a symptom of a definite defect in the nervous system, is a postulate without empirical ground. The defect of Luria's argumentation is admitted by himself when he continues the above quotation: 'We still do not know the special mechanism that underlies this aphasia which is known in neurology as "telegraphic style"'.

Yet another example of Luria's description of a behavioral disturbance is this [p. 286] :

> A special place among the patients having disturbances of understanding are patients with syndrome of the so-called 'afferent motoric aphasia', which is caused by lesions of the postcentral parts of the speech zones in the cortex of the left hemisphere.
>
> As we have seen already these patients have great difficulty in distinguishing closely similar articulations. They confuse sounds of closely similar articulation such as 'l' and 'd' and 'l' and 't' or 'm' and 'b' and do the same errors when they write (they write for example *chalat* as *chadat).*
>
> One might think that these disturbances were pure matters of articulation, and that they should not have an influence upon the understanding of a verbal message. However, as well known the apparatus of speech is very important in establishing the meaning of words, and so these patient also have difficulties in deciphering messages, in the understanding of the lexical contents of messages in the cases that the lexical units are complicated with respect to articulation.
>
> We still do not know the kind of the disturbance of the understanding of 'afferent motoric aphasia', but conceivably the analysis of this form of aphasia, by which the command of the language codes is destroyed in the articulary-phonetic link, may reveal many interesting data.

As discussed in section 6.6 below, Luria's problem here was completely solved around 1880 by Wernicke and Charcot, as reported by James.

(2) Luria's book ignores the rich insight presented by James. It makes the whole discussion revolve around an elaborate theory of what is called language and mental life, developed through about 200 pages. This theory is grounded in speculative notions about the human activity leading to speech, presented dogmatically as obvious truths, and yet given no empirical support. Repeatedly the notions are admitted to be flawed, thus on page 194:

> The verbal statement is a definite form of activity (with its own motive, own initial thought or purpose, and own control), whose psychological structure is as yet a riddle. … Psychology has not so far established sufficient knowledge about what characterizes the very complex process of the generation of a statement.

In discussing his theory Luria refers only to literature from after 1946. Thus in Lecture 9, p. 158-179, titled 'Complex forms of utterance - Paradigmatic components in syntagmatic structures', Luria discusses a number of works by Luria (1946, 1947, 1966, 1970,1974, 1975, 1976), H. J. Greenberg (1966), G. Miller, et al. (1953, 1967, 1969, 1970), G. Miller, J. Fodor, et al. (1962),H. H. Clark (1969, 1970, 1974), T. G. Bever (1970, 1974). They all claim to clarify what it is to *understand* a spoken phrase.

Luria further in Lecture 10, p. 180-194, makes the assumption (p. 180) that it makes sense to talk of 'the psychological process of shaping the verbal statement from the thought by way of the internal schema of the statement and the inner speech into the broad external speech which constitutes the verbal communication.' This is discussed at length, including references to the works by Ostin (1969),

L. Wittgenstein (1968), G. Lakoff (1971, 1972), H. P. Grice (1971), R. Rommetveit (1968, 1970), M. A. K. Halliday (1967, 1967, 1973) and J. V. Wertsch (1974, 1975). However, the discussion fails completely to clarify the subject. Thus page 184 tries to clarify 'the thought which is the basis of the utterance', but concludes that 'it has not been possible to give a psychological description of the thought'. James's description of the stream of thought is clearly unknown to Luria.

(3) Throughout his book Luria makes assumptions about human speech that have no empirical support. Thus in Lecture 11, p. 195-207, Luria says [p. 195] :

> As well known there are two forms of broad, outer speech: The *oral* and the *written*. The oral speech may again be divided into the *dialogical* and the *monological* speech. … We have said that the oral speech occurs in three basic forms: Exclamations, dialog (answer to question) and monolog (independent, broad statement originating in an internal thought.) - The first form—exclamation—cannot, as said earlier, be considered as real speech. It does not transfer any account of a happening or of a relation with the aid of the codes of language. Rather, exclamations are affective speech reactions that are generated involuntarily as answer to an unexpected phenomenon. We shall therefore consider this speech form as something special and will in what follows only be concerned with the two basic forms of broad, oral speech: dialog and monolog.

Luria makes these statements about speech without giving any evidence that they present valid insight into human speech. That they are invalid is obvious as soon as they are confronted with genuine speech, for example the samples represented in section 4.2 above.

Luria's Lecture 15, p. 253-278, is titled 'The cerebral organization of the speech activity - The pathology of the verbal statement.' On page 255 Luria presents a brief survey of the study of the disturbances of speech since 1861, starting from a brief mention of the observation of Broca and Wernicke, and concluding:

> These observations formed the basis of the clinical study of the cerebral organization of human speech activity. They showed that local brain lesions do not entail a general deterioration of the speech activity as a whole, but differentiated speech disturbances that are structurally different. Consequently *the speech process builds upon a series of cooperating zones in the cerebral cortex, each of which has its specific importance to the organization of the speech activity as a whole.*
>
> These observations seemed to open wide perspectives for an accurate study of the cerebral organization of human speech activities. However, the scientists soon met considerable difficulties that it took several decennia to surmount. The grounds of the difficulties were on the one hand that one lacked basic theoretical notions about the structure of language, and on the other that one had erroneous understanding of the basic question of the relation of language to the brain.

By these and the following remarks Luria ignores the insight into the neural ground of aphasias that had been established during 1861-1889 and is reviewed by James.

Instead Luria continues on pages 259-278 to discuss ‘The cerebral organization of the motivational basis and of the programming of a verbal statement’ and ‘The cerebral organization of the syntagmatic structure of the statement’.

Brain lesions are treated in *EncycNeuro* in the article *Aphasia* by N. F. Dronkers and J. Ogar (2003). The article *Aphasia* is similar to the other articles in the *EncycNeuro* examined in chapter 1 above, by being entirely committed to a cognitivist view of mental life, talking of aphasia as a ‘language impairment’, of ‘retrieving words from the lexicon’, of ‘lexical storage per se’, of ‘the language system’, and of ‘information processed in posterior language areas’. The descriptions in the article of the behavioral evidence are summary and unclear, with no attempt to isolate particular disorders. *Agraphia*, the inability to write, is not mentioned at all.

The article is further marred by a prominent place given to ‘problems in finding the desired word’, called *anomic aphasia*, and described at length. This is entirely misguided. Difficulty in finding the desired word is not a symptom of anything. It is like finding it difficult to hit the ball when playing tennis or problems in getting out of bed in the morning. Awkward indecision is a well known state to the shopper who has not taken his shopping list along, as well as to the actor on the stage who gets stuck on his cue, and to Igor Stravinsky when he gets stuck when he has to begin his solo at the beginning of the second movement of his concerto. Difficulty in finding the desired word is displayed in many places of every one of the six spoken comments presented in section 4.3 above. Such difficulties are all well known aspects of mental life that are commonly referred to by such words as hesitancy, irresolution, indecision, and wavering. William James [I 249] describes such states of mind as *feelings of tendency.* Talking about these features in the same breath as motoric aphasia just makes for confusion. In order to overcome such problems no consultation of the neurologist will help. They are all matters of insufficiently established habits, and there is only one way to reduce them: rehearsal, practice.

The article *Aphasia* in *EncycNeuro* mentions a result of modern neuroimaging techniques that will be discussed below. Apart from that the article brings no usable neural functional evidence of mental life.

6.3 Local excitations into normal brains

The effect of various controlled excitations into certain locations on the surface of normal brains have been studied extensively. James writes [I 12]:

> CHAPTER II. THE FUNCTIONS OF THE BRAIN. … [I 31] The one thing which is *perfectly* well established is this, that the ‘central’ convolutions, on either side of the fissure of Rolando, and (at least in the monkey) the calloso-marginal convolution (which is continuous with them on the mesial surface where one hemisphere is applied against the other), form the region by which all the motor incitations which leave the cortex pass out, on their way to those executive centres in the region of the pons, medulla, and spinal cord from which the muscular contractions are discharged in the last resort. The existence of this so-called ‘motor zone’ is established by the lines of evidence successively given below:

(1) *Cortical Irritations.* Electrical currents of small intensity applied to the surface of the said convolutions in dogs, monkeys, and other animals, produce well-defined movements in face, fore-limb, hind-limb, tail, or trunk, according as one point or another of the surface is irritated. These movements affect almost invariably the side opposite to the brain irritations: If the left hemisphere be excited, the movement is of the right leg, side of face, etc. … [I 32 footnote] Recently the skull has been fearlessly opened by surgeons, and operations upon the human brain been performed, sometimes with the happiest results. In some of these operations the cortex has been electrically excited for the purpose of more exactly localizing the spot, and movements first observed in dogs and monkeys have then been verified in men.

(2) *Cortical Ablations.* When the cortical spot which is found to produce a movement of the fore-leg, in a dog, is excised …, the leg in question becomes peculiarly affected. … [I 35]

In man we are necessarily reduced to the observation *post-mortem* of cortical ablations produced by accident or disease (tumor, hemorrhage, softening, etc.). What results during life from such conditions is either localized spasm, or palsy of certain muscles of the opposite side. The cortical regions which invariably produce these results are homologous with those which we have just been studying in the dog, cat, ape, etc. … [I 37]

(4) *Anatomical proof* of the continuity of the rolandic regions with these motor columns of the cord is also clearly given. Flechsig's 'Pyramidenbahn' forms an uninterrupted strand (distinctly traceable in human embryos, before its fibres have acquired their white 'medullary sheath') passing upwards from the pyramids of the medulla, and traversing the internal capsule and corona radiata to the convolutions in question … . … Electrical stimulation of this motor strand in any accessible part of its course has been shown in dogs to produce movements analogous to those which excitement of the cortical surface calls forth.…[I 41]

Sight. Ferrier was the first in the field here. He found, when the *ang* convolution (that lying between the 'intra parietal' and the 'external occipital' fissures, and bending round the top of the fissure of Sylvius, in Fig. 6.1) was excited in the monkey, that movements of the eyes and head as for vision occurred;

The evidence of local excitations on the surface of convolutions of the brain producing activations of particular muscles supports the way the synapse-state description of the brain has all muscular activations pass through the nodes of the motor layer. Clearly these nodes are located in the surfaces of the convolutions of the brain.

6.4 Evidence from brains having local lesions

An important source of insight into neural functions of human brains are the behavioral effects of lesions of the brain that impair the function of localized parts of the brain tissue, lesions that have been caused accidents or tumors. The behavioral effects are particularly noticeable in the victim's speech, writing, and perception of language sounds and script. Such effects are commonly denoted *aphasias,* with the understanding that there are several different kinds that in the individual case will often come together and produce complicated behavioral effects.

The analysis of such effects poses great difficulties, for two different reasons: (1) The lesions whose behavioral effect may be studied differ greatly in their local extent in the brain from one case to another. Thus many individual cases will display the behavioral effects of several different functions of the brain combined. (2) Interpreting a particular behavioral effect as being caused by a particular localized function presupposes a sound understanding of what the functions of localized parts of the brain are. In this respect the cognitivist creed has been particularly harmful, by its misguided insistence on speech activities as being matters of what is called language processing, depending on words being retrieved from a lexicon.

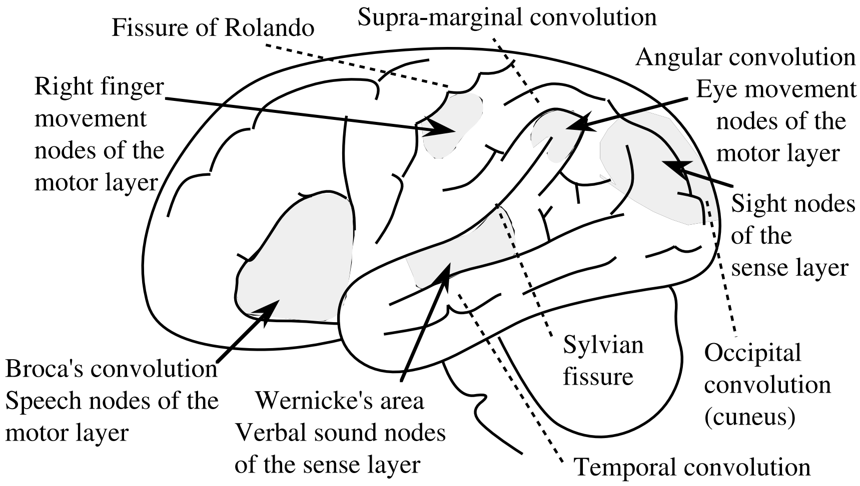

Fig. 6.1 Left hemisphere of human brain - Outer surface

6.5 Impaired muscular activity

One kind of aphasia is described by James in this way [I 37]:

> One of the most instructive proofs of motor localization in the cortex is that furnished by the disease now called aphemia, or *motor Aphasia*. Motor aphasia is neither loss of voice nor paralysis of the tongue or lips. The patient’s voice is as strong as ever, and all the innervations of his hypoglossal and facial nerves, except those necessary for speaking, may go on perfectly well. He can laugh and cry, and even sing; but he either is unable to utter any words at all; or a few meaningless stock phrases form his only speech; or else he speaks incoherently and confusedly, mispronouncing, misplacing, and misusing his words in various degrees. Sometimes his speech is a mere broth of unintelligible syllables. In cases of pure motor aphasia the patient recognizes

his mistakes and suffers acutely from them. Now whenever a patient dies in such a condition as this, and an examination of his brain is permitted, it is found that the lowest frontal gyrus (see Fig. 6.1, Broca's convolution) is the seat of injury. Broca first noticed this fact in 1861, and since then the gyrus has gone by the name of Broca's convolution.… [I 40] It will be noticed that Broca's region is homologous with the parts ascertained to produce movement of the lips, tongue, and larynx when excited by electric currents in apes.… The evidence is therefore as complete as it well can be that the motor incitations to these organs leave the brain by the lower frontal region.

All the cases of motor aphasia may be explained in terms of destructions of nodes of the motor layer, which then would be located in Broca's convolution. The details will be accounted for in terms of Fig. 6.2 in which the nodes of the motor layer are shown in the sets NM-1… and NM-2… that activate the muscles M-1… and M-2… contributing to speech, and the set NM-other… that activates all other muscles of the organism. All the speech habits are embodied in action aggregates. Each speech action aggregate consists of one or more subaggregates, each for speaking one part of a core-phrase. Fig. 6.2 shows two such subaggregates, A and B, A consisting of the node PART-PHRASE-A and the synapse sets SS-A… , SM-A1…, and SM-A2…, and B of the node PART-PHRASE-B and the synapse sets SS-B… , SM-B1…, and SM-B2….

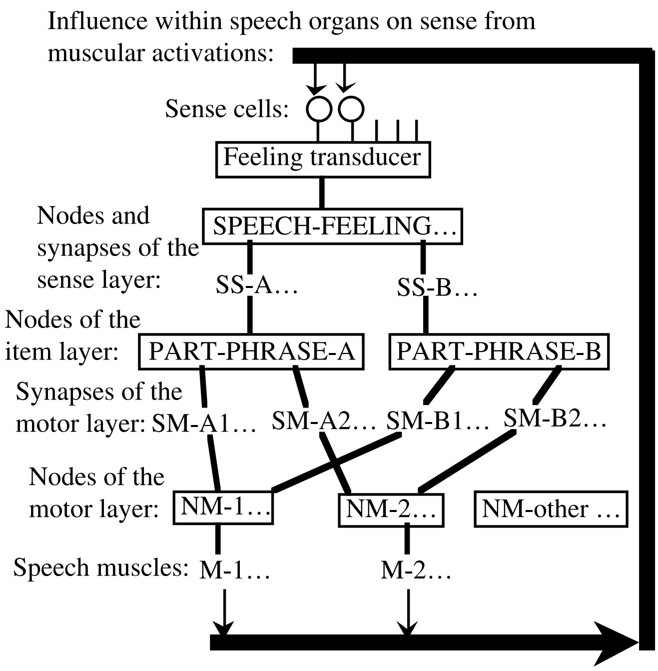

Fig. 6.2 The embodiment of motor aphasia

During normal speech, upon excitation of the node PART-PHRASE-A the nodes of the sets NM-1… and NM-2… will become activated according to the conductivities of the synapses of the sets SM-A1… and SM-A2…. This will activate the sets of speech muscles M-1… and M-2…, which again will excite the sense cells in the speech organs, some of the nodes of the set SPEECH-FEELING…, and through the synapse set SS-B… the node PART-PHRASE-B.

With such motor aphasia that the person is unable to utter any words at all, all the nodes of the sets NM-1… and NM-2… will have been destroyed.

Other states of motor aphasia may be understood as the consequence of the destruction of the node set NM-1… while the set NM-2… is preserved. Then the excitation of the node PART-PHRASE-A will activate only some of the speech muscles of normal speech, and so the speech sound will emerge in a distorted form. Further, the excitation of the sense cells in the speech organs will differ in some way from the way they were excited in normal speech, with the consequence that they will not excite the normal follower, PART-PHRASE-B, but some other part-phrase node. In other words, the normal sequencing of excitations of part-phrase nodes, as it is the result of the training of the speaking, will be completely upset. Thus it is quite understandable that as described by James, it may hold for such a patient that [I 37]:

> 'a few meaningless stock phrases form his only speech; or else he speaks incoherently and confusedly, mispronouncing, misplacing, and misusing his words in various degrees. Sometimes his speech is a mere broth of unintelligible syllables.'

The article *Aphasia* in *EncycNeuro* by N. F. Dronkers and J. Ogar (2003) brings a relevant refinement of Broca's observation, saying:

> … modern neuroimaging techniques… lesions to Broca's area alone are now known to produce only a transient mutism that resolves in 3-6 weeks. A much larger lesion is necessary to produce the symptoms that result in a persisting Broca's aphasia. Chronic Broca's aphasia occurs as a result of a lesion that typically encompasses Broca's area as well as adjacent frontal areas, underlying white matter, the insula, the anterior superior temporal gyrus, and the arcuate/superior longitudinal fasciculus in more severe cases.

In terms of Fig. 6.2 this may be understood as follows. Broca's area embodies the nodes NM-1… and NM-2…. The underlying matter mentioned embodies the synapses SM-A1…, SM-A2…, SM-B1…, and SM-B2…. While the nodes may heal soon after lesions, the synapses cannot since their plastic states embody the reaction habits that have been built up over years.

James continues [I 40]:

> Victims of motor aphasia generally have other disorders. One which interests us in this connection has been called *agraphia:* they have lost the power to *write.* They can read writing and understand it; but either cannot use the pen at all or make egregious mistakes with it. The seat of the lesion here is less well determined, owing to an insufficient number of good cases to conclude from. There is not doubt, however, that it is (in right-handed people) on the left side, and little doubt that it consists of elements of the hand-and-arm region

specialized for that service. The symptom may exist when there is little or no disability in the hand for other uses. If it does not get well, the patient usually educates his right hemisphere, i.e. learns to write with his left hand.

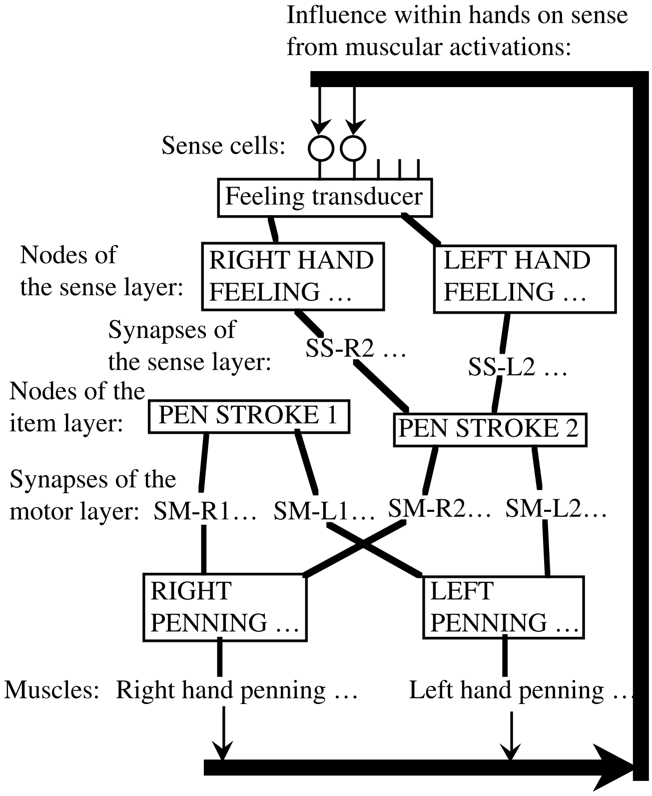

Fig. 6.3 The embodiment of agraphia

The embodiment of agraphia may be explained by Fig. 6.3. Any writing is done by a sequence of pen strokes. Each pen stroke is produced by the activation of a set of muscles in, normally, the right hand, shown as Right hand penning…. These muscles are activated by excitations coming from a set of nodes: RIGHT PENNING… The excitations for the first stroke come from a node PEN STROKE 1 through the synapse set SM-R1…. The execution of the first stroke will produce changes in the hand that produce excitations of certain sense cells, that get transmitted through the node set RIGHT HAND FEELING… and the synapse set SS-R2… into the node PEN STROKE 2, which through the synapse set SM-R2… produces the second pen stroke. Agraphia sets in when the node set RIGHT PENNING… is destroyed. Learning to write with the left hand is a matter of educating the synapse sets SM-L1…, SS-L2…, and SM-L2….

By similarity with the parts ascertained to produce movements of the fingers in monkeys, shown in James (1890) Fig. 6, the nodes RIGHT PENNING… of the motor layer producing the finger movements of writing may be assumed to be located next to the fissure of Rolando, as shown in Fig. 6.1, which then would be the centre of writing.

James concludes his discussion of motor aphasias [I 40] :

> All these phenomena are now quite clearly explained by separate brain-centres for the various feelings and movements and tracts for associating these together. … [I 41] The different lines of proof which I have taken up establish conclusively the proposition that *all the motor impulses which leave the cortex pass out,* in healthy animals, *from the convolutions about the fissure of Rolando.*

In terms of the synapse-state theory, the convolutions about the fissure of Rolando is where the nodes of the motor layer are located.

6.6 Impaired reactions of vision and sight

Rich behavioral evidence of impairments of the functions of vision and sight resulting from neural insults in monkeys, dogs, birds, and men, was obtained during the years up to 1889 by a number of researchers quoted by James (1890, I 41-52), including Brown and Schaefer, Christiani, Exner, Ferrier, Goltz, Hitzig, Lannegrace, Loeb, Luciani, Munk, Nothnagel and Naunyn, Seguin, and Seppili.

Accounting for the neural impairments of the functions of vision and sight as observed by these authors is a complicated matter, owing to several different circumstances:

(1) Vision and sight undoubtedly involves an interplay of a number of separate neural mechanisms. The influences of these mechanisms upon the observable behavior of the organisms are indirect. Interpreting the evidence is a difficult matter.

(2) The evidence of the neural mechanisms mostly comes from observations of the behavior of organisms that are the victims of accidental lesions of the brain and of vivisection upon animals. In either case the extent of the organic change involved cannot be controlled with great precision. As a matter of fact the researchers in the field have in several cases disagreed strongly about the relevant evidence.

(3) Whether a creature sees, has visual experience, is sometimes difficult to ascertain. James says [I 45]:

> The question whether a dog is blind or not is harder to solve than would at first appear; for simply blinded dogs, in places to which they are accustomed, show little of their loss and avoid all obstacles; whilst dogs whose occipital lobes are gone may run against things frequently and yet see notwithstanding. The best proof that they may see is that which Goltz's dogs furnished: they carefully avoided, as it seemed, strips of sunshine or paper on the floor, as if they were solid obstacles. This no really blind dog would do.

(4) One has to distinguish between *sensorial* and *psychic* blindness. A further relevant issue is *visual imagination*. As James says [I 41]:

> Sensorial blindness is absolute insensibility to light; psychic blindness is inability to recognize the *meaning* of the optical impressions, as when we see a page of Chinese print but it suggests nothing to us.

Concerning imagination in visual form James says [I 50]:

> A man whose power of visual imagination has decayed (no unusual phenomenon in its lighter grades) is not mentally blind in the least, for he recognizes perfectly all that he sees. On the other hand, he *may* be mentally blind, with his optical imagination well preserved; as in the interesting case published by Wilbrand in 1887.

(5) Visual disturbances which result when only one hemisphere is injured are *hemiopic*. James writes [I 42]:

> A hemiopic disturbance of vision is one in which neither retina is affected in its totality, but in which, for example, the left portion of *each* retina is blind, so that the animal sees nothing situated in space towards its right.

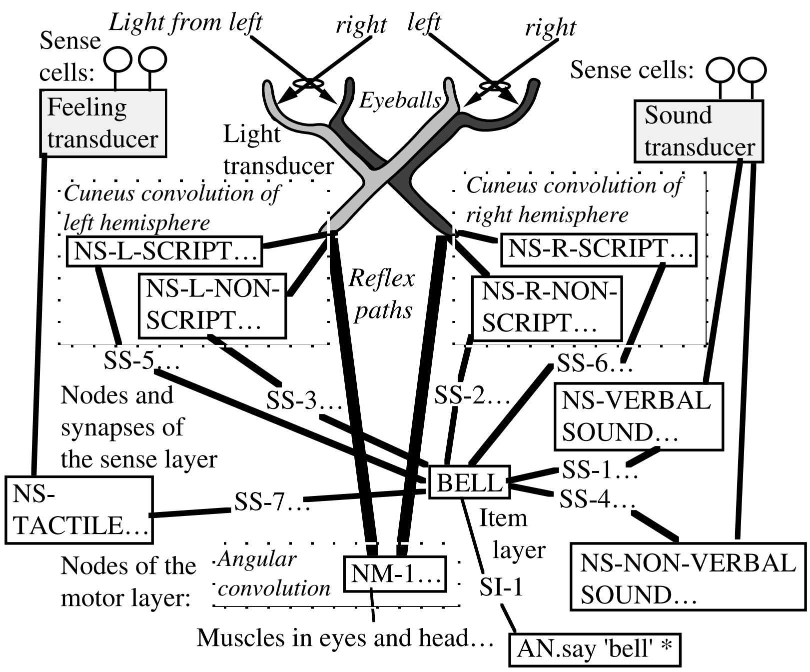

Fig. 6.4 The embodiment of vision and sight

The way the synapse-state theory is supported by the neural functional evidence will here be demonstrated by the way the rich empirical evidence presented by James makes sense in terms of the description of the phenomena of vision and sight in Fig. 6.4. In this figure the form of the light transducer has been taken over from James's Fig. 15 [I 49], copied from Seguin. The figure shows the sense cells in the retinas excited from the light coming from the left (right) half of the field of view in both eyes connected to the cuneus convolution in the right (left) hemisphere.

The figure shows the nodes of the sense layer involved in sight and vision, divided into those excited by the sight of script: NS-L-SCRIPT… and NS-R-SCRIPT…, and those excited by other sights: NS-L-NON-SCRIPT… and NS-R-NON-SCRIPT…. For example, the node BELL will become excited by the sight of such script as ‘bell’, or ‘BELL’, or ‘Bell’, through the synapse sets SS-5… and SS-6…, and by the sight of a real bell, or a picture of a bell, through the synapse sets SS-2… and SS-3… In addition, BELL will become excited by the sound of a bell through the synapse set SS-4… and by the sound of the spoken word ‘bell’ through the synapse set SS-1…. BELL might also become excited by the person’s feelings in the fingers of touching a bell, through the synapse set SS-7…

The figure also shows how instinctive muscular reactions in the eyes and head are transferred by reflex paths, drawn thick, directly from the light transducer into nodes of the motor layer, NM-1….

The evidence of the neural functions and its interpretation is as follows:

(1) James writes [I 41]:

> Munk almost immediately declared total and permanent blindness to follow from destruction of the *occipital lobe* in monkeys as well as dogs …

The *cuneus convolution* being part of the *occipital lobe,* this observation confirms that if in Fig. 6.4 the nodes NS-L-SCRIPT…, NS-R-SCRIPT…, NS-L-NON-SCRIPT…, and NS-R-NON-SCRIPT…, are destroyed, the sense impressions coming from the eyes cannot reach the nodes of the item layer, such as BELL, and so no perception from visual impressions will happen, in other words, the person cannot see that what is in the field of view is a bell.

(2) James writes [I 42]:

> All of Munk’s *birds* seemed totally blind (blind sensorially) after removal of the hemispheres by his operation. … But Schrader, who operated after Munk and with every apparent guarantee of completeness, found that all his pigeons saw after two or three weeks had elapsed, and the inhibitions resulting from the wound had passed away. They invariably avoided even the slightest obstacles, flew very regularly towards certain perches, etc. differing *toto cælo* in these respects with certain simply *blinded* pigeons who were kept with them for comparison. They did not pick up food strewn on the ground, however.

In terms of Fig. 6.4 these observations may be understood as follows: Picking up food strewn on the ground is a matter of visual perception and so is impossible for a bird without the hemispheres. But avoiding obstacles and finding perches is only a matter of movements activated by *reflex paths* that do not involve the hemispheres. This is further confirmed thus [I 43]:

> *In rabbits* loss of the entire cortex seems compatible with the preservation of enough sight to guide the poor animals’ movements, and enable them to avoid obstacles. Christiani’s observations and discussions seem conclusively to have established this.

(3) James writes [I 44]:

> *In dogs* … Other observers, Hitzig, Goltz, Luciani, Loeb, Exner, etc., find, whatever part of the cortex may be ablated on one side, that there usually results a *hemiopic* disturbance of *both* eyes, slight and transient when the anterior lobes are the parts attacked, grave when an occipital lobe is the seat of injury, and lasting in proportion to the latter's extent. … *In man* … we cannot vivisect, but must wait for pathological lesions to turn up. The pathologists who have discussed these … conclude that the occipital lobes are the indispensable part for vision in man. Hemiopic disturbance in both eyes comes from lesion of either one of them, and total blindness, sensorial as well as psychic, from destruction of both.

These observations confirm the pattern of neural connections from the two parts of the retina of each eye shown in Fig. 6.4.

(4) Concerning *mental blindness* James's explanation is so explicit that it is possible to identify the neural embodiment of every item of it in terms of the synapse-state theory. This is accomplished in the following quotation by adding the designation as it is shown in Fig. 6.4, of each neural item referred to in James's description. James writes [I 48]:

> A most interesting effect of cortical disorder is *mental blindness.* This consists not so much in insensibility to optical impressions, as in *inability to understand them.* Psychologically it is interpretable as *loss of associations* between optical sensations and what they signify; and any interruption of the paths between the optic centres and the centres for other ideas (SS-2…, SS-3…, SS-5…, and SS-6…) ought to bring it about. Thus, printed letters of the alphabet, or words, signify certain sounds and certain articulatory movements. If the connection (SI-1 or SS-1…) between the articulating (AN, say 'bell' *) or auditory (NS-VERBAL SOUND…) centres, on the one hand, and the visual centres (NS-L-SCRIPT…, NS-R-SCRIPT…, NS-L-NON-SCRIPT…, and NS-R-NON-SCRIPT…) on the other, be ruptured, we ought *a priori* to expect that the sight of words would fail to awaken the idea of their sound, or the movement for pronouncing them. We ought, in short, to have *alexia*, or inability to read: and this is just what we do have in many cases of extensive injury about the fronto-temporal regions, as a complication of *aphasic* disease. … In the still more interesting case of mental blindness recently published by Lissauer (Archiv f. Psychiatrie, vol. 21, p. 222) though the patient made the most ludicrous mistakes, calling for instance a clothes-brush a pair of spectacles, an umbrella a plant with flowers, an apple a portrait of a lady, etc. etc., he seemed, according to the reporter, to have his mental images fairly well preserved.

The circumstances of this case may be understood to come about merely by the destruction of only some, but not all, of the nodes NS-L-NON-SCRIPT… and NS-R-NON-SCRIPT… in Fig. 6.4. It is a matter of the embodiment of the visual perception of familiar things, as illustrated in Fig. 6.5. The figure shows the neural components involved in the person’s perception by visual sense impressions of a clothes-brush and a pair of spectacles. The perception of one of these things happens when certain nodes of the sense layer become excited from the light transducer. In the figure these nodes have been shown as the set NS-A… that contributes to the perception of a clothes-brush, the set NS-C… that contributes to the perception of a pair of spectacles, and the set NS-B… that contributes to the perception of both. Each of these sets will consist of a certain large number—probably many thousands—of nodes corresponding to all the individual visual qualities of the things. The perception of the two things further depends on the synapse sets SS-1…, SS-2…, SS-3…, SS-4…, that in the normal organism have been educated into states of conductivity when the person learned to recognize clothes-brushes and spectacles by sight. The person’s perception of a clothes-brush happens when the light impressions arriving in the sense cells from such a thing have excited some of the nodes of sets NS-A… and NS-B… so strongly that the sum of the excitations transferred through the synapse sets SS-1… and SS-2… into CLOTHES-BRUSH are sufficient to excite the attention synapse ATT-1. Similarly the person’s perception of a pair of spectacles happens when SPECTACLES becomes excited from the node groups NS-B… and NS-C… sufficiently to excite the attention synapse ATT-2.

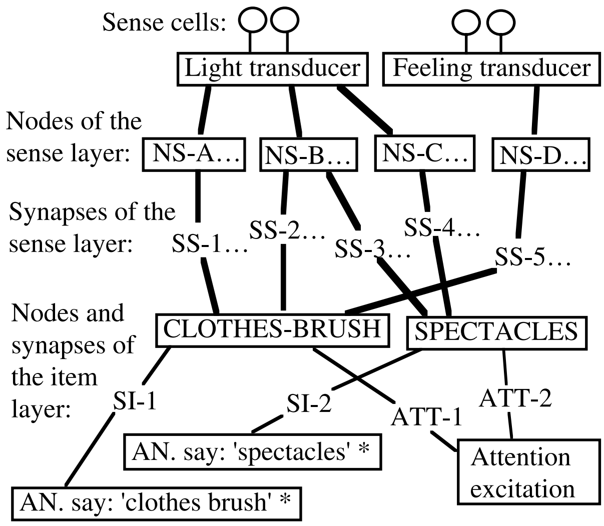

Fig. 6.5 Perceiving clothes-brush as spectacles

It should be kept in mind that the set of excitations of the nodes of the sense layer that achieve the actual perception of an item such as a clothes-brush normally will be different from one occasion of perception to another. The selection of the item actually perceived depends only on the sums of excitation arriving in the nodes of the item layer through such synapses as SS-1…, SS-2…, SS-3…, and SS-4….

Now consider perception when some of the nodes of the sense layer have been destroyed, in particular such that most of the nodes NS-A… fail to transfer excitations while the nodes NS-B… function normally. Then it may well happen that when a clothes-brush comes into view the sum of the excitations coming into SPECTACLES through NS-B…, SS-3…, NS-C…, and SS-3…, exceeds that of the excitations coming into CLOTHES-BRUSH through NS-B… and SS-2… As a result the attention synapse ATT-2 will become excited, contributing a strong excitation into SPECTACLES. This strong excitation will again give rise to visual imagination, through the synapses SS-3… and SS-4…. And so what the person will experience visually will be an imagined pair of spectacles.

By this explanation of the confused perception it is clear that the patient will perceive the thing in view as *another one that has some of the same visual features as the thing in view*. In other words, it will be expected that what James calls the ludicrous mistakes of the patient must be such that the things the patient confuses with each other must pairwise have certain visual features in common. This is confirmed by the three particular pieces of evidence given. A clothes-brush and a pair of spectacles are both oblong things of the same moderate size. An umbrella and a plant with flowers both have a vertical stem with an widening at the top. An apple and a portrait of a lady both appear as round reddish things.

It may be added that faulty visual perception happens quite often in normal people, sometimes deliberately. Overlooking a misprint while reading a text is one very common case. James gives details of another case [II 96]:

> *The Proof-reader's Illusion.* I remember one night in Boston, whilst waiting for a 'Mount Auburn' car to bring me to Cambridge, reading most distinctly that name upon the signboard of a car on which (as I afterwards learned) 'North Avenue' was painted. The illusion was so vivid that I could hardly believe my eyes had deceived me. All reading is more or less performed in this way.

Seeing 'the man in the Moon' and towers of castles in the clouds around the setting Sun are cases of deliberate faulty visual perception.

(5) In some cases of mental blindness, perception is achieved through the tactile sense, through touch. Of one of these cases James writes [I 51]:

> Where an object fails to be recognized by sight, it often happens that the patient will recognize and name it as soon as he touches it with his hand.

How this happens is clear from Fig. 6.5. The perception from touch depends on the nodes NS-D… and the synapses SS-5… and will happen independently of any destruction of the nodes that provide for perception by sight, such as NS-A….

Yet another case is described by James [I 40]:

> In other cases of which we shall say more a few pages later on, the patient can write both spontaneously and at dictation, but cannot *read* even what he has himself written! … [I 62] I must add a word about the connection of aphasia with the tactile sense. On p. 40 I spoke of those cases in which the patient can write but not read his own writing. He cannot read by his eyes, but he can read

by the feeling in his fingers, if he retrace the letters in the air. It is convenient for such a patient to have a pen in hand whilst reading in this way, in order to make the usual feeling of writing more complete. In such a case we must suppose that the path between the optical and the graphic centres remains open, whilst that between the optical and the auditory and articulatory centres is closed. Only thus can we understand how the look of the writing should fail to suggest the sound of the words to the patient's mind, whilst it still suggests the proper movement of graphic imitation. These movements in their turn must of course be felt, and the feeling of them must be associated with the centres for hearing and pronouncing the words.

This description is evidence that the patient, who in a previous normal state would perceive a piece of writing such as *Broca* before the eyes as signifying a subject, Broca, by an injury had lost this ability, but yet had retained an ability such that the writing before the eyes was sufficient for guiding his finger movements so as to perform all strokes of the writing, thereby achieving perception of the subject.

The neural embodiment of this case will be explained by Fig. 6.6. This is centered on the subject node BROCA and shows how in the normal person the perception of the subject Broca through sight when the text *Broca* comes into view is provided by the synapse set SS-5… that transfers excitations from the sense node set SCRIPT… into BROCA. It further shows how the habit of writing the word *Broca* by hand has been established as the action aggregate comprising the nodes AN: Write '*Broca*'*, *Broca2*, *Broca3*, etc. and the synapse sets SM-1…, SM-2…, SM-3…,…, and SS-1…, SS-2…,…. Thus when the action node AN: Write '*Broca*'* gets strongly excited the first pen stroke is performed by the muscles activated through the excitations of some of the nodes NM… through the synapse set SM-1…. The feelings produced in the fingers by this activation, suggested by the thick arrow, get transmitted as excitations through the Feeling transducer, some of the nodes NS…, and the synapse set SS-1…, into the node *Broca2*, from where they activate the second pen stroke. At each occasion when the writing of *Broca* has been in progress, the node BROCA will have been strongly excited and so each of the nodes AN: Write '*Broca*'*, *Broca2*, *Broca3*,… will have become connected to BROCA though conductive synapses, shown as SI-1, SI-2, SI-3,….

In the patient who cannot perceive the meaning of his own writing the nodes SCRIPT… must have become destroyed. However, the fact that the patient is still able to retrace by his fingers the writing before his eyes shows that there are other qualities of the sight of the writing *Broca* before his eyes that he *can* perceive, to wit the graphic qualities of the writing sensed, the way the sight consists of lines in certain arrangements. There must therefore be certain nodes, GRAPHIC…, that may transfer the corresponding excitations through the synapses SS-4… into AN: Write '*Broca*'*, and that are still intact in the patient.

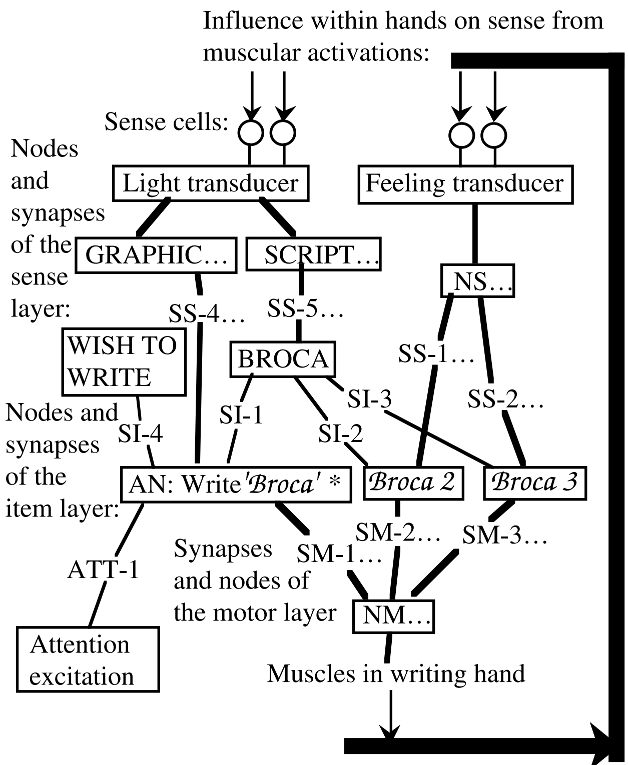

Fig. 6.6 Reading by pen stroke feelings

Now consider a moment when *Broca* is in the field of view of the patient, who is well aware that he cannot read what he sees, but who instead wishes to express it by means of motions of his fingers. This wish will be embodied in excitation of such a node as WISH TO WRITE, which in its turn transfers preexcitations into all action nodes that initiate hand writing. Among these nodes AN: Write '*Broca*'* is special as having already been excited from GRAPHIC…, and so this is the one to be excited also from its attention synapse, ATT-1. As the first effect of this excitation a number of the muscles in the writing hand are activated so as to do the first stroke of writing *Broca*, through the synapses SM-1… and the nodes NM…. This activation in the hand gets picked up by feeling sense cells, as suggested by the thick black arrow, and thereby gives rise to excitations of certain of the nodes NS…, and through the synapse set SS-1… to excitation of the node *Broca2*. This in its turn through SM-2… and NM… activates certain of the muscles in the hand, thereby effecting the second stroke of the pen. All this happens according to habits embodied in the states of the synapses SM-1…, SM-2…, SM-3…, etc., and SS-1…, SS-2…, etc. As a result the feelings in the hand will give rise to excitations of the nodes *Broca2*, *Broca3*, etc. in quick succession, as when the actual writing took place. The excitation of these nodes will be transmitted into the node BROCA through the synapses SI-1, SI-2, SI-3, etc. and so will excite BROCA strongly. The total effect will be like perceiving the writing *Broca* by the senses.

6.7 Impaired reactions of hearing and sound

James reports on the results of vivisectional investigations of the hearing in dogs and monkeys as follows [I 52]:

> *In the dog*, Luciani's diagram will show the regions which directly or indirectly affect it for the worse when injured. As with sight, one-sided lesions produce symptoms on both sides. … Of all the region, the temporal lobe is the most important part.

In describing hearing in *man*, one may distinguish between crude hearing on the one hand, and the linguistic use of hearing on the other. Concerning the complicated influence of impaired hearing upon speech, James's explanation is so clear and explicit that it is possible to identify the neural embodiment of every item of it in terms of the synapse-state theory. This is represented in the following quotation by adding the designation as it is shown in Fig. 6.7, of each neural item referred to in James's description. The figure shows how the perception of a namable X, embodied in excitation of the node NAMABLE X, may have its source in VISUAL SCRIPT QUALITIES… through the synapses SS-3…, in VISUAL NON-SCRIPT QUALITIES… through the synapses SS-6…, in SPEECH SOUNDS… through the synapses SS-1…, and in TACTILE QUALITIES… through the synapses SS-7…. The name X is spoken when the node Action node, say 'X'* is excited strongly.

With insertion of the references to Fig. 6.7 James writes [I 53]:

> *In man* the temporal lobe is unquestionably the seat of the hearing function (node sets SPEECH SOUNDS… and NON-SPEECH SOUNDS…), and the superior convolutions adjacent to the sylvian fissure is its most important part. The phenomena of aphasia show this. We studied motor aphasia a few pages back; we must now consider *sensory aphasia.* Our knowledge of this disease has had three stages: we may talk of the period of Broca, the period of Wernicke, and the period of Charcot. What Broca's discovery was we have seen. Wernicke was the first to discriminate those cases in which the patient can *not even understand* speech from those in which he can understand, only not talk; and to ascribe the former condition to lesion of the temporal lobe. (Der aphasische Symptomencomplex (1874). See in Fig. 6.1 the convolution marked WERNICKE.) The condition in question is *word-deafness,* and the disease is *auditory aphasia.* The latest statistical survey of the subject is that by Dr. Allen Starr (The Pathology of Sensory Aphasia, 'Brain', July 1889). In the seven cases of *pure* word-deafness which he has collected, cases in which the patient could read, talk, and write, but not understand what was said to him, the lesion was limited to the first and second temporal convolutions in their posterior two thirds. The lesion (in right-handed, i.e. left-brained, persons) is always on the left side, like the lesion in motor aphasia. Crude hearing would not be abolished, even were the left centre for it utterly destroyed; the right centre would still provide for that. But the *linguistic use* of hearing appears bound up with the integrity of the left centre more or less exclusively.

Here it must be that the words heard (SPEECH SOUNDS…) enter into association with the things which they represent (SS-…1), on the one hand, and with the movements necessary for pronouncing them (Action node, say 'X'* through SS-2…), on the other.

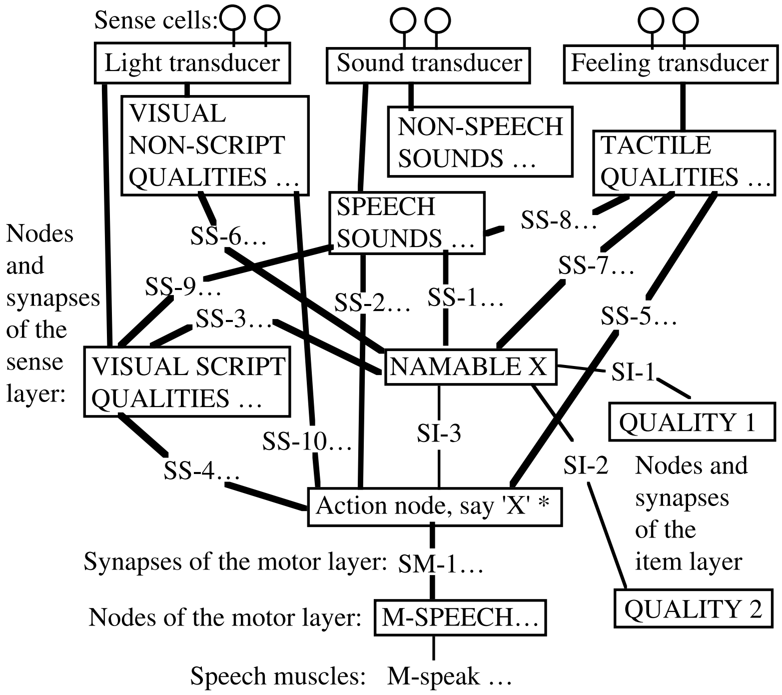

Fig. 6.7 Embodiment of sensory aphasia

Thus in pure word-deafness the node set SPEECH SOUNDS…, located on the left side, and none other has been destroyed. James continues:

> In the large majority of Dr. Starr's fifty cases, the power either to name objects or to talk coherently was impaired. This shows that in most of us (as Wernicke said) speech must go on from auditory cues; that is, it must be that our ideas (NAMABLE X) do not innervate our motor centres directly (through SI-3), but only after first arousing the mental sound of the words (via SS-1… and SS-2…). This is the immediate stimulus to articulation; and where the possibility of this is abolished by the destruction of its usual channel in the left temporal lobe (the set of nodes SPEECH SOUNDS…), the articulation must suffer. In the few cases in which the channel is abolished with no bad effect on speech we must suppose an idiosyncrasy. The patient must innervate his speech-organs (Action node, say 'X'*) either from the corresponding portion of the other

hemisphere or directly from the centres of ideation, those, namely, of vision (SS-3… and/or SS-4…), touch (SS-5…), etc., without leaning on the auditory region (SPEECH SOUNDS…). It is the minuter analysis of the facts in the light of such individual differences as these which constitute Charcot's contribution towards clearing up the subject.

> Every namable thing, act, or relation (NAMEABLE X) has numerous properties, qualities, or aspects. In our minds the properties of each thing (QUALITY 1, QUALITY 2), together with its name (Action node, say 'X'*), form an associated group (through SI-1, SI-2, SI-3,…). If different parts of the brain are severally concerned with the several properties, and a farther part with the hearing, and still another with the uttering, of the name, there must inevitably be brought about (through the law of association which we shall later study) such a dynamic connection (conductivity of synapses) amongst all these brain-parts that the activity of any one of them will be likely to awaken the activity of all the rest. When we are talking as we think, the *ultimate* process is that of utterance. If the brain-part for *that* (excitation of M-SPEECH…) be injured, speech is impossible or disorderly, even though all the other brain-parts be intact: and this is just the condition of things which, on page 37, we found to be brought about by limited lesion of the left inferior convolution. But back of that last act various orders of succession are possible in the associations of a talking man's ideas. The more usual order seems to be from the tactile (SS-8…), visual (SS-9…), or other properties of the things thought-about to the sound of their names (SPEECH SOUNDS…), and then to the latter's utterance (SS-2…). But if in a certain individual the thought of the *look* of an object or of the *look* of its printed name be the process which habitually precedes articulation (transferred through SS-10… or SS-4…), then the loss of the *hearing* centre (SPEECH SOUNDS…) will *pro tanto* not affect that individual's speech. He will be mentally deaf, i.e. his *understanding* of speech will suffer, but he will not be aphasic. In this way it is possible to explain the seven cases of *pure* word-deafness which figure in Dr. Starr's table.
>
> If this order of association be ingrained and habitual in that individual, injury to his *visual* centres (VISUAL SCRIPT QUALITIES… and VISUAL NON-SCRIPT QUALITIES…) will make him not only word-blind, but aphasic as well. His speech will be confused in consequence of an occipital lesion. Naunyn, consequently, plotting out on a diagram of the hemisphere the 71 irreproachably reported cases of aphasia which he was able to collect, finds that the lesions concentrate themselves in three places: first, on Broca's centre; second, on Wernicke's, third, on the supra-marginal and angular gyri under which those fibres pass which connect the visual centres with the rest of the brain (see Fig. 6.1). With this result Dr. Starr's analysis of purely sensory cases agrees.

Thus in summary of the present subsection, the individually different forms of sensory aphasia may be completely understood to arise from impairment of the SPEECH SOUND… nodes of the sense layer as these impairments interact with individually different sets of habits of speech muscle activation.

7. Non-sensual experience and alternating mental states

Non-sensual experience is experience that a person may have that is not dependent upon impressions on sense cells. Experience of *imagery* and of *dreams* are examples.

Alternating mental states is a matter of changes of the mental state that involve changes of the person's set of responses to, and experience of, sense impressions, the responses that have been trained as habits during the person's previous life. Such alternations of mental states vary from one person to another. Persons may enter into a certain alternate state temporarily and then come back into their ordinary state for a duration and in a manner that varies from one person to another. The most common alternations are the transitions from being awake into *sleep* and between *dreamless sleep* and *dreaming*. Other relevant mental states are commonly described under the headings *hypnotic trances* and *multiple selves*.

Non-sensual experience and alternating mental states are usually described in terms of categories under denotations such as delusions, illusions, insanity, madness, etc. and often happen together, as aspects of the same phenomenon of mental life. But as said by James [I 375] 'our knowledge of the elements and causes of these changes of personality is so slight that the division into types must not be regarded as having any profound significance.' For this reason the account in the present chapter of the neural embodiments of non-sensual experience and of alternate mental states will mainly be based on descriptions of individual cases.

7.1 Sleep and dreaming

The state of sleep is experienced recurrently by anyone. Dreams are probably experienced by all people during many nights of sleep, and so, like the stream of thought, are considered so obvious that those who talk about dreams tend to neglect to present purely descriptive accounts of what dreams are like, but immediately turn to some kind of interpretation of the dream experience. This holds even for James whose main account of dreams is in a footnote [II 283]:

> CHAPTER XXL. THE PERCEPTION OF REALITY. … [II 293] THE WORLD OF 'PRACTICAL REALITIES' … [II 294]: *The world of dream is our real world whilst we are sleeping, because our attention then lapses from the sensible world. Conversely, when we wake the attention usually lapses from the dream-world and that becomes unreal. But if a dream haunts us and compels our attention during the day it is very apt to remain figuring in our consciousness as a sort of sub-universe alongside of the waking world. Most

people have probably had dreams which it is hard to imagine not to have been glimpses into an actually existing region of being, perhaps a corner of the 'spiritual world.' And dreams have accordingly in all ages been regarded as revelations, and have played a large part in furnishing forth mythologies and creating themes for faith to lay hold upon. The 'larger universe,' here, which helps us to believe both in the dream and in the waking reality which is its immediate reductive, is the *total* universe, of Nature *plus* the Supernatural. The dream holds true, namely, in one half of that universe; the waking perceptions in the other half. Even to-day dream-objects figure among the realities in which some 'psychic-researchers' are seeking to rouse our belief. All our theories, not only those about the supernatural, but our philosophic and scientific theories as well, are like our dreams in rousing such different degrees of belief in different minds.

In this account by James one may note particularly his saying that 'Even to-day dream-objects figure among the realities in which some 'psychic-researchers' are seeking to rouse our belief.' Little did James foresee that a few years later, in 1899, Sigmund Freud would publish his *Traumdeutung* and thereby as a new 'psychic-researcher' launch his theories of the 'unconscious' that haunted psychology for several generations. As a result any talk of dreams became completely polluted by Freudian notions of mysterious agencies, such as complexes.

In the context of explaining hypnotic trance, James makes one further remark about dreams [II 593]:

CHAPTER XXVII. HYPNOTISM. …[II 601] THE SYMPTOMS OF THE TRANCE. … [II 602] In the earlier stages of hypnotism the patient remembers what has happened, but with successive sittings he sinks into a deeper condition, which is commonly followed by complete loss of memory. He may have been led through the liveliest hallucinations and dramatic performances, and have exhibited the intensest apparent emotion, but on waking he can recall nothing at all. The same thing happens on waking from sleep in the midst of a dream—it quickly eludes recall. But just as we may be *reminded* of it, or of parts of it, by meeting persons or objects which figured therein, so on being adroitly prompted, the hypnotic patient will often remember what happened in his trance. One cause of the forgetfulness seems to be the disconnection of the trance performances with the system of waking ideas. Memory requires a continuous train of association. …

Lacking published descriptive accounts of dream to build upon I shall describe what my own dreams are like. A typical dream, as it may come to me in the early morning when I have already been half awake, is a follows: I experience myself in a situation in a place of some kind of gathering or conference, at a moment when the program of the gathering is approaching its end and the attention is turned to the journey back to home. This raises some problems of the available means of transportation—ferries, of their time tables and of the way how to get to them, producing feelings of uncertainty and concern. Little happens during the dream, mostly vague and unresolved inquiries.

What I experience while having this dream is partly some vague visual images of buildings and landscape, but mostly strong feelings, partly of the character of the situation, being at the end of some gathering, partly, and in particular, of the unsolved problem of how to arrange for the required transportation.

In another recurrent kind of dream I am a young person and am about to attend a particular lesson at school, but I am not well prepared for that lesson since I have not gotten hold of the schoolbook. Again my dream experiences are only vaguely visual and are dominated by strong feelings of the situation and of my own inadequacy in it.

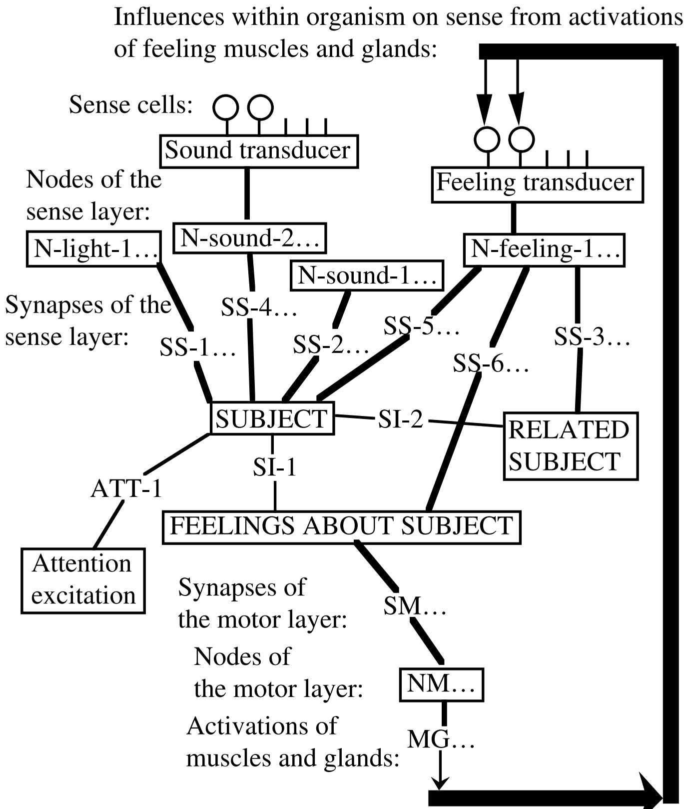

Fig. 7.1 Neural excitations in dreaming

The neural mechanism of dreams will be described in terms of the synapse-state theory with the aid of Fig. 7.1. During dreamless sleep there will be a constant activity of brief and slight excitations of some of the nodes of the item layer from whatever sense impressions impinge on the sense cells. Being slight and brief these excitations will not produce any experience. The experience of the dream will begin when during this activity some node of the item layer, shown as SUBJECT, by some sense impressions, assumed to be by the hearing of some sound transferred through the nodes N-sound-2... and the synapses SS-4..., excite SUBJECT sufficiently to excite its attention synapse ATT-1. This excitation will differ from the excitations of other nodes of the item layer during dreamless sleep only by happening to be stronger.

The excitation of SUBJECT will generate experience of the same kind as what I have when I imagine the subject. This experience is generated by the excitations of such nodes of the sense layer as N-light-1..., N-sound-1..., and N-feeling-1..., transferred through the synapses SS-1..., SS-2..., and SS-5.... Thus this experience will be similar to that of imagination, that is mostly vague and faint.

The excitation of SUBJECT may also lead to excitation of associated quality nodes, such as FEELINGS ABOUT SUBJECT, and thereby, through the path SM..., NM..., MG..., organic influence, sense cells, Feeling transducer, N-feeling-1..., to further generation of experience of feelings.

These excitations may additionally give rise to excitation through SI-2 and the synapse set SS-3... of nodes embodying other subjects associated to the subject, such as RELATED SUBJECT. By this mechanism there will be a development of the neural state such that the attention will circulate among such nodes of the item layer that are associated to the first subject and have strong feelings associated with them.

This description of the way dreams come to be is confirmed by the common experience that many dreams start from a sudden strong sense impression which is not perceived as it would be in a wake state but instead triggers a dream.

By this explanation of dreams, the dream experience will in each individual be similar in quality to that of imagery, which, as found by Galton and reported by James, differs greatly among individuals. I am not aware that anyone has tried to investigate the similarity of dreams and imagery empirically.

7.2 Hypnotic trance

The circumstances of the mental states of 'hypnotic,' 'mesmeric,' or 'magnetic' trance, are described by James [II 593]:

> CHAPTER XXVII. HYPNOTISM. MODES OF OPERATING, AND SUSCEPTIBILITY. The 'hypnotic,' 'mesmeric,' or 'magnetic' trance *can be induced in various ways,* each operator having his pet method. The simplest one is to leave the subject seated by himself, telling him that if he close his eyes and relax his muscles and, as far as possible, think of a vacancy, in a few minutes he will 'go off.' On returning in ten minutes you may find him effectually hypnotized. Braid used to make his subjects look at a bright button held near their forehead until their eyes spontaneously closed. The older mesmerists made 'passes' in a downward direction over the face and body, but without contact. Stroking the skin of the head, face, arms and hands, especially that of the region round the brows and eyes, will have the same effect. ... [II 595] Children under three or four, and insane persons, especially idiots, are unusually hard to hypnotize. This seems due to the impossibility of getting them to fix their attention continuously on the idea of the coming trance. A certain amount of mental training, sufficient to aid concentration of

the attention, seems a favorable condition, and so does a certain momentary indifference or passivity as to the result. … [II 601]

THE SYMPTOMS OF THE TRANCE. … [II 602] First of all comes *amnesia*. In the earlier stages of hypnotism the patient remembers what has happened, but with successive sittings he sinks into a deeper condition, which is commonly followed by complete loss of memory. He may have been led through the liveliest hallucinations and dramatic performances, and have exhibited the intensest apparent emotion, but on waking he can recall nothing at all. The same thing happens on waking from sleep in the midst of a dream—it quickly eludes recall. But just as we may be *reminded* of it, or of parts of it, by meeting persons or objects which figured therein, so on being adroitly prompted, the hypnotic patient will often remember what happended in his trance. One cause of the forgetfulness seems to be the disconnection of the trance performances with the system of waking ideas. Memory requires a continuous train of association. … [II 602]

Suggestibility. The patient believes everything which his hypnotizer tells him, and does everything which the latter commands. … [II 603]

Effects on the voluntary muscles seem to be those most easily got … Tell the patient that he cannot open his eyes or his mouth … and he will be immediately smitten with absolute impotence in these regards. The effect here is generally due to the *involuntary contraction* of antagonizing muscles. … [II 604]

Hallucinations of all the senses and *delusions* of every conceivable kind can be easily suggested to good subjects. The emotional effects are then often so lively, and the pantomimic display so expressive, that it is hard not be believe in a certain 'psychic hyper-excitability,' as one of the concomitants of the hypnotic condition. … [II 606]

Real sensations may be abolished as well as false ones suggested.… [II 609]

Hyperæsthesia of the senses is as common a symptom as anæsthesia. On the skin two points can be discriminated at less than the normal distance. …

By the synapse-state theory, the symptoms of the hypnotic trance may be understood to come about as a result of excitations of response habit nodes. Details of the way the hypnotic trance is induced will be explained in terms of Fig. 7.2. In this figure the response habit node NORMAL is supposed to be the one excited in the person's state of normal responses to the sense impressions of light and sound in the situation when the operator takes over.

The disciplines of induction of the trance described by James may be understood as aiming at making such a response habit node as NORMAL in the subject become unexcited, from lack of such excitations that normally come from sensations and from attention to subjects. NORMAL is seen to become excited from certain light impressions through the synapses SS-2… and from certain sound impressions through the synapses SS-3…. NORMAL is kept continuously excited for the duration of the specious present from the node SPEC-NORMAL. NORMAL transmits preperception excitation into PENCIL through SI-1. When in a normal mental state a pencil comes into sight, the nodes NS-1… get excited from the light transducer and so the experience of seeing the pencil is produced. When the neural system has been educated so as to recognize pencils by sight, the synapses SS-1… will have become conductive, and so the sight of a pencil will give rise to a summation of excitations into PENCIL so as to excite also ATT-pencil. So the pencil will not only be sensed but also perceived, bringing about the excitation of its fringe, such as YELLOW, through SI-2.

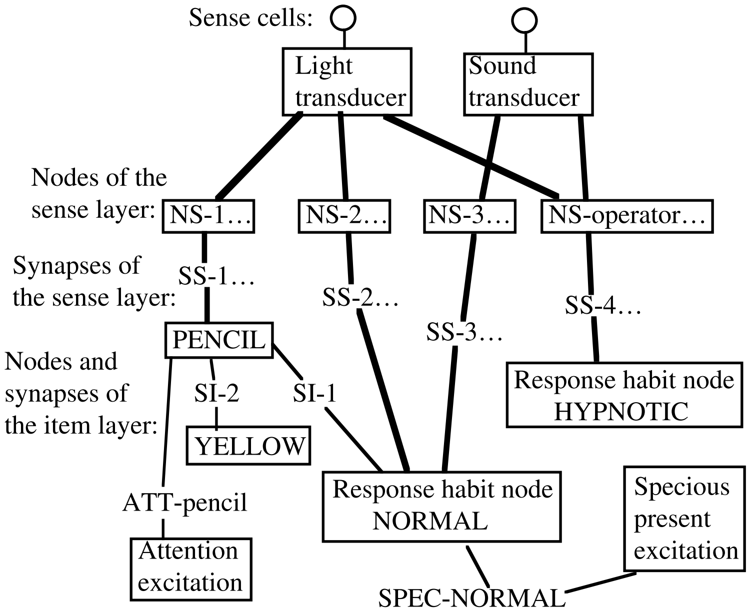

Fig. 7.2 Inducing the hypnotic trance

When as a result of the subject's deliberate ignoring the ordinary sense impressions from the environment the node NORMAL ceases to be excited, the subject will get into a state of non-responsiveness to the ordinary sense impressions in the situation, in the sense that although they are experienced, none of the habitual perceptions will happen. This is the state of hypnotic trance.

The first time the subject gets into this state the operator will then by suitable behavior, such as words spoken and movements done, establish a new response habit node, HYPNOTIC, which will thereafter be excited by the sense impressions coming from the operator, his words, his looks, the movements of his hands, etc. The sense impressions received from the operator will be experienced in the usual way, but the perceptions, that is the subject and quality nodes excited by the sense impressions will be new and will take on the properties dictated by the operator. Thus the responses in the state of hypnotic trance will be established in the usual way, by training. This will be taken care of by the operator, who in this way gets a dominating influence upon the person's reactions in the state of trance.

Reflex reactions will be unaffected. This explains that as said by James [II 605]:

> Subjects in this condition will receive and execute suggestions of crime, and act out a theft, forgery, arson, or murder. A girl will believe that she is married to her hypnotizer, etc. It is unfair, however, to say that in these cases the subject is a pure puppet with no spontaneity. His spontaneity is certainly not in abeyance so far as thing go which are harmoniously associated with the suggestion given to him. He takes the text from his operator; but he may amplify and develop it enormously as he acts it out. His spontaneity is lost only for those systems of ideas which *conflict* with the suggested delusion. In extreme cases the rest of the mind would seem to be actually abolished and the hypnotic subject to be literally a changed personality, a being in one of those 'second' states which we studied in Chapter X. But the reign of the delusion is often not as absolute as this. If the thing suggested be too intimately repugnant, the subject may strenuously resist and get nervously excited in consequence, even to the point of having an hysterical attack.

The effects of suggestibility, including voluntary muscular activity, in the hypnotic trance, may be explained as follows. Submitting to suggestions is a normal feature of mental life. In normal situations the typical reactions to requests such as 'Give me …' or 'Tell me …' are to engage on the action suggested. In neural terms, in the normal situation the corresponding urge nodes are preexcited, and so will become strongly excited when a request is sensed. Thus all the verbal signs of request will normally be obeyed. When they are not it is because there are conflicting requests active in the person's nervous system at the same time.

In submitting to the operator's treatment the patient in hypnotic trance has deliberately accepted to obey the operator's suggestions. In neural terms, nodes in the person's nervous system embodying conflicting concerns are not preexcited.

Hallucinations suggested by the operator are produced as submission to the suggestion of the imagery.

Hyperæsthesia of the senses shall be explained by an example, in terms of Fig. 7.3. Consider for example the feeling of pain that is produced by certain influences upon the right index finger of the person, such as pressing or pricking with a needle. By the normal education of the nervous system such pains that have been experienced by the person have given rise to the establishment of a quality node, call it PAIN ON RIGHT INDEX. This node will be excited through conductive synapses SS-1, SS-2, SS-3, and SS-4, from certain sense nodes of the sense layer, NS-1, NS-2, NS-3, and NS-4, that is from certain feelings and light impressions. PAIN ON RIGHT INDEX will also receive preexcitation from the response habit node NORMAL. As a result any of a number of different sense impressions on sight or feeling, for example such that excite node NS-1, will result in excitation of one and the same quality node PAIN ON RIGHT INDEX. When this gets strongly excited from its attention synapse ATT-PAIN it will give rise to excitations of the nodes NS-2, NS-3, and NS-4, as imagery. Consequently a sense impression upon any of these nodes of the sense layer will give rise to experience of the excitation of them all.

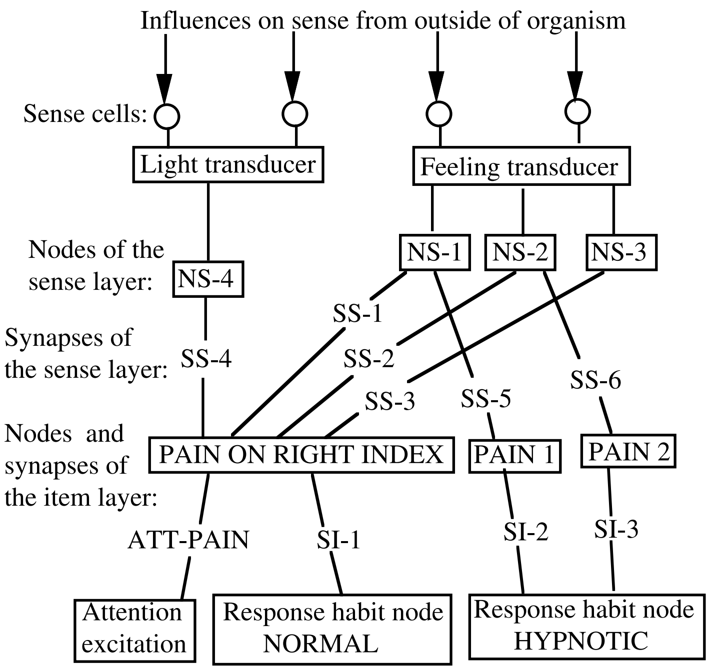

Fig. 7.3 Hyperæsthesia of touch in hypnotic trance

Consider now the corresponding reaction in the hypnotic state. In this state NORMAL is not excited, and so PAIN ON RIGHT INDEX receives no preexcitation. When a sense impressions excites a node of the sense layer such as NS-1 this may give rise to the education of a quality node, PAIN 1. This will become educated to receive preexcitation from HYPNOTIC. Similarly excitation of NS-2 will educate a node PAIN 2. But the two experiences of the impressions will remain separate.

7.3 Mutations of the self and multiple selves

Certain alternations of mental states are related to the self. They are described by James as follows [I 291]:

> CHAPTER X. THE CONSCIOUSNESS OF SELF. … [I 373] THE MUTATIONS OF THE SELF may be divided into two main classes: 1. Alterations of memory; and 2. Alterations in the present bodily and spiritual selves. … [I 375] When we pass … to abnormal *alterations in the present self* we have still graver disturbances. These alterations are of three main types, from the descriptive point of view. But certain cases unite features of two or more types; and our knowledge of the elements and causes of these changes of personality is so slight that the division into types must not be regarded as having any

> profound significance. The types are: (1) Insane delusions; (2) Alternating selves; (3) Mediumships or possessions.

In the section on Insane delusions James quotes a report on a case of a person experiencing two different personal identities [I 379]:

> The woman, Bridget F., "has been many years insane, and always speaks of her supposed self as 'the rat,' asking me to 'bury the little rat,' etc. Her real self she speaks of in the third person as 'the good woman,' saying, 'The good woman knew Dr. F. and used to work for him,' etc. Sometimes she sadly asks: 'Do you think the good woman will ever come back?' She works at needlework, knitting, laundry, etc., and shows her work, saying, 'Isn't that good for only a rat?' She has, during periods of depression, hid herself under buildings, and crawled into holes and under boxes. 'She was only a rat, and wants to die,' she would say when we found her."

From this very brief description one may well get the impression that the rat identity is originally deliberately adopted by the person, as a convenient solution of some personal problems. Later the person supports and keeps up the delusion by such performances as are mentioned.

One may question whether not all delusions are of this kind. The person will of course defend his or her adopted view of themselves. This is just in the same way as people will defend their political, religious, and philosophical, views. In such contexts evidence counts for nothing.

In the section on *alternating personality* James quotes a report on a case of a person alternating between two different personal identities [I 379]:

> The most famous case, perhaps, on record is that of Fèlida X., reported by Dr. Azam of Bordeaux. At the age of fourteen this woman began to pass into a 'secondary' state characterized by a change in her general disposition and character, as if certain 'inhibitions,' previously existing, were suddenly removed. During the secondary state she remembered the first state, but on emerging from it into the first state she remembered nothing of the second. At the age of forty-four the duration of the secondary state (which was on the whole superior in quality to the original state) had gained upon the latter so much as to occupy most of her time. During it she remembers the events belonging to the original state, but her complete oblivion of the secondary state when the original state recurs is often very distressing to her, as, for example, when the transition takes place in a carriage on her way to a funeral, and she hasn't the least idea which one of her friends may be dead. She actually became pregnant during one of her early secondary states, and during her first state had no knowledge of how it had come to pass. Her distress at these blanks of memory is sometimes intense and once drove her to attempt suicide.

This description gives too few details of the mental states of the case to support an account of the case in terms of the synapse-state theory. A more adequate description follows [I 381]:

> Another remarkable case is that of Mary Reynolds, lately republished again by Dr. Weir Mitchell. This dull and melancholy young woman, inhabiting the Pennsylvania wilderness in 1811, was found one morning, long after her habitual time for rising, in a profound sleep from which it was impossible to arouse her. After eighteen or twenty hours of sleeping she awakened, but in a state of unnatural consciousness. Memory had fled. To all intents and purposes she was as a being for the first time ushered into the world. "All of the past that remained to her was the faculty of pronouncing a few words, and this seems to have been as purely instinctive as the wailings of an infant; for at first the words which she uttered were connected with no ideas in her mind." Until she was taught their significance they were unmeaning sounds. Her eyes were virtually first time opened upon the world. Old things had passed away; all things had become new. Her parents, brothers, sisters, friends, were not recognized or acknowledged as such by her. She had never seen them before,—never known them,—was not aware that such persons had been. … To the scenes by which she was surrounded she was a perfect stranger. … She had not the slightest consciousness that she had ever existed previous to the moment in which she awoke from that mysterious slumber. … The first lesson in her education was to teach her by what ties she was bound to those by whom she was surrounded, and the duties devolving upon her accordingly. This she was very slow to learn … The next lesson was to re-teach her the arts of reading and writing. She was apt enough, and made such rapid progress in both that *in a few weeks* she had readily relearned to read and write … The next thing that is noteworthy is the change which took place in her disposition. Instead of being melancholy she was now cheerful to extremity. Instead of being reserved she was buoyant and social. … Thus it continued for five weeks, when one morning, after a protracted sleep, she awoke and was herself again. … She now had all the knowledge that she had possessed in her first state previous to the change, still fresh and in as vigorous exercise as though no change had been. But any new acquisitions she had made, and any new ideas she had obtained, were lost to her now—yet not lost, but laid up out of sight in safe-keeping for future use. … These alternations from one state to another continued at intervals of varying length for fifteen or sixteen years, but finally ceased when she attained the age of thirty-five or thirty-six, leaving her *permanently in her second state.* In this she remained without change for the last quarter of a century of her life.

The case Mary Reynolds will here be accounted for in terms of the neural description of Fig. 7.4. This shows in particular the response habit node RESPONSE HABIT A which is here understood to be the crucial component in the alternations of her personality.

From the characterization of Mary Reynolds as a 'dull and melancholy young woman, inhabiting the Pennsylvania wilderness' we must be justified in assuming that her range of experience has been severely limited, so that only a few response habit aggregates will have been formed in her brain. In particular it will be assumed that the preexcitations of the actions nodes of writing and of the subject nodes of her relations and friends, such as the nodes JANE, SISTER, and AN: say 'Jane'*, have all been taken care of by one single response habit node, RESPONSE HABIT A. This node will also have excited a quality node GLOOMY, which through the path SM-1…, NM-1…, M-gloomy…, organic influence into sense cells, Feeling transducer, will excite the nodes of the set GLOOMY FEELING… that by their excitation produce the feeling of gloominess in the person. RESPONSE HABIT A will have been excited by a great variety of sense impressions, of which only the path from the Light transducer through the sets NS-3… and SS-5… has been shown in the figure.

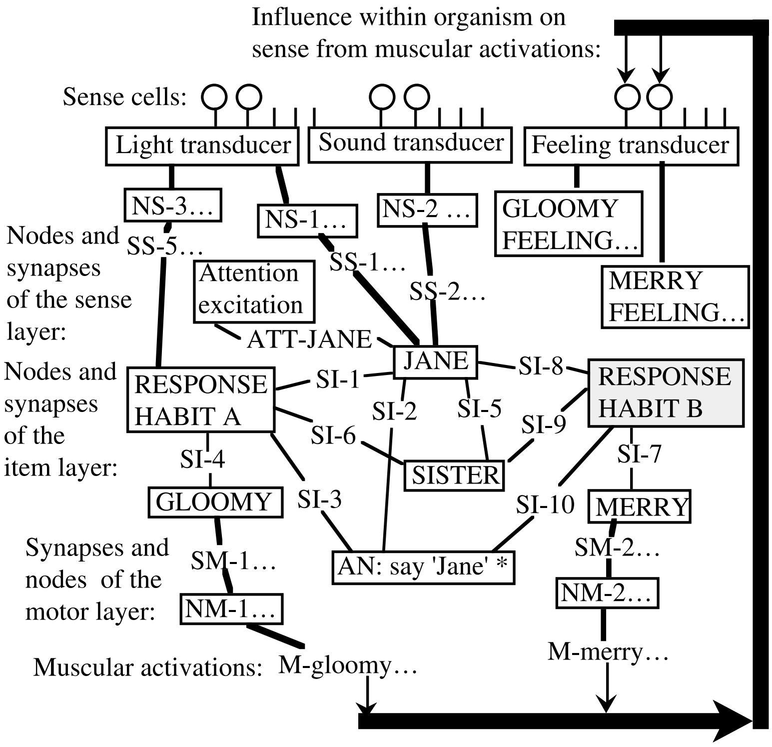

Fig. 7.4 The alternating personality of Mary Reynolds

By the synapse-state theory the alteration of Mary Reynolds's mental state during her long sleep has been caused by some organic influence, perhaps infection, which has made parts of the brain tissue, in particular the node RESPONSE HABIT A, inactive. As a consequence the responses to the sense impressions of the person's daily life fail to excite the habitual subject and quality nodes. For example, even if the sight of the person Jane will excite the node set NS-1… and through the synapse set SS-1… transmit excitations into the subject node JANE, when the excitation from RESPONSE HABIT A through SI-1 is not forthcoming JANE will fail to become sufficiently strongly excited to excite its attention synapse ATT-JANE, and so the person will fail to perceive the person Jane, with all that implies of the excitation of its fringe.

The development of Mary Reynolds's mental state subsequent to the alternation may then be understood to be the effect of the education of a new response habit node, RESPONSE HABIT B. This education consists of the plastic development of the conductivities of a number of synapses. By this education synapses such as SI-8 and SI-9, connecting this node to the subject and quality nodes of the ordinary sense impressions, JANE and SISTER, will gradually become more conductive.

The person's predominant mood in the alternate state will become determined by what quality node happens to be excited at the moment when RESPONSE HABIT B is first excited. Her mood in the alternate state is described as merry and jocose. So RESPONSE HABIT B has become associated, through SI-7, to a quality node MERRY which through the path SM-2…, NM-2…, M-merry, organic connection, Feeling transducer, SS-4…, will excite the node set MERRY FEELING…, giving rise to the experience of merriment.

The reeducation of her ability to write 'in a few weeks' is understandable. When only the response habit node is incapacitated the action aggregates of the writing actions are intact and will produce the proper movements of the hand as soon as they receive the initial excitations of their first nodes. Thus as soon as RESPONSE HABIT B and its preactivation of JANE through SI-8 has been well established, the excitation of JANE from sense impressions, that is through the paths NS-1…, SS-1… and/or NS-2…, SS-2…, will contribute excitations into AN: say 'Jane" through SI-2. When excitations from other nodes are also received the core-phrase 'Jane' will be spoken.

One case of alternating personality has been know to William James by personal acquaintance. James writes [I 391]:

> The Rev. Ansel Bourne, of Greene, R. I., was brought up to the trade of a carpenter; but, in consequence of a sudden temporary loss of sight and hearing under very peculiar circumstances, he became converted from Atheism to Christianity just before his thirtieth year, and has since that time for the most part lived the life of an itinerant preacher. He has been subject to headaches and temporary fits of depression of spirits during most of his life, and has had a few fits of unconsciousness lasting an hour or less. He also has a region of somewhat diminished cutaneous sensibility on the left thigh. Otherwise his health is good, and his muscular strength and endurance excellent. He is of a firm and self-reliant disposition, a man whose yea is yea and nay, nay; and his character for uprightness is such in the community that no person who knows him will for a moment admit the possibility of his case not being perfectly genuine.
>
> On January 17, 1887, he drew 551 dollars from a bank in Providence with which to pay for a certain lot of land in Greene, paid certain bills, and got into a Pawtucket horse-car. This is the last incident which he remembers. He did not return home that day, and nothing was heard of him for two months. He was

published in the papers as missing, and foul play being suspected, the police sought in vain his whereabouts. On the morning of March 14th, however, at Norristown, Pennsylvania, a man calling himself A. J. Brown, who had rented a small shop six weeks previously, stocked it with stationery, confectionery, fruit and small articles, and carried on his quiet trade without seeming to any one unnatural or eccentric, woke up in a fright and called in the people of the house to tell him where he was. He said that his name was Ansel Bourne, that he was entirely ignorant of Norristown, that he knew nothing of shop-keeping, and that the last thing he remembered—it seemed only yesterday—was drawing the money from the bank, etc., in Providence. He would not believe that two months had elapsed. The people of the house thought him insane; and so, at first, did Dr. Louis H. Read, whom they called in to see him. But on telegraphing to Providence, confirmatory messages came, and presently his nephew, Mr. Andrew Harris, arrived upon the scene, made everything straight, and took him home. He was very weak, having lost apparently over twenty pounds of flesh during his escapade, and had such a horror of the idea of the candy-store that he refused to set foot in it again.

The first two weeks of the period remained unaccounted for, as he had no memory, after he had once resumed his normal personality, of any part of the time, and no one who knew him seems to have seen him after he left home. The remarkable part of the change is, of course, the peculiar occupation which the so-called Brown indulged in. Mr. Bourne has never in his life had the slightest contact with trade. 'Brown' was described by the neighbors as taciturn, orderly in his habits, and in no way queer. He went to Philadelphia several times; replenished his stock; cooked for himself in the back shop, where he also slept; went regularly to church; and once at a prayer-meeting made what was considered by the hearers a good address, in the course of which he related an incident he had witnessed in his natural state of Bourne.

This was all that was known of the case up to June 1890, when I induced Mr. Bourne to submit to hypnotism, so as to see whether, in the hypnotic trance, his 'Brown' memory would not come back. It did so with surprising readiness; so much so indeed that it proved quite impossible to make him whilst in the hypnosis remember any of the facts of his normal life. He had heard of Ansel Bourne, but "didn't know as he had ever met the man." When confronted with Mrs. Bourne he said that he had "never seen the woman before," etc. On the other hand, he told of his peregrinations during the lost fortnight, and gave all sorts of details about the Norristown episode. The whole thing was prosaic enough; and the Brown-personality seems to be nothing but a rather shrunken, dejected, and amnesic extract of Mr. Bourne himself. He gives no motive for the wandering except that there was 'trouble back there' and he 'wanted rest.' During the trance he looks old, the corners of his mouth are drawn down, his voice is slow and weak, and he sits screening his eyes and trying vainly to remember what lay before and after the two months of the Brown experience. "I'm all hedged in," he says: "I can't get out at either end. I don't know what set me down in that Pawtucket horse-car, and I don't know how I ever left that

> store, or what became of it." His eyes are practically normal, and all his sensibilities (save for tardier response) about the same in hypnosis as in waking. I had hoped by suggestion, etc., to run the two personalities into one, and make the memories continuous, but no artifice would avail to accomplish this, and Mr. Bourne's skull to-day still covers two distinct personal selves.
>
> The case (whether it contain an epileptic element or not) should apparently be classed as one of spontaneous hypnotic trance, persisting for two months. The peculiarity of it is that nothing else like it ever occurred in the man's life, and that no eccentricity of character came out.

By the care with which this case is presented by William James, and by the complications of the case, involving both spontaneous alterations and alterations provoked by hypnotic influence, this description is valuable evidence of alternations of mental life. Thus as one important general issue, the case presents strong empirical evidence that hypnotic trances and altered personalities come about from the same neural mechanisms.

For all its clarity James's report calls for some interpretation, so as to remove certain inconsistencies. One inconsistency is indicated by the statement saying:

> 'The remarkable part of the change is, of course, the peculiar occupation which the so-called Brown indulged in. Mr. Bourne has never in his life had the slightest contact with trade.'

This statement cannot be accepted at face value, since it is also said that Bourne was brought up to the trade of a carpenter, and moreover:

> He said that his name was Ansel Bourne, that he was entirely ignorant of Norristown, that he knew nothing of shop-keeping, and that the last thing he remembered—it seemed only yesterday—was drawing the money from the bank, etc., in Providence.

These statements can only be reconciled on the assumption that the Bourne personality is ignorant of any circumstance related to the Brown personality, and so cannot pronounce validly on any of the Brown personality's engagements in the past.

Plausibly the Brown personality had in the past been engaged in and obtained experience in trade. Most likely the main alternation from the Brown to the Bourne personality is what is described in the words: 'in consequence of a sudden temporary loss of sight and hearing under very peculiar circumstances, he became converted from Atheism to Christianity just before his thirtieth year'. In this explanation, which must originate in the Bourne personality, it seems safe to assume that the vague designation 'Atheism' is used merely as a designation of something so alien and repulsive that the Bourne personality refuses to think of it. It seems clear that what Bourne refers to is the character of the Brown personality as it was before what is called the conversion from Atheism to Christianity. Bourne's strong negative feelings about anything related to the Brown personality are again evidenced by the words 'such a horror of the idea of the candy-store that he refused to set foot in it again'.

On these assumptions it seems plausible that the initial alternation from the Brown to the Bourne personality, the change described as the conversion from Atheism to Christianity, was occasioned by strong feelings occasioned by problems of some kind, perhaps financial, into which the Brown personality had gotten. The strong feelings of depression associated with the Brown personality are manifest in his appearance during the hypnotic trance, as described in the words: 'During the trance he looks old, the corners of his mouth are drawn down, his voice is slow and weak, and he sits screening his eyes.'

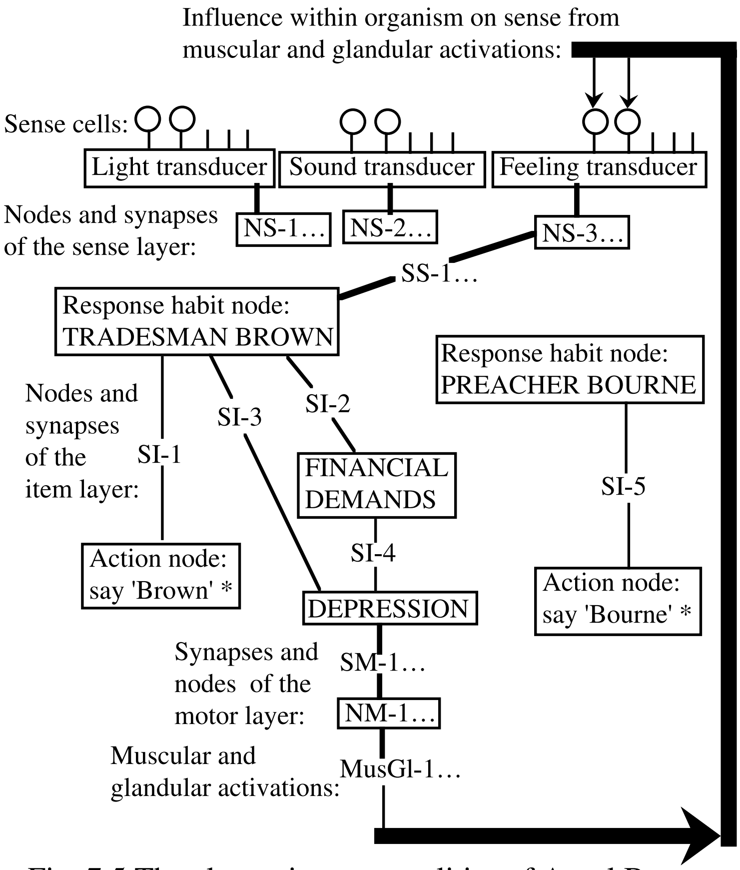

Fig. 7.5 The alternating personalities of Ansel Bourne

In terms of the synapse-state theory the details of the case will here be understood as semi-permanent breakdowns of the function of particular nodes of the nervous system. Details of such changes will here be accounted for in terms of the neural description of Fig. 7.5. First, in view of the person's varied past experience over many years, it is clear that a large number of response habit aggregates will have been formed in his brain. Those of them that have been involved in the personality alterations are shown in the figure as TRADESMAN BROWN and PREACHER BOURNE.

The change in the personality described in the words: 'in consequence of a sudden temporary loss of sight and hearing under very peculiar circumstances, he became converted from Atheism to Christianity just before his thirtieth year', must be understood as having been a matter of cessation of functioning of certain nodes. The temporary loss of sight and hearing might have been caused by disfunctioning of the nodes shown as NS-1… and NS-2…. The conversion will have been caused by disfunctioning of the response habit node TRADESMAN BROWN as distributor of excitations, and education of the response habit aggregate PREACHER BOURNE.

Plausibly these changes of the functionality of the nodes will have arisen as a consequence of an overloading of the nodes with excitations embodying strong feelings. These changes will undoubtedly have involved many nodes of the thought network, of which only a few are shown in the figure. The figure shows the quality nodes FINANCIAL DEMANDS and DEPRESSION that through the paths SM-1…, NM-1…, MusGl-1…, bodily influence, sense cells, Feeling transducer, NS-3…, and SS-1…, will contribute excitations into the response habit node TRADESMAN BROWN. The assumption is that these and other excitations have overloaded the response habit node, making it temporarily inactive. This will have prevented perceptions that depended on preperception excitations from TRADESMAN BROWN. Thus the situation is open to attention to such perceptions that receive preperceptions from PREACHER BOURNE, that is to establishing a new set of response habits.

The return to the Brown personality on January 17, 1887, might be occasioned by the person being in a situation, having 551 dollars in his hand, at a time when the dysfunction of the response habit node TRADESMAN BROWN had healed itself. In this situation sense impressions related to matters of business would excite the node TRADESMAN BROWN. Thus the particular phase of his life described by James may be understood to have been caused by excitation of the response habit aggregate that had been the dominating one in his earlier phases of life

The return to the Bourne personality two months later might then be occasioned by new financial difficulties in the trade. Such difficulties are manifest when it is said that when he was taken back to Providence at the end of the Norristown episode 'He was very weak, having lost apparently over twenty pounds of flesh during his escapade.' Plausibly the Brown episode became a sustenance disaster as a result of financial difficulties. This is not contradicted by the reports from neighbors saying that Brown was 'taciturn, orderly in his habits, and in no way queer…; cooked for himself in the back shop, where he also slept'.

7.4 Loss of remarkable visual imagination

Other valuable evidence of several aspects of mental life was presented by James where he writes [II 44]:

> CHAPTER XVIII. IMAGINATION. … [II 50] INDIVIDUALS DIFFER IN IMAGINATION. … [II 58] A particularly instructive case was published by

Charcot in 1883. The patient was Mr. X., a merchant, born in Vienna, highly educated, master of German, Spanish, French, Greek, and Latin. Up to the beginning of the malady which took him to Professor Charcot, he read Homer at sight. He could, starting from any verse out of the first book of the Iliad, repeat the following verses without hesitating, by heart. Virgil and Horace were familiar. He also knew enough of modern Greek for business purposes. Up to within a year (from the time Charcot saw him) he enjoyed an exceptional *visual* memory. He no sooner thought of persons or thing, but features, forms, and colors arose with the same clearness, sharpness, and accuracy as if the objects stood before him. When he tried to recall a fact or a figure in his voluminous polyglot correspondence, the letters themselves appeared before him with their entire content, irregularities, erasures and all. At school he recited from a mentally seen page which he read off line by line and letter by letter. In making computations, he ran his mental eye down imaginary columns of figures, and performed in this way the most varied operations of arithmetic. He could never think of a passage in a play without the entire scene, stage, actors, and audience appearing to him. He had been a great traveller. Being a good draughtsman, he used to sketch views which pleased him; and his memory always brought back the entire landscape exactly. If he thought of a conversation, a saying, an engagement, the place, the people, the entire scene rose before his mind.

His *auditory memory* was always deficient, or at least secondary. He had no taste for music.

A year and a half previous to examination, after business-anxieties, loss of sleep, appetite, etc., he noticed suddenly one day an extraordinary change in himself. After complete confusion, there came a violent contrast between his old and his new state. Everything about him seemed so new and foreign that at first he thought he must be going mad. He was nervous and irritable. Although he saw all things distinct, he had entirely lost his memory for forms and colors. On ascertaining this, he became reassured as to his sanity. He soon discovered that he could carry on his affairs by using his memory in an altogether new way. He can now describe clearly the difference between his two conditions.

Every time he returns to A., from which business often calls him, he seems to himself as if entering a strange city. He views the monuments, houses, and streets with the same surprise as if he saw them for the first time. Gradually, however, his memory returns, and he finds himself at home again. When asked to describe the principal public place of the town, he answered, "I know that it is there, but it is impossible to imagine it, and I can tell you nothing about it." He has often drawn the port of A. To-day he vainly tries to trace its principal outlines. Asked to draw a minaret, he reflects, says it is a square tower, and draws, rudely, four lines, one for ground, one for top, and two for sides. Asked to draw an arcade, he says, "I remember that it contains semi-circular arches, and that two of them meeting at an angle make a vault, but how it *looks* I am absolutely unable to imagine." The profile of a man which he drew by request was as if drawn by a little child; and yet he confessed that he had been helped to draw it by looking at the bystanders. Similarly he drew a shapeless scribble for a tree.

> He can no more remember his wife's and children's faces than he can remember the port of A. Even after being with them some time they seem unusual to him. He forgets his own face, and once spoke to his image in a mirror, taking it for a stranger. He complains of his loss of feeling for colors. "My wife has black hair, this I know; but I can no more recall its color than I can her person and features." This visual amnesia extends to dating objects from his childhood's years—paternal mansion, etc., forgotten.
>
> No other disturbances but this loss of visual images. Now when he seeks something in his correspondence, he must rummage among the letters like other men, until he meets the passage. He can recall only the first few verses of the Iliad, and must *grope* to read Homer, Virgil, and Horace. Figures which he adds he must now whisper to himself. He realizes clearly that he must help his memory out with auditory images, which he does with effort. *The words and expressions which he recalls seem now to echo in his ear, an altogether novel sensation for him.* If he wishes to learn by heart anything, a series of phrases for example, he must *read them several times aloud,* so as to impress his ear. When later he repeats the thing in question, the sensation of inward hearing which precedes articulation rises up in his mind. This feeling was formerly unknown to him. He speaks French fluently; but affirms that he can no longer think in French; but must get his French words by translating them from Spanish or German, the languages of his childhood. He dreams no more in visual terms, but only in words, usually Spanish words. A certain degree of verbal blindness affects him—he is troubled by the Greek alphabet, etc.

The case of Mr. X will be described in terms of Fig. 7.6. The case is above all a question of the plastic properties and states of the synapses of the sense layer connected to the nodes that connect to the light transducer, some of which are shown as the sets SS-1..., SS-2..., and SS-3..., specially marked in the figure.

The original remarkable visual imagination of Mr. X will have been a result of these synapses being extremely sensitive in their plastic changes of conductivity, such that *merely one single exposure to excitations from both of their connected neurons would put a synapse into a state of high conductivity in both directions.* Thus the very first perception of a remarkable sight, such as that of the port of A., would put each of the synapses connecting the relevant node of the item layer, PORT OF A, with one of the set of nodes of the sense layer, NS-1..., that was excited at the sight, into a strongly conductive state. As a result, whenever the person would hereafter think of the port of A., making the node PORT OF A strongly excited, this excitation would be transferred through each of the highly conductive synapses SS-1... into the nodes NS-1... and thereby produce the experience of the image of the port of A. precisely as this was seen the first time the person saw the sight. Unlike imagination in probably most other persons, which depends on the sense impressions of the imagined thing at several occasions, the imagination of Mr. X. would bring back to his visual experience precisely the visual image as he saw it *the first time he perceived the sight.* Otherwise it can make no sense that, as it is said, 'He no sooner thought of persons or thing, but features, forms, and colors arose with the same clearness, sharpness, and accuracy as if the objects stood before him.'

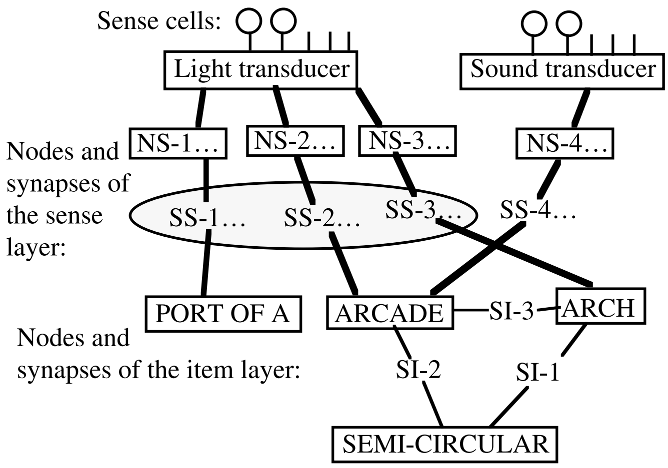

Fig. 7.6 Loss of remarkable visual imagination

The change that took place in Mr. X. may be explained by an organic change in his brain such that all of a sudden all the sense layer synapses connecting to visual sense nodes, including the sets SS-1…, SS-2…, and SS-3…, lost their conductivities. The effect of this will be that the person will have no perceptions from visual impressions. Visual impressions will give experience—excitations of nodes such as NS-1…—but no nodes of the item layer will become excited from visual impressions. The person will be able to think of the port of A., thereby producing excitation of the node PORT OF A, but no nodes of the sense layer will thereby become excited, so there will come no visual images. If spoken to about arcades the spoken sounds will through the synapses SS-4… excite the node ARCADE, so the person will think about arcades. But when the synapses SS-2… do not conduct, this thought will not produce any visual experience. On the other hand, the excitation of ARCADE will excite other nodes of the items layer, such as ARCH and SEMI-CIRCULAR, so the person may consider and argue about arcades, but since the synapse sets SS-2… and SS-3… do not conduct, no visual imagery will accompany the thinking.

About Mr. X. James explains [II 59]:

> ‘Every time he returns to A., … he seems to himself as if entering a strange city. He views the monuments, houses, and streets with the same surprise as if he saw them for the first time. Gradually, however, his memory returns, and he finds himself at home again’

This shows that although such synapses as SS-1… have lost their original remarkable sensitivity, they in the changed state of Mr. X. have plastic properties such that repeated excitation from their connected neurons over a period of days will make them conductive. And so after some time each sight of a familiar view, such as the port of A., will again give rise to excitation of the corresponding node of the item layer, PORT OF A.

But the remarkable visual imagination has not returned. His images in the new state are crude. ‘He can no more remember his wife’s and children’s faces than he can remember the port of A.’

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Peter Naur: The neural embodiment of mental life by the synapse-state theory

Summary

1. Introduction reviews the place of neural embodiments of mental life in the scientific literature of psychology and neurology from around year 2000, on the basis of 25 articles. It is found that every one of these articles is committed to a cognitive view of the function of the neural system, centered around the notion of memory as a neural organ. No neural embodiments are presented in the articles, neither of what is called memory, nor of the functions of mental life described in psychology.

2. Mental life and the synapse-state theory. The neural embodiment of mental life as established in psychology and neurophysiology around 1860-1910 is presented. The activation of muscles in voluntary movements was accounted for by neural excitations. Habits were found to be embodied in the plasticity of the neural material. On this basis the synapse-state theory is proposed: Structurally the neural system is a network consisting of neurons, plastic synapses, and nodes, distributed into five closely connected layers: sense layer, motor layer, item layer, attention layer, and specious present layer. The activity consists in continuously changing excitations of parts of the network. This structure and activity is shown to account for all the basic aspects of mental life: the stream of thought and feelings, thought objects with their fringes, sensation, perception, attention, imagination, the specious present, recall of thoughts, association of subjects thought of, feelings, emotions.

3. Node/synapse aggregates and their functions. The mental functions of mature individuals are embodied in node/synapse aggregates of which five kinds are described: (1) Response habit aggregates: the embodiment of personal modes and styles. (2) Subject aggregates: the embodiment of what one may think of. (3) Quality aggregates: the embodiment of how we feel about things. (4) Urge aggregates: the embodiment of the urge to take action. (5) Action aggregates: the embodiment of muscular actions.

4. The neural embodiment of speech. The muscular activity of speech is embodied in excitations of action aggregates, each embodying the action of pronouncing one core-phrase. Core-phrases are personal, embodied in each person's nervous system as an arsenal of the corresponding action aggregates. In spontaneous speech the selection of the next core-phrase to be spoken happens at the moment it is pronounced, in a combination of the ways, partly, how the core-phrases have habitually been used in speaking about the subjects and qualities of present concern and, partly, how they have habitually been spoken in immediate sequence.

5. The education of the neural system. By education, habits become embodied in synapse states, mostly by development from instinctive reactions. In the foetus habitual sensations and perceptions become embodied in protoaggregates. In processes of discrimination of parts and qualities, the protoaggregates are educated into subject and quality aggregates. By the imitation instinct, voluntary acts become embodied in urge and action aggregates.

6. Neural functional evidence. Neural functional evidence of the synapse-state theory is available in observations of the effect of local excitations into normal

brains, and from the aphasias of patients with brains having local lesions. The lesions affect muscular activity, including speech, reactions of vision and sight, and reactions of hearing and sound.

7. Non-sensual experience and alternating mental states. Alternating mental states manifest in sleep, dreaming, hypnotic trance, mutations of the self, and multiple selves, are embodied in excitations and decay of response habit nodes.

Resumé

1. Introduktion resumerer den plads det mentale livs neurale legemliggørelse har i den videnskabelige litteratur fra omkring år 2000, ud fra 25 artikler. Det findes at hver eneste af disse artikler er bundet til et kognitivistisk syn på nervesystemets funktion, centreret i tanken om hukommelse - memory - som et neuralt organ. I artiklerne præsenteres ingen neurale legemliggørelser, hverken af det der kaldes memory, eller af det mentale livs funktioner som de beskrives i psykologi.

2. Det mentale liv og synapsetilstandsteorien. Det mentale livs legemliggørelse som fastslået i psykologi og neurofysiologi omkring 1860-1910 fremlægges. Aktiveringen af muskler i viljemæssige bevægelser blev fundet at skyldes neurale excitationer. Vaner fandtes legemliggjort i det neural materiales plasticitet. På dette grundlag fremsættes synapsetilstandsteorien: Strukturelt er nervesystemet et net bestående af neuroner, plastiske synapser, og knuder, fordelt i fem tæt forbundne lag: sanselaget, motorlaget, emnelaget, opmærksomhedslaget, og det brede nus lag. Aktiviteten består i kontinuert skiftende excitationer af dele af nettet. Med denne struktur og aktivitet kan der gøres rede for alle det mentale livs aspekter: strømmen af tanker og følelser, tankeobjekter med deres bræmmer, sansning, perception, opmærksomhed, forestillinger, det brede nu, genkaldelse af tanker, association af emner der tænkes på, følelser, emotioner.

3. Knude/synapseaggregater og deres funktioner. Modne personers mentale funktioner legemliggøres i knude/synapseaggregater af hvilke der beskrives fem arter: (1) Responsvaneaggregater: legemliggørelsen af personlige måder og stilarter. (2) Emneaggregater: legemliggørelsen af hvad man kan tænke på. (3) Egenskabsaggregater: legemliggørelsen af hvordan vi føler om tingene. (4) Tilskyndeaggregater: legemliggørelsen af tilskyndelsen til at handle. (5) Handlingsaggregater: legemliggørelsen af muskelhandlinger.

4. Talens neurale legemliggørelse. Talens muskelmæssige aktivitet legemliggøres i excitationer af handlingsaggregater, hvoraf hver enkelt legemliggør den handling at udtale én kernefrase. Kernefraser er personlige, legemliggjorte i hver persons nervesystem som et arsenal af de tilsvarende handlingsaggregater. Under spontan tale sker udvælgelsen af den næste kernefrase der udtales i det øjeblik den udtales, ved en kombination af de måder, dels hvordan kernefraser vanemæssigt har været brugt ved tale om de emner og egenskaber der i øjeblikket er på tale, dels hvordan de vanemæssigt er blevet udtalt i umiddelbar følge.

5. Uddannelsen af nervesystemet. Uddannelsen består i at vaner bliver legemliggjorte i synapsetilstande, mest i udvikling fra instinktive reaktioner. I fosteret legemliggøres vanemæssige sansninger og perceptioner i protoaggregater. Gennem udskillelse af dele og egenskaber bliver protoaggregaterne uddannet til emne- og egenskabsaggregater. I kraft af imitationsinstinktet bliver viljemæssige handlinger legemliggjorte i tilskynde- og handlingsaggregater.

6. Nervefunktionsmæssige bekræftelser. Nervefunktionsmæssige bekræftelser af synapsetilstandsteorien er til rådighed i iagttagelser af virkningen af lokale excitationer i normale hjerner og af afasier hos patienter med lokale hjerneskader. Skaderne påvirker muskelaktiviteten, derunder tale, reaktioner på synsindtryk, og reaktioner på lydindtryk.

7. Ikke-sanselige oplevelser og alternerende mentale tilstande. Alternerende mentale tilstande som de manifesterer sig i søvn, drømmen, hypnotisk trance, mutationer af selvet, og multiple personligheder, legemliggøres i excitationer og forfald af responsvaneknuder.

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