2021

NIGERIAN JOURNAL OF SOCIAL PSYCHOLOGY

Online ISSN: 2682-6151
Print ISSN: 2682-6143
Volume 4, Issue 1
2021

Published by
Nigerian Association of Social Psychologists
www.nigerianjsp.com

SOCIAL PSYCHOLOGY

Memory, Judgments, and Embodiment Effects in our Psychological and Philosophical Reasoning

Jude Godwins
Department of Philosophy
Seat of Wisdom Seminary,
Imo State University, Owerri
judegodwins8@gmail.com

Abstracts

Studies show an overwhelming influence of motorics on memorial functions. This raises critical questions. If a phenomenon as fundamental as motor behaviour does influence memory this much what impact would this have on our addressing questions and issues? What meaning would terms such as objectivity, fidelity, accuracy, truth, impartiality, and the like have for humans whose cognitive operations have much to do with a memory system whose efficiency could be consequent upon circumstantial matters as whether motor activity or mere verbal encoding is involved?

Keywords: accuracy, fidelity, objectivity, impartiality, truth.

Introduction

1.1. Memory

Some conceive of memory as a shift in one's ability to react in a specific way to a certain stimulus. In this sense, one knows a thing when one's nervous systems are capable of processing a certain stimulus input with a specific output. This understanding of human memory refuses to picture it as a sort of thing-in-itself, and thus deliberately distinguishes it from the memory of a computer. The computer does not forget; man does. At the stroke of a single key, the memory of a computer could be erased outright. The human memory never gets entirely erased.

Types of Memory:

(a)***Short-term memory*****:** Whatever is remembered immediately after its occurrence, precisely within 30 seconds, is the function of short-term memory. Some say short-term memory could be better called repetition span or attention span.

(b)***Long-term memory*****:** Whatever is remembered after 30 seconds is said to belong to the long-term memory.

(c) ***Episodic memory*****:** Retaining particular things or specific events (e.g., the world trade center bombing) is said to be the function of episodic memory. It is memory for the events one personally experiences.

(d) ***Semantic memory*****:** Having general knowledge, such as remembering how to play tennis without remembering where one learnt it, is associated with semantic memory.

1.2.1 Assessing Memory

Retention could be assessed through recall, recognition, and relearning.

(*a*) ***Recall*****:**

In recall studies, recall procedures of what subjects had just experienced could be sequential (orderly) - verbatim recall, or free (not restricted to any order) - free recall. When an original recall is not as complete as subsequent or successive recall, the additional recall is described as reminiscence. (Plato describes knowledge as reminiscence.) When people cannot recall the entire presented data unguided, they are assisted, cued, with associated signals to enable them recount more elements. This practice is termed cued recall.

(b)***Recognition*****:**
In what is accepted as a more direct way of prompting, new data, "distractors," are embedded in original data, and subjects are asked to sift the original from the collection. Recognition studies reveal that people, under fair conditions of distraction, do recognize a lot better than they recall.

(c) ***Relearning*****:**
Learning studies show that things, once learnt and presently forgotten, could be relearned in a fraction of the initial learning time. The difference in the two learning times is termed a savings score, and is associated with the experiments of Hermann Ebbinghaus. That there is a certain savings in a learnt thing implies that a certain residue of the first learning lingers on and can be harnessed (exploited).

1.2.2. The Component Process Model of Memory

Morris Moscovitch (1994) sketches a four-component process model of memory. Each of these allows for the processes that prevail in performance on four distinct forms of memory tests. The first is a non-frontal neocortical component, consisting of several perceptual and semantic modules, which permits and influences functioning on item-specific, implicit (indirect) memory tests. The second is a basal-ganglia component that allows for and influences performance on sensory-motor procedural memory tests. The third is a medial-temporal/hippocampal component, a modular component that enables and influences memory acquisition, storage, and retrieval on explicit-episodic tests of memory, which are associative/cue-dependent. The fourth is a central-system frontal-lobe component, which he says "works with memory," permitting and influencing operations on tests that are explicitly *"strategic*" or explicitly rule-based (Moscovitch, 1994, 269).

His model is a neuropsychological analysis of memory at the structural and process levels. He isolates the components of memory and attempts an understanding of their functions. While emphasizing dissociations in memory, he stresses that memory components, while separable in principle, remain peculiarly exceedingly interconnected in practice. The function of a memory component is not regulated merely by its internal organization but as well by its connection networks in relation to other components. Their performance rests on the interplay of the components and the processes they permit and influence. Moscovitch specifies the processes each of the memory components allows for and influences, the information each represents, and some of the possible interactions among the components.

1.3. Theories of Memory.

Two outstanding theories of memory exist in the literature, namely, (i) disuse, and (ii) interference. Both are built on the passage of time. Added to these are inhibition studies, which could be (iii) retroactive, or (iv) proactive.

(i) ***Disuse Theory***
The disuse theory assumes that over time, past events start looking shadowy, begin to fade, and are increasingly less well recalled. To be retained data must be rehearsed.

(ii) ***Inference Theory***
The inference theory claims that something learnt to a certain criterion is retained to that criterion until an earlier or recently learnt stuff interferes with it.

(iii) ***Retroactive Inhibition***
Studies in retroactive inhibition reveal a drop in retention when a later stuff, B, is somewhat similar to an earlier stuff, *A*.

(iv) ***Proactive Inhibition***

Proactive inhibition studies show that when *B* is similar to *A*, having learned A, learners have more difficulty learning *B*, than a control group that never learnt *A*. Interference is said to be more likely a function of proactive inhibition than of retroactive inhibition (Bugelski,1987, 701-703).

1.4. Memory Disorders

Acquired information and experience are regarded as somewhat permanently stored in memory. Most psychologists use the information processing analogy to describe memory. In this case, information that is taken in through the senses is, as it were, operated upon, stored, retrieved, and used as need arises. The operation phase is said to attach fitting cues to information, connect related events, set priorities, and select information to avert confusion. Memory disorders could be (a) non-pathological, as in forgetting, or (b) pathological, as in amnesia, aphasia, apraxia, and prosopagnosia.

A. Non-pathological Memory Disorders: Forgetting

Memory loss consequent upon want of availability and accessibility is said to account for forgetting, which is the most common non-pathological type of memory disorder. The objective of the memory system is to retrieve stored data effectively. Incidentally, retrieval is impaired, among other ways, through want of availability or accessibility of the desired material.

(i) ***Want of Availability***

Taking in too much information could result in memory capacity being exceeded and in an eventual information loss.

(ii) ***Want of Accessibility***

Failure to recall the uppermost priority material, following unsuitable attachment of priority to some other material, confusion and interference during retrieval, resulting from poor attention and the application of highly similar cues to other materials, all block accessibility.

Forgetting, following want of availability of stored data, could be the consequence of too little repetition or rehearsal of the desired data or due to priority accorded recently acquired data in contrast to previous ones. Psychologists associate the major cause of forgetting with interference or confusion, arising from semantically or acoustically alike materials.

B. Pathological Memory Disorders

(i) ***Amnesia***

Amnesia, loss of memory, can be either retrograde or anteriograde, and results from cortical or emotional trauma and from alcohol or substance abuse. Amnesia can be: *localized*, causing marked elements of the time frame about the trauma to cease being both accessible and available for recall; *selective*, resulting in the inability to recall particular events, such as one’s involvement in a plane crash; *generalized*, so that one fails to recall all of one’s life events up to and around the span of a traumatic experience; and continuous, such that one fails to recall events bordering the traumatic event and extending to the present.

(ii) ***Senility-related Memory Disorders***

Memory disorders associated with senility reflect lucidity in memory for incidents from far-off past, in all their attendant situational and emotional magnitude, thrown in awkwardly into the present.

(iii) ***Confabulation-related memory disorders***
Confabulation describes the act of telling stories to make up for a blanking-span. It follows from drug or alcohol abuse that for sessions probably exceeding 48 hours interferes with encoding and storage potentials, blocking accessibility and availability.

(iv) ***Aphasia***
In aphasia, a neurological disorder resulting, perhaps, from cortical trauma, stroke, and so on, leads to loss of formerly intact functions such as writing, reading, picture recognition, speaking. Thus, previously proficient readers lose their reading power, becoming *alexic*. People, who formerly possessed fine motor skills, lose their fine motor movement capacity, becoming suddenly *apraxic*. Others surprisingly lose their facial recognition power, becoming *prosopagnosic*.

Probably neurophysiological research, inevitably relying on behavioral data, could resolve the presently theoretical conjecture, regarding whether memory is made up of cells or of diffuse neuronal nets, or whether particular cortical regions could be designated for particular linguistic, pictorial, or episodic data (Fisher, 1987, 703-704). But then, Goldstein argues differently. He asserts the existence of modules for form and movement analysis. Neurophysiological researches, he holds, shows that the mediotemporal area of the brain is specialized for the processing of movement, while the inferotemporal area is specialized for the processing of form. In the inferotemporal area, he writes, neurons have been discovered that react best to faces. The area in question has been termed fusiform face area, and could also be identified in humans (Goldstein, 2002, 126).

It is of interest to our inquiry to ascertain whether memory functions and motor behavior share any commonality. Could one in any form mediate the order? Could they interact? Could it be that motoricity in both its afferent and efferent forms not only mediates judgments and provokes embodiment effects but also affects memory? (In afferent activities, nervous impulses are conveyed from a peripheral part to a nerve center, such as the brain or spinal cord: conducting inwardly. Contrastingly, in efferent activities, nervous impulses are conveyed from a nerve center to an effector: bearing outwardly.)

1.5. Memory and Motoricity

A. Molecular Motor and Higher Brain Activity (Mediating Synapses, Neuronal Plasticity, Memory, and Learning).

Setou, M. and his companions (2000) report their experiments with vesicles that contain *N*-methyl-D-aspartate (NMDA) receptor 2B (NR2B subunit). Their experiments reveal that these (vesicles containing NMDA) are ferried along microtubules by KIF17. KIF17 is molecular motor that is not only specific to neurons but also has a motility that is directed toward the plus end of microtubules. It attaches itself directly and precisely to a PDZ domain of Mint1/X11 (mLin-10,) transporting the huge complex of proteins that contains the NR2B subunit, which forms the NMDA receptor with the NRI subunit. Choosy transport is realized by the KIF17 tail directly interacting with a PDZ domain of mLin-10 (Mint1/X11), a constituent of an enormous complex of proteins that includes NR2B subunit, mLin-2 (CASK), and mLin-7 (MALS/Velis). Interactions such as this are a specificity of a neurotransmitter receptor critical for plasticity in post-synaptic terminals. And Setou and his colleagues say they could be regulatory crossroads for the plasticity of synapses and morphogenesis of neurons (Setou, 2000, 1796).

Setou and his colleagues submit that neurons of the kinesin super-family (KIFs) bolster manifold systems of transport in cells. KIF17, they reveal, is a microtubule plus-end-directed motor. It can operate in the absence of a coenzyme and can mediate speedy intracellular transport. It is a dendrite-specific motor protein. Apparently brain-specific, it is abundantly present in the gray matter (Setou, 2000, 1796)[6]. They report that KIF17 transports a membranous cargo, being itself linked to the periphery of the membrane. The receptor for KIF17 on the membrane is the mLin-10, a sorting protein. NR2B sorting vesicle, they reveal, is transported by KIF17-mLin-10 complex. The scaffolding Mint 1 (mLin-10) abides in a protein complex with mLin-2 and mLin-7 that attaches itself to the NMDA receptor subunit NR2B (Setou, 2000, 1798)[7].Theyreport that cargoes that contain NR2B are ferried along by KIF17 and that the binding tail of the mLin-10 is necessary for this activity of the KIF17. Putting their whole findings together, they state that KIF17, a motor neuron in the neuronal dendrites, interacts directly with a mLin-10 domain, giving rise to the transportation of NR2B in the dendrites (Setou, 2000, 1801).

Miki, H. and his associates (2001) report the identification of all kinesin super-family protein (KIFs) in the human genome. They note a total of forty-five KIFs in man. The human brain alone contains thirty-eight of these, indicating that its functions need an immensely complex intracellular system of transport. KIFs, they report, are not merely engaged in the transport of organelles, protein complexes, and mRNAs, but also take part in the movement of spindle and chromosomes during mitosis and meiosis. The cell utilizes KIFs and firmly guides the direction, target and speed of the transportation of the respective essential functional molecules.

Experiments by Wong, R.W. *et al*. (2002) reveal that when laboratory procedures over express motor protein (KIF17,) in mice, spatial and working memory is enhanced. Their KIF17 transgenic mice show improved learning and memory in a wide range of behavioral tests, as well as exhibiting a NR2B expression that is regulated upward.

The transportation of *N-methyl-D-aspartate* (NMDA) form of glutamate receptors from cell bodies to synapses has been known in the biology of learning to be crucial for learning and memory. The NR2B subunit, which abounds in forebrain structures, is contained in this NMDA. Its over-expression in a model of a mouse (in vitro) improves learning and memory. KIF17 is the motor of NR2B. Hence, wanting to establish the *in vivo* function of KIF17, Wong and his colleagues over express it in the NR2B of mice (by raising transgenic mice whose KIF17s are over-expressed mostly in the forebrain). In an open field test, they evaluate the anxiety level and the general loco-motor behavior of the mice, and record their running speed, overall distance and time at the areas of the tasks. They also check the behavioral phenotypes of the transgenic mice *vis-à-vis* the natural mice. They observe that the transgenic mice show normal exploratory behavior and respond to anxiety in the same way natural mice do.

To assess their working and episodic memory, Wong and his colleagues test the activities of the mice in a delay matching place task (DMP). This task checks the capacity of the mice to quickly encode ongoing events. It entails the NMDA receptor. They discover that the transgenic mice remember new platform locations and find their escape routes at quicker rates (based on simply one exposure to these routes) than the normal mice. Measuring the levels of NR2B mRNA in the forebrain of the mice, they discover that those of the transgenic mice were twice more than those of the normal mice. They establish that *molecular motor, by means of transportation, does a critical function in the higher brain activity in vivo* (in the living body).

The DMP task reveals an improvement in working and episodic memories in the mice whose KIF17 were over expressed (transgenic mice). They report that the difference of minimizing time expended on task (observed in the transgenic mice in contradistinction to the natural mice,) indicates that the transgenic mice have an added capacity to learn the new platform location fast simply by a single attempt, while they suppress the interfering memory of the former place of the platform. The performance of the transgenic mice in the Morris water maze task, a test that takes spatial learning and memory to task, is particularly noteworthy. In this test, mice learn to locate a hidden platform in a pool with a circular orientation. In a quite significant way, the transgenic mice expend lesser time in escaping, and employ shorter routes than the control mice. Interestingly enough, basic behaviors, loco-motor functions, and swimming speed remain the same for both groups of mice. Thus, Wong and his associates (2002) rule out improvements in sensory-motor function and the processes of motivation/emotion as possible explanations of the enhanced performance in working memory and spatial learning tasks in the transgenic mice.

Their findings show links between the movement of NR2B by KIF17, synaptic events, the role of CREB, and the fact that phosphorylated CREB does a "transcriptional regulation" of NR2B and of KIF17 (CREB= cAMB-response element-binding protein). Increasing KIF17 synthesis brings about a rise in the quantity of NMDA receptor subunits (NR2b) that are trafficked (ferried about) in dendrites. This in turn, perhaps, facilitates synaptic activity. Therefore, so Wong and his colleagues, the movement of KIF17 could be at the basis of memory and learning in vivo (Wong et al., 2002, 14505).

Guillaud and his colleagues (2003) undertake an experiment whose aim is to establish the dynamic properties of KIF17 in living mammalian neurons. In their introductory notes, they point out that sorting and transportation of organelles, in cells such as neurons**,** rely on the kinesin super-family proteins (KIFs) (Hirokawa, 1998). Defects in KIFs, they note, hamper the functions of neurons, such as the propagation of action potential or the release of transmitters (Zhao et al., 2001). They observe that while the characterization of KIFs has been done *in vitro (Miki et al., 2001),* not much is known of the real-time dynamic properties and roles of motor proteins *in vivo.*

Guillaud and his companions note that KIf17, a motor protein having a N-terminal motor domain, is a member of the Osm-3/KIF17 family. *In vitro*, KIf17 has been identified as binding precisely, via its tail domain, to the postsynaptic density-95/disc large/zona occludens-1 (PDZ) domain of the Mint1/X11 (mLin10) inside an extensive scaffolding protein complex containing the NR2B subunit of the NMDAR (NMDA receptor) (Setou et al., 2000). MintI/X11, a component shared by the "polarized protein localization pathways" in epithelia and neurons, is expressed only in neurons. It comprises a variable N-terminal region and a non-variable C-region containing two PDZ domains; one of these domains is known to bind to KIF17.

Guillaud and his colleagues note that NMDARs, a subtype of glutamate receptors, are ion channel complexes resulting from the assembly of various subunits, namely, NR1, NR2A, NR2B, NR2C and NR2D. The NMDAR channel is essential for circuit development, synaptic plasticity, memory, and learning (Tsien et al, 1996). The NR2B subunit of the NMDAR is crucially important for the synaptic localization of the NMDAR channel (Mori et al., 1998) and has a direct involvement in the facilitation of learning and memory in mice (Tang et al., 1999). It is against this backdrop that Guillaud and his colleagues attempt to establish the dynamic properties of KIF17 *in vivo* (in living mammalian neurons). They seek to ascertain whether the trafficking of NR2B by KIF17 also happens *in vivo*. They aim at determining as well what happens to NR2B when KIF17 transport is inhibited. They seek to know whether KIF17 (motor) and NR2B (cargo) have other relationships.

Guillaud and his associates find that KIF17 vesicles penetrate and progressively travel along dendrites, at an average velocity of 0.76µm/sec. These vesicles, being actively associated with extra-synaptic NR2B, ferry and convey NR2B to the dendrites. KIF17 does not appear to directly enter the synaptic regions, though. It ferries vesicles from the cell body to the tip of dendrites. Knocking down the cells of or blocking the functions of KIF17 hampers the expression of NR2B and its synaptic localization. Over-expressing KIF17, forces the scaffolding protein mLin10 that is believed to be implicated in the binding with NR2B into redistribution. They report a parallel rise in the amount of NR2A subunits at synapses following a decline in the amount of synaptic NR2B subunits.

On the contrary, up-regulating the level of expression of the NR2B, simultaneously raises the level of expression of KIF17. Guillaud and his associates judge that their findings about the down-regulation and up-regulation of KIF17 and NR2B indicate a possible existence of a common process of regulation between KIF17 (the motor) and NR2B (the cargo). Their overall results, they say, demonstrate the complex mechanisms at the basis of the effective movement and regulation of the cargo, NR2B, by the molecular motor, KIF17, in living mammalian neurons.

B. Memory as Based on Motor Programs

Could memory be based on motor programs? Daily life, observe Mecklinger and his associates (2002,) goes with retaining information in mind for brief time spans. Rehearsing the content of a message or memorizing a friend’s car number are two instances of this daily memory function. Retaining verbal information and non-verbal information in mind do differ. For one, verbal information allows phonological encoding. This permits us to map articulation directly onto hearing. An “articulatory rehearsal mechanism,” which recurrently keeps phonological codes afresh and in this way capacitates the retaining of verbal materials in working memory, could be in place. Thanks to this mechanism of articulatory rehearsal, we are able to access our phonological codes (Wilson & Emmorey, 1998).

One implication of the forgoing is the opinion that verbal working memory has two components. Recent findings in brain imaging provide experimental evidence for this view. On the one hand, they reveal that the posterior parietal brain areas represent the features of the verbal working memory that are mainly sensory-related. On the other hand, they show that the chiefly action-oriented features of verbal working memory are represented by the prefrontal/premotor regions (Mecklinger et al., 2000). For instance, the Broca’s area in the posterior inferior frontal gyrus is said to be associated with the working memory’s phonological rehearsal component. This follows from experimental evidence that shows it being active in verbal working memory tasks (D’Esposito et al, 1998) as well as in tasks that require phonological processing (Fiez, 1997).

Whereas we employ phonological codes to maintain verbal information in working memory, it does seem, at the moment, unclear how the same could be realized for information for which verbal codes are hard to come by. Models attempting to address this matter abound. Some propose that spatial motor programs form a mechanism for the rehearsal of spatial information, in the same manner that sub-verbal articulation allows for and influences verbal rehearsal

(Schneider, 1999).

There exits yet another category of visual information, one more complex than materials that are location-specific, so Mecklinger and his colleagues. This includes photographs of natural scenes and drawings of objects. We can verbally re-code objects, they assert, given that these comprise a huge repertoire of properties that are visual and functional. Neurophysiological studies, they point out, reveal that objects are represented in our brains in line with their attributes and features. Mecklinger and his colleagues single out manipulable objects. The uniqueness of these kinds of objects, they say, lies in their strong association with specific hand movements. The critical importance of motor properties for object representation has been variously acknowledged. One source of evidence for this acknowledgment are models of visual processing that concede a commonly shared basis of representation for a perceived event in both its action-oriented and sensory-oriented aspects (Prinz, 1997). Further justification for this comes from studies in neuroimaging revealing that observing tools or silently naming tools is traceable to activity in the hand area of the ventral premotor cortex. This refers to the brain regions that become active as we perform actions with (manipulable) objects (Decety et al., 1999).

It is in the light of the foregoing that Mecklinger and his colleagues (2002) undertake a couple of experiments in which they probe if we employ motor programs for use of objects when we have to maintain information on manipulable objects in working memory. They utilize functional magnetic resonance imaging (fMRI) to examine if similar brain areas become active as we retain information on manipulable objects in working memory. They ask their subjects to retain manipulable objects in mind for ten seconds. Subsequently, they present a test stimulus in which their subjects decide if it is the same as or a mirror image of the object they had maintained in mind. They examine their brain activation during the delay interval. Their argumentation is that if the premotor cortex becomes active during the retention period for manipulable objects but does not for non-manipulable ones, it would be an evidence for the tenet that motor programs for the use of objects mediate our power to rehearse manipulable objects in working memory.

The experiments probe the effects of the manipulability of objects on the pattern of activation of the brain in a working memory task. Interestingly, whereas object manipulability does not affect error rates and reaction times, the experiments reveal differential activation with the two categories of objects during the retention interval. Mecklinger and his colleagues find that maintaining information in working memory on manipulable objects activates the left ventral premotor cortex and the left inferior frontal gyrus (Broca's area). Inversely, retaining information about non-manipulable objects in working memory co-activates the Broca's area and the left angular gyrus. Contrasting these directly reveals that manipulable objects (in contrast to non-manipulable ones) activate the left ventral premotor cortex and the anterior intraparietal sulcus. Previous studies reveal that this very circuitry (left ventral premotor cortex together with the anterior intraparietal sulcus) allows for and influences the transformation of properties of objects that are relevant for movement into hand actions. Put together, these results establish that *working memory* for objects we can handle and move around is *based on motor programs* linked to their use. In what follows, we take a closer look at manipulable and non-manipulable objects.

(i) ***The Neural Circuitry for Retaining Objects We Can Handle and Move Around (Manipulable Objects)in Memory.***

Contrasting the memory trials with manipulable and non-manipulable objects, Mecklinger and his colleagues find there is in manipulable objects a co-activation of the left hemisphere of the ventral premotor cortex and the anterior intraparietal sulcus. Studies show that the anterior intraparietal sulcus becomes active as humans prepare for motor activities (Deiber et al., 1996), and as people attend to movements [i.e. as they imagine movement {visuomotor imagination} or actually move {actual movement}](Deiber et al., 1998). Researches investigating limb movements also find the anterior intraparietal sulcus (AIP) to be crucial for the attentional involvement that goes with limb movements. Rushworth (2001) refers to this as motor attention.

Studies on animal brains, Mecklinger and his associates note, disclose a high responsiveness of neurons in the AIP to object properties (e.g., the handle of a play-instrument or toy) associated with movement (Rizzolatti et al., 1995). Lesions in humans in areas bordering on the IPS (intraparietal sulcus) are shown to cause more grasping handicaps than reaching impairments (Binkofski et al., 1998); a phenomenon that indicates how the IPS in both the human and animal (monkey) brains could be identically functionally organized. [The study by Binkofski and his colleagues on this theme is two-fold. First, they examine patients with cortical lesions in the anterior lateral bank of the IPS, and discover that these have deficits in coordinating finger movements that are relevant for object grasping. Second, using fMRI, they examine normal control subjects, establishing that during grasping there is a precise activation of the anterior lateral bank of the intraparietal sulcus. This leads them to conclude that this region and, perhaps too, the human equivalent of the AIP may be mediating the human sensory-motor integration of precise finger movements].

The anterior intraparietal sulcus is linked to the ventral premotor cortex, providing the premotor regions with movement-related sensory-motor information for dealing with objects (Schubotz & Von Cramon, 2001). There is strong indication, argue Mecklinger and his colleagues, that the anterior intraparietal sulcus and some part of the inferior premotor cortex form neuronal circuitries, transforming inherent properties of objects into hand movements. Rizzolatti and his colleagues not only buttress this view in their experiments, but also argue that the two ventral motor regions of the human motor cortex (ventral 6a and area 44) could be the equivalents of the monkey areas F4 and F5 respectively (Rizzolatti et al., 1998, 292). They base their view on recent anatomical and brain imaging evidence, and point as well to motor cortex ontogeny and the possibility that the functional areas of the ancient sulci retain their fundamental locations in phylogenesis.

Buccino and his associates (2001) employ functional magnetic resonance imaging (fMRI) to localize brain areas that become active as people observe activities performed by others. They present object- and nonobject-related activities, performed with various effectors (hand, mouth, foot,) to their participants. They find that when participants observe object- and nonobject-related activities, it brings about a “somatotopically organized” activity in the premotor cortex. This somatotopic pattern, they find, is akin to patterns in the classical motor cortex homunculus. In addition, they find that as participants observe object-related activities there is a somatotopically-organized activation in the posterior parietal lobe. So it is that when people observe motor behaviors, an internal copy of that behavior is automatically created in their premotor cortex. In object-related activities, an added object-related analysis is carried out in the parietal lobe, as though the participants were actually manipulating/utilizing those objects. These findings, Rizzolatti and his associates state, give the earlier notion of a matching system of an action observation and execution (mirror system) a rather broader perspective. The new and larger picture is that this behavioral matching system (mirror system) is not limited to the ventral premotor cortex, but engages many so matotopically ordered motor circuits.

One more relevant aspect of these results is that they demonstrate a notable differentiation between brain activations as we observe object-related activities and when we view non object-related ones. Whenever an action is directed toward an object, the parietal lobe becomes vigorously active. This object-related activation is organized in a somatotopic manner, and relies on the effector in use.

The parietal lobe, Jearnnerod and his colleagues *(*1995) report, plays the role of a 'pragmatic,' action-oriented description of objects, describing objects for action, whereas the infero-temporal lobe describes semantically. Buccino and his associates (2001) report that their findings also suggest that a 'pragmatic' analysis is done when we observe object-directed activities others perform. Should our understanding of actions depend on higher cognitive functions, they argue, this analysis by the parietal lobe would not be required. This makes a clear case for a bottom-up understanding of human behavior.

Joining the pieces together, their findings demonstrate that when we observe motor behaviors, we engage the same neural substrates that are usually engaged in the actual performance of the motor behaviors we are observing. When we observe motor activities, we encode them in relation to the movements associated with them. We map the motor behaviors we observe onto the correlating/matching motor representations of the frontal lobe; when the motor activities we observe are object-related activities, we map the viewed objects onto the pragmatic representations related to the relevant effector in the parietal lobe (Buccino et al., 2001, 404).

Chao and Martin (2000) using fMRI examine the neural response in frontal and parietal cortices that have ties with observing and naming photographs of various object categories. Given that tools are usually connected with specific hand movements, they predict that photographs of tools (rather than other object categories) should evoke activity in brain areas that store information on motor-dependent properties. They find that looking at photographs of tools (by right-handed subjects) selectively activates the left ventral premotor cortex (BA 6). They recall that experiments with monkeys show neurons in the rostral section of the ventral premotor cortex (canonical F5 neurons) responding to ocular presentation of graspable objects, even when no subsequent motor activity is present. Hence, they argue that the ventral premotor area that selectively responds to tools in their experiment could be the human equivalent of the canonical F5 area in monkeys.

They also find that looking at and naming tools (by right-handed subjects) selectively activates the left posterior parietal cortex (BA 40). They note that this response is akin to activations of the anterior intraparietal neurons in response to ocular presentation of graspable objects. They, thus, argue that in both monkeys and humans there does seem to be a close connection between manipulable objects and information about motor behaviors relating to their use. They argue too that the selective activations in the left posterior parietal and the left ventral premotor cortices by tool photographs indicate that the power to recognize and identify these tools depends on activity in the ventral and dorsal visual processing pathways. Summing up their findings, they rule that in humans (right-handed,) areas of the middle temporal gyrus, fusiform gyrus, left ventral premotor cortex, and the left posterior parietal cortex make up a network that connects information about the distinctive optical features and attributes of tool-objects with the appropriate hand and finger movements these tools require in order to be used.

In Grèzes & Decety (2002,) presenting subjects with graspable objects in a number of different tasks results in the co-activation of the anterior parietal and premotor areas. Grèzes & Decety, thus, argue that these co-activations agree with the notion that motor representations are already involved during object perception. This, they argue, furnish us with yet another neurological evidence that object perception "automatically affords actions" (applicable to it).

Notably, what all the studies being reviewed in this section have in common is that looking at or attending to features of optical objects elicits the retrieval of information on movement that relates to the objects, surprisingly, even when no actual motor functions are needed. Mecklinger and his colleagues maintain that their findings substantiate and broaden the results of the aforementioned studies. They reveal that *object-specific motor programs retain information on manipulable objects in working memory.*

(ii)***Non-manipulable Objects and Verbal Rehearsal***.

Mecklinger and his colleagues also find that in contrast to their control trials, non-manipulable objects result in more intense activations in the Broca's area and left angular gyrus. Studies associate the Broca's area with speech motor processes, especially phonological processing. Verbal working memory tasks now and again implicate the Broca's area in sub-vocal rehearsal processes.

Cohen and his associates (1997) investigate the temporal dynamics of brain activity in a working memory task. First, they acknowledge that information needed for higher cognitive functions (e.g. planning, language, problem solving) are stored on short-term basis and manipulated on-line by working memory. Second, they note that traditional psychology partitions working memory into a two-fold process. The first type of process, executive control, governs the manipulation of encoding and the retrieval of information in working memory. The second type, active maintenance, keeps information available 'online'. Some psychologists also assume, they remark, that distinct cortical structures subserve these two forms of processes. While the prefrontal cortex is assumed to house the processes of executive control, the posterior regions are said to shelter the active maintenance processes. These systems, they argue, take part in the temporary processes of the working memory: comparing, updating contents, rehearsing.

Rehearsal is of much relevance, so Cohen and his colleagues, given the activation pattern they witness in the Broca's area, especially as this region is known to play a crucial part in articulatory rehearsal. The pattern of continuous activation in the Broca's area, which they observe, is consistent with what psychologists associate rehearsal with, namely, an ongoing process. Same as the ventral premotor cortex, the Broca's area lies anterior to the inferior precentral sulcus. Studies associate the Broca's area with movement representation, precisely, with articulatory movement (Schubotz & Von Cramon, 2001)[35]. There are lots of experimental evidences to buttress this belief. One such proof is the work of Chao and Martin (2000,) where the Broca's area becomes active as subjects name tools. Another evidence is the experiment by Grafton *et al.* (1996,) where naming the use of tools activates the Broca's area. Studies also show Broca's area getting active during language comprehension, especially during syntactic operations.

Apart from linguistic tasks, studies also show that Broca's area becomes active during non-linguistic tasks. Such is the case in tasks requiring the timing of movement, such as synchronizing movements with sensory events. Rao and his companions (1997) obtain this result when, using fMRI, they image subjects as these taps with their fingers in synchrony with tones split by consistent intervals (synchronization), which they replace subsequently by tapping in the absence of an auditory cue (continuation). Their overall results indicate that internally generating precisely timed movements depends on three complementary neural systems. The one takes care of explicit timing (putamen, ventrolateral thalamus, supplementary motor area); the other mediates auditory sensory memory (inferior frontal gyrus, superior temporal gyrus); and the third does sensory motor processing (sensory motor cortex, dorsal dentate nucleus).

One more non-linguistic task, requiring the timing of movements, where Broca's area activation takes place, is in cognitively analyzing musical structures. Maess and his comrades (2001), using magneto encephalography, undertake to localize neural substrates that process music-syntactic discrepancies. Processes such as this are electrically known to be marked by early right-anterior negativity, which happens when harmonically inappropriate chords occur in a "major-minor tonal" setting. In their study, such chords evoke an early effect, which they regard as the magnetic equivalent of the early right-anterior negativity. They localize the source of this activity of the magnetic equivalent of the early right-anterior negativity in the Broca's area and in its right-hemisphere homologue, regions associated with syntactic analysis in auditory language comprehension. They discover that it is these regions that analyze "incoming harmonic sequences," rather than doing purely language-specific functions. Again, the Broca's area is also activated as people perceptually analyze temporal patterns. All this, say Mecklinger and his colleagues, indicates a functional overlap between linguistic and non-linguistic processes and shows that the Broca's area plays a larger generic functional part in coordinating and regulating sequential activities in various effector domains (tasks involving chewing, grasping, leg-kicking etcetera).

That both manipulable and non-manipulable objects activate the Broca's area, argue Mecklinger and his colleagues, suggests a somewhat phonological recoding and sub-vocal rehearsal in the retention interval, for the two forms of objects. Nonetheless, the overall results of their study reveal that varied neuronal circuitries permit manipulable and non-manipulable object to be retained in visual working memory. A direct contrast reveals that manipulable objects, in contrast to non-manipulable objects, co-activate left ventral premotor cortex and anterior intraparietal sulcus; this region is a neuronal circuitry known to transform properties of objects that have relevance for movement into hand actions. Such is the case that it is possible that "visual working memory for manipulable objects is based on object-specific motor programmes." Put differently, working memory, for objects we can move around with the hand, is based on information about actions relating to their use. Thus, as in verbal working memory, where "speech motor actions" permit the retention of objects in working memory, so also do "hand motor actions" enable objects to be maintained in working memory over brief spans (Mecklinger et al., 2002, 1122). Mecklinger and his colleagues, therefore, afford us a solid evidence that *working memory is based on motoricity*.

C. Motor Affordances and Working Memory Retention

Mecklinger and his companions (2004) study the place of motor affordances of objects in the processes involved in retaining objects in working memory. They perform three experiments in which subjects passively look at real world objects or retain the objects in working memory in order to compare them with a S2 stimulus later on. Using functional magnetic resonance imaging (fMRI), they record brain activations in subjects as they perform the three tasks.

They observe a remarkably differential hemodynamic activation in their movement and size tasks. They find that retaining information on manipulable objects (objects one can work with or operate with the hand) in working memory activates the hand area of the ventral premotor cortex that is contra-lateral to the dominant hand. Inversely non-manipulable objects activate the left inferior frontalgyrus. This result, they report, indicates that "working memory for objects with motor affordance is based on motor programs associated with their use."

Further experimentations, Mecklinger and his colleagues narrate, show that task demands can moderate the way motor programs are activated. These supplementary experiments reveal that keeping and maintaining objects in working memory for an impending *motor* comparison task activates the ventral premotor cortex contra-lateral to the dominant hand. Conversely, keeping and maintaining the same objects in working memory for an impending *size* comparison task activates the posterior brain areas. This discovery, they state, places hand-motor-program activation under top-down regulation. This makes it easier to flexibly adapt the activation of hand motor programs to diverse task demands. They propose that hand motor programs could be doing a working memory function equivalent to that done by speech motor programs for contents of working memory that can be verbalized. They also assert that the premotor system does mediate the temporal integration of motor representations with other task-relevant representations to assist goal-oriented behavior.

There experiments establish the function of motor memories in maintaining information on objects in working memory. In all the three experiments they perform with right-handed subjects, objects having high motor affordance activate the hand area of the left ventral premotor cortex. The ventral premotor cortex is a higher order motor region that becomes active too whenever one has to perform an action with an object that corresponds to it. Their experiments, they submit, reveal that we can intentionally modulate the activation of motor memory. This capacity for intentional activation of motor memory makes it possible for it to be adapted to varying task demands with some flexibility. Thus, when subjects keep information in working memory for prospective movement discernment task, manipulable objects make active the ventral premotor cortex, the inferior frontal, and the posterior parietal regions. But then, when subjects retain information for an upcoming size discernment task, the same objects this time around make active the occipital and posterior parietal brain areas. Mecklinger and his colleagues take this shift as suggesting that the features of sensory objects are selectively processed. They hold that the results of their experiments indicate that the processing of motor affordances is under a "top-down attentional control."

Mecklinger and his colleagues recall that studies in neurophysiology (Gallese et al., 1996) show that the ventral PMC of monkeys (F5) includes two types of neurons: canonical and mirror neurons. The canonical neurons are known to be activated when monkeys view graspable objects as well as when they grasp the objects. The mirror neurons are shown to fire when monkeys watch others grasp objects as well as when they grasp objects themselves. In the brain of a monkey, area F5 receives direct stimuli from the parietal area, AIP. Researchers, say Mecklinger and his colleagues (Rizzolatti et al., 1998), propose that in the brain of a monkey, the AIP-F5 forms a network of neurons that transforms properties of objects relevant to action into hand movements. They state that the results of their experiments buttress the growing opinion (Grezes et al., 2003) that the AIP-F5 circuitry does exist too in humans. The activation of the ventral premotor cortex in humans, they hold, could be the human equivalent of the intense neuronal firing in the F5 region of the monkey brain. By the same stretch, they argue that the increased hemodynamic response in the anterior intraparietal sulcus (of their subjects: experiment 3) in movement tasks, could be equivalent to the increased discharge rates in the area AIP of monkeys.

Mirror neurons could be further defined as those neurons that fire both when we perform actions and when we observe the same actions carried out by a conspecific. The neurons mirror the behavior of another animal, as if the observer were carrying out the activity himself. These neurons have been identified in birds, primates, and humans in Broca's and the inferior parietal cortex of the brain. Mirror neurons first came to the fore in the works of Giacomo Rizzolatti, Leonardo Fogassi and Vittorio Gallese in the 1980's and 1990's.

Mecklinger and his colleagues state that their findings confirm the opinion that motor schemata for the use of objects are a constituent component of the retention network of working memory. These form part of object representations when one has to retain information, about manipulable object-forms, in working memory. These results strengthen the idea that working memory is the outcome of a "coactivation of perceptual and motor memories," whose activations are done in order to serve purposeful actions (Mecklinger et al., 2004, 268). They agree with findings (Fuster, 2002) that the major function of the premotor system is temporally integrating motor representations with other representational units that are relevant to a task into a sequence that leads to a goal. Mecklinger and his colleagues maintain that their studies provide strong evidence for the function of motor memories in the retention processes of working memory. They show how working memory for objects having motor affordance is based on motor programs linked to their use.

D. Motoric Encodings are Multi-modal, have Contextually Rich Properties and Multiple Features, and are Better Organized

In three experiments Bäckman, Nilsson, & Chalom (1986) test the viewpoint that memory performance, following motor encoding, is superior to that after verbal encoding. Under three conditions, they compare free recall following memory acquisition based on motor activities subjects carry out (motor encoding) and free recall after memory formation based on sentences subjects listen to (verbal encoding). The three conditions are: (1) undivided versus divided attention for organizable materials, (2) organizable versus unorganizable materials, and (3) undivided versus divided attention for unorganizable materials. They find that recall in both motor and verbal encoding decrease in divided attention conditions. They also observe a decline in recall for both motor and verbal encoding when subjects use unorganizable items rather than when they use organizable items. Moreover, they report greater clustering scores for motor encoding than for verbal encoding.

In the end, they conclude that we automatically encode the motor-activity elements of motoric encoding (such as motor features, texture, and shape), and strategically encode their verbal components. They propose that the multi-modal and contextually rich properties of motoric encoding facilitate the recognition and use of the semantic categories on which organizations of items are constructed. These properties help tasks after motor encoding to group and organize items according to their subordinate and super-ordinate categories. Hence motor encoding is better organized than verbal encoding.

Besides, Bäckman, Nilsson, & Chalom (1986) establish that memory for action events (motor activities) are multi-modal and remarkably deep. They argue this position based on a huge number of studies (Backman, 1985, Backman, Nilsson, 1984, 1985)[42]. There studies reveal a two-fold distinction between motor encoding tasks and verbal encoding tasks. In the first place, *motor encoding tasks are multi-modal*, since they involve many sensory systems at encoding. They argue that in reading the tasks to the subjects, the experimenters indirectly do an auditory presentation of their information. There is as well the involvement of the visual system during the presentation and execution of motor encoding tasks. Instructing subjects to do motor activities activates the tactual mode. Moreover, some motoric encoding tasks (such as 'chew the chewing gum and note how it smells') activate the gustatory and olfactory modes. In the second place, every motoric encoding task entails a "*variety of features*" forming the base for encoding. The features there are include, verbal, sound, texture, shape, and color features. There are also motoric features, arising from doing motor behaviors. Some of the features tender themselves in dual modalities, as in shape and motor features.

Such is the case that the multi-modal and contextually abundant properties of tasks on motoric encoding separate them from tasks on verbal memory. In verbal tasks the amount of properties could be restricted to the graphic, semantic and phonemic traits of the items. Consequently, the amount minimum for types of information we acquire, in tasks following motor encoding, is two. These include the verbal commands and the motor activities. In contrast, the typical presentation in verbal encoding could be "unimodal," argue Bäckman, Nilsson, & Chalom (Backman, Nilsson & Chalson 1986, 340).

E. Motor Influences, Memory Dynamics, and Cognitive Responses

Förster & Strack (1996) provide evidence to show that not only that compatibility of movements with cognitive contents persuades cognitive responses, but also that such motor influences do go beyond attitudinal persuasions to influence the dynamics of memory. Their experiments demonstrate that the correspondence/agreement of head movements with information contents not only decides the "persuasiveness of communication" but also mediates basic memory processes. They find that encoding and recall are poor when information does not concur with head movement. They discover that motor behaviors do still influence processing of information even when they disguise the social denotations of such behaviors to deter subjects from deducing judgments from them. Their participants base their encoding of positive and negative information on the head movements that concur with them. They note that the compatibility between the perceptual and the motoric which they find in their work is the product of a compatibility between the conceptual and the motoric, implying that the activation of thoughts and feelings and the carrying out of particular behaviors that concur with them rest on their "natural co-occurrence" (Forster & Strack, 1996, 429).

Zimmer and Engelkamp (1996) perform four experiments investigating the influence various controls of motor actions have on memory for these motor behaviors. They test subjects with: (a) verbal-to-motor-action tasks, wherein subjects do motor actions following verbal commands; (b) movement-to-motor-action tasks, wherein subjects do motor actions after the example of (mimicking) an actor (imitation). Precisely, they compare free recall of motor behavior that we encode either through perceiving motor actions, through imitating the motor actions we see, through doing motor actions following verbal commands, or through doing motor behavior following verbal commands in addition to imitating motor actions we see. They test memory for motor actions by recall or recognition of the motor behaviors by the subjects. In order to compare these movement tasks with the results of verbal tasks from other studies, they also add a verbal task. In verbal tasks that test verbal encoding and verbal learning, subjects simply here verbal meanings or denotations; they merely listen to action phrases and attempt to memorize them.

Their results reveal a better recall for motor actions we do than for verbal denotations we merely hear, in line with many studies before theirs. They report too that recognition for *motor* actions (movements) we do is "nearly perfect" compared to recognition for merely listening to action phrases (Knopf, 1991).They assert that learning through motor behavior, by doing motor actions, is a “very efficient encoding condition” (Zimmer & Engelkamp, 1996, 60). It involves lesser cognitive effort than does the usually effortful verbal encoding, they hold (Cohen, 1983). The results of their experiments are remarkable. Firstly, they find that, without any exception, all conditions of non-verbal encoding outdo verbal encoding. Secondly, they discover that within the conditions of non-verbal encoding of movement behaviors, memory is greater when subjects do motor actions on commands than when they imitate (doing after an actor) motor actions. Thirdly, they observe, interestingly enough, that imitating a perceived (watched) motor behavior does not led to an *additional* enhancement of memory when compared to perceiving (watching) only the motor behavior; and again perceiving (watching) a motor behavior done by someone else, does not led to an additional enhancement of memory when compared to simply doing the motor behavior yourself.

The finding that in all conditions of non-verbal encoding memory is better than in the verbal condition is consistent with a huge number of experiments on multi-modal (motor) encoding (Engelkamp & Zimmer, 1994). Zimmer & Engelkamp (1996) explain this effect not simply in terms of an “enriched conceptual encoding” but in terms of the added effect that information encoding acquired through visuo-kinesthetic motor program (non-verbal memory traces) has on recall.

Many researchers explain the enriched memory trace, they associate with the high memory performance in encoding via motor behavior, in terms of the motor components and the motor information required to do the motor action (Engelkamp & Zimmer, 1994). These researchers, Zimmer & Engelkamp opine, agree that as a result of movement (motor action) a somewhat instantiation of a motor program becomes part of the memory trace. Processing motor information devoid of an overt movement (watching someone move) is also known to have an almost similar effect.

Zimmer & Engelkamp (1996) also find that doing motor actions, following verbal commands, leads to greater memory efficiency than does imitating motor actions. They associate this effect (improved memory efficiency) with the varied routes to motor behavior in the two conditions. When subjects begin a motor behavior from verbal command, they explain, they are confronted with the meaning of the phrase and have to search the motor word-stock for the “visuo-kinesthetic motor” memory trace. The information they get from that program directs them as they do the motor action. This provides an additionally efficient memory trace.

Contrastingly, when people imitate a motor behavior, they directly use the information they perceive to direct their movement. A top-down generation of motor program is not necessary in this case. Should the processing of conceptual information be at all needed, that too would be minimal when we imitate motor actions. Zimmer & Engelkamp, thus, identify the crucial component in enhanced memory efficiency with the “generation of the motor program”. They maintain that selecting and evaluating an appropriate motor action, and putting in place the motor program, together make their contribution to memory trace and influence memory (Engelkamp & Zimmer, 1996, 73). Memory for motor action is at its best when the motor behavior is planned (top-down) rather than merely imitated (bottom-up). Doing motor action on command entails planning (top-down). Thus, *movement enhances memory, and how you generate the motor program is an added memory-enhancing factor*.

The third aspect of their finding is a little curious. They wonder why imitating refuses to enhance memory when contrasted with perceiving, and why perceiving hesitates to enhance memory when contrasted with doing motor action upon verbal command. Perceiving motor behavior and imitating motor behavior, they explain, afford us with the same movement information. Such that it becomes redundant when both are done. Neither imitating the motor behaviors we perceive (watch/view) nor perceiving (watching/viewing) a motor behavior done by someone else does introduce any novel information to our memory trace. Accordingly, memory performance remains unchanged. This indicates that a “common visuo-spatial core” is utilized in perception and action.

In a nut shell, the results of the study by Zimmer and Engelkamp reveal that memory for actions is not only dependent on doing motor behavior, but depends as well on the manner these motor behaviors are inaugurated or generated. Actions we do by imitating what we see are somewhat distinct from those we do following verbal commands. When we imitate, we directly utilize the information we perceive in carrying out a motor behavior, whereas when we do motor actions on command, we generate motor behaviors ourselves, and that involves planning. The former employs information from perception, bereft of selection and detailed planning of motor behavior. The latter looks up the motor program and thus plans in detail. The fall-outs from these varied avenues to action, say Zimmer and Engelkamp, are disparate memory traces and disparate performances. Nevertheless, merely observing someone else do motor action (perceiving,) is enough for the enhancement of memory performance, as does merely doing motor actions. Yet, when we merge these two, memory performance remains unchanged.

In Zimmer *et al.* (2000,) executing actions during study (engaging in motor behavior) enhances remembering of action phrases without improving relational information. Through this mechanism, pieces of information cross our minds in the absence of any active search; this process lengthens the recency effect. Zimmer and his colleagues establish the presence of an elongated recency effect and the relevance it has for the recall advantage of actions we do ourselves. They find that doing the motor activities, rather than semantic processing, brings about the effect. They discover that the “extended recency effect” is not a product of a deliberate memory strategy where previous items are displaced to make room for new ones. They observe that although executing an enigmatic task (a mathematic task) while attempting to remember lessens memory efficiency, it does not affect the extended recency effect. They, thus, provide experimental evidence that doing motor activities during study enhances the efficacy of an “automatic pop-out mechanism” in free recall.

In researches on memory for subject-performed tasks (SPTs; i.e., doing the motor activities during research,) subjects perform motor activities denoted by verbal commands (such as ‘pull the table’ or ‘kick the ball,’) from the experimenters. The objects are either handed out to them and they really carry out the motor activities, or the experimenters request them to do the motor behaviors without using real/physical objects (that is to say, they feign the motor behaviors.) Subsequently, subjects recall the commands on demand. We contrast this form of memory acquisition with verbal tasks (VTs; i.e., with the standard verbal learning conditions,) where subjects receive the same phrases for recall but do not have to do any motor activities (real or imaginary). But for a few additions, Zimmer and his colleagues follow this procedure in their experiments. In comparison to VTs, SPTs manifest heavily improved memory performance, as has been variously indicated in this paper. This definitive memory enhancement, through engaging in motor behaviors, say Zimmer and his colleagues, is a robust and credible facilitating effect. How come, they ask, that doing motor activities during study enhances free recall?

F. Doing Motor Activity, Item-specific Encoding, Reflexive Retrieval, and Free Recall

Advantage

As some studies report, relational-information availability heavily determines memory performance in free recall (i.e., inter-item information or item-to-context information (Hunt & Einstein, 1981)[51]. People assume that subjects do actively 'forage' their memory along the lines of encoded relational information, accessing earlier encoded information in this foraging process. Thus, it is held, weak relational structures precipitate low recall results, whereas rich relational structures produce high recall efficiency. Hence the degree of relational-information availability virtually decides the amount of materials to be recalled. This interpretation, Zimmer and his colleagues note, could lead us into believing that enhanced recall in SPTs is essentially the function of the superb relational information that SPT encoding enhances.

Yet, Zimmer and his colleagues (2000) maintain, available experimental evidence eliminates this probability. Doing motor activity during study (SPT), studies reveal, does not enhance the inter-item association. Koriat, Ben-Zur, & Druch suggest that input events, another person's behaviors, bear "deeper contextual integration" than output events, one's own behaviors (Koriat, Ben-Zur & Druch, 1991, 268). They point to studies showing that the direction of attention to the internal mental processes that underlie response generation, account for the generation effect in SPTs. Subjects remember responses they generate themselves much better because they utilize cues associated with the internal processes relating to their generation. So it is that the same processes associated with the superiority of one's own behaviors in memory for occurrences are also responsible for their lower contextual integration.

Subject performed motor activities do not improve the categorical organization either (Engelkamp & Zimmer, 1996: Zimmer, 1991). Moreover, order reconstruction is similar in subject-performed tasks and verbal tasks (Olofsson, 1996), indicating that temporal retrieval paths, which some assume to be critical for recall, are not improved by doing motor activity during study. On the contrary, engaging in motor activity impairs the establishment of novel associations between actions that are not related. The study by Engelkamp, Mohr, & Zimmer (1991), ascertains that self-performed motor behaviors yield "excellent item-specific information" that one can barely surpass or improve upon. It also concludes that carrying out actions not only produces excellent item-specific information, but as well impedes pair-relational encoding (of words: for both nouns and verbs) or pair integration (the integration of pairs of words.)

What is more, argue Zimmer and his colleagues, studies not only reveal that engaging in motor activity does not influence relational information, but that encoding, following carrying out motor activities during study, appears to minimize the relevance of relational information for memory. Concerning categorical lists, researches find that carrying out motor activities during study makes the correlation between organization and the amount of motor behaviors participants recall to be generally low (Engelkamp & Zimmer, 1996). Cognitive powers that are essential for relational encoding have been found to influence verbal encoding more than they do motor encoding (Cohen & Steward, 1982). Also, variables that have facilitating effects on relational encoding (such as lengthier study periods (Cohen, 1985) or intense conceptual processing (Zimmer & Engelkamp, 1999) affect verbal encoding more than they do motor encoding (i.e., memory formation after engaging in motor activities).

Alternatively, performing motor activity yields a recognition performance that is "nearly perfect" and is rarely hampered as tasks become increasingly difficulty. Given that (a) in free recall we observe an advantage of tasks on motoric encoding over tasks on verbal encoding, even as tasks on motoric encoding do not improve relational processes; (b) variables researches establish as affecting relational encoding exact only minimal influence on tasks on motoric encoding; and (c) the effect of tasks on motoric encoding (the effect of motor behavior) is especially “robust in recognition,” one cannot but agree with the view that the effect of tasks on motoric encoding is the function of “item-specific encoding” (Zimmer & Engelkamp, 1989).

Thus, it could be the case that performing motor activities during study improves item-specific rather than relational information, and this (improved item-specific information) is efficient in free recall that in turn occasions the advantage tasks on motoric encoding have. But then, one would like to know, Zimmer and his colleagues note, how this improved item-specific information gets to be efficient in free recall. Two explanations are at hand. First, when we search our memories, the attendant good item-specific information in motoric encoding enhances the subsequent process of recognition such that more items generated in the process are reflected in tasks on motoric encoding than in tasks on verbal encoding (Zimmer, 1991). Two, engaging in motor behavior elicits a unique process of recall that is not grounded in relational information. The sense is that, because doing motor activities heightens item-specific information, and this improves on the effectiveness of a scan-like process, remembering could be improved, even as relational information, and *ipso facto* the active search, remains unimproved.

Performing motor activity is an added retrieval component that does not require an active search in order to be effective, Zimmer and his companions opine. As in recognition, two processes sustain free recall. The first is a memory search that is directed; the second, a retrieval that is automatic. Engaging in motor activity during study enhances this process of automatic memory retrieval. Doing the motor behavior that the command of the presenter denotes, spawns exceedingly “distinct memory entries” of information materials, and these “prominent items” are inclined to automatic retrieval when subjects “think back” on recent events (Zimmer et al., 2000, 659).

Zimmer and his companions draw attention to Moscovitch who postulates that memories could “pop into mind” and that such a component “responds reflexively” in the absence of any memory search. In Moscovitch (1994) a memory module, which in a rapid and somewhat obligatory manner conveys to conscious experience the information relating to the tendered cue, mediates this recall process. This module responds spontaneously to cues. The module engages itself if an event gets ample conscious attention. Such that should the event reflexively come into contact with a memory trace, such as an intended behavior, then, the outcome of that encounter/contact is conveyed to conscious experience. Such is the case that we remember innumerable day-to-day events in the absence of any intention to recollect them: memories often “pop into mind,” in the same way as cognitively unconscious perceptual inputs “pop out” of their setting.

In line with the framework of levels of processing, argues Moscovitch, what decides what we recollect is not our intention to recall as such, but the degree to which we attend to events, deeply processing and properly organizing the information we get from them. Once consciousness thoroughly apprehends events, an automatic hippocampal component of memory, the hippocampus, obligatorily takes them up and encodes them (Moscovitch, 1994, 276-277).

Zimmer and his co-workers note that McDaniel and his associates (1998) posit a prospective remembering that stems from this type of reflexive memory, such that when we intend motor activities, they pop into mind in a manner indicative of spontaneity. McDaniel and his colleagues assert that “reflexive episodic associative” system of memory allows for and influences the process of prospective remembering (i.e., remembering to effectuate a plan at a given situation, such as remembering to pass an information to a colleague when he crosses your way). This demands spontaneous memory retrieval. The appearance of the target event (e.g., pumping into the colleague you intend to give a message) triggers a “familiarity process” that in turn stimulates the prospective remembering. Thus, one effectuates the intended behavior when one encounters the “target environmental event”.

McDaniel and his colleagues, therefore, propose that it is this reflexive associative system of remembering that mediates the retrieval of an intended activity whenever we encounter and process an environmental event that has been hitherto connected with the intended activity. They maintain that theirs offers an explanation of remembering in the absence of the prompting of any external agent, that is to say, when one is not in a retrieval frame of mind. They also note that the type of memory acquisition that promotes the “reflexive interaction” between an event information (cue) and a memory trace is the kind that offers increased distinctive information. This is the system that leads to spontaneous memories popping into mind, they maintain (McDaniel et al., 1998, 131).

Mandler (1994) too, proposes a “mind popping” process that is built on the integration of items, adding that the level of the item-specific information (its distinctness) determines the extent of the enhancement of the processes. Mandler makes a case for thought and remembering in the absence of any conscious effort to do so. Hitherto inaccessible memories and thoughts, he notes, come to consciousness after several trials (e.g., reminiscence or hypermnesia,) following elapsed time of pause, recess, recline (incubation,) or involuntarily as we do exercises not connected with them (mind popping). These phenomena form part of our day-to-day experiences. For example, instances abound when we attempt to recall a number of things (e.g., our first grade class mates) and succeed only in remembering a few**,** buton a subsequent attempt more names surface. We also have the experience of reaching an impasse while doing some simple calculations. We are, however, able to resolve the calculations with ease after discontinuing with them, and then returning to them sometime later. At other times we find ourselves abandoning the search after a futile attempt at remembering, for instance, the name of our biology teacher, only to experience the name popping into our consciousness much later without our intending it.

The three phenomena we described shortly, argue Mandler, “violate” orthodox tenets on memory and thought. Our inherited nineteenth-century teaching on rationality has no room for an enhanced memory in the absence of any mediating knowledge acquisition process. It has no place for problem solving by merely refraining from cogitating or reasoning on the problems. It has no notion of solutions to teething problems springing up or popping up into minds as we deliberately contemplate other matters. Let us discuss these three phenomena in more details.

Reminiscence Effect: The first of these phenomena, reminiscence effect, refers to recalling items on a delayed test that could not be recalled in the initial test. In reminiscence, forgotten items are remembered in the absence of any mediating chances for acquiring knowledge. It is a subset of hypermnesia, which denotes an improvement in net recall. For Mandler, at the center of this hypermnesia/reminiscence effect are the processes of organization and elaboration of underlying representations.

Elaboration: Inter-event elaboration refers to relationships between the representation of the event and other contents of the mind. This process connects mental structures to one another. It is held to be a conscious process that activates earlier formed links between mental contents, and permits novel links to be built, enriching both "activation and retrievability" in the process. Hence, activation can happen in the absence of any awareness or elaboration, but any elaboration necessarily generates activation, since it accesses the event representation.

Incubation: Incubation reflects the unintentional, mostly abrupt springing-up of an idea or a solution to some matter of concern, after an earlier failed attempt at resolving the matter. Experiments on incubation reveal that a delay could have an enabling effect on problem solving. Incubation rests on the processes of activation of underlying representations.

Integration/Activation: Integration/activation influences the relations among an object's/event's features. It is an automatic process that takes place whenever we process an event representation, Mandler discloses. Presenting information (objects, motor activities, events) provokes the activation of applicable existing units of knowledge (schemas) and upgrades the activation level of the event's constituent features. Integration takes place reflexively as the connections among the event's features that had been earlier established induce additional activation of the item's connected features, *integrating* the particular activated event. Activation/integration heightens as the representation is accessed again and again. If there is no such further activation, the representation's "steady-state activation" slims down to a low level. The higher the integration of a structure is, the easier it is recalled as a unit, the greater its distinctiveness from other (alike) schemas, and the higher the probability for facets of the schema to activate the entire schema. The human experience of heightened familiarity and "perceptual fluency," Mandler maintains, are but a few outgrowths of such activation.

Even as activation is principally a perceptual phenomenon - resulting in modality effects referred to as specific - because when an event is presented in a certain modality its features are the first to be activated; yet other modalities get comparatively activated, given that some other features also become active through "indirect verbalization, spread of activation," *et cetera*. (Recall that Zimmer and his associates contend that the very command to perform a motor activity also activates verbal features, while the performance itself activates motor features). What is normally referred to as implicit structures, asserts Mandler, is actually the operation of activation, while structures that are known to be explicit go with "elaborated structures".

Zimmer and his associates (2000) believe that tasks on motoric encoding enhance such a retrieval component that is based on item-specific information. Their belief is that it is this supplementary mechanism that improves free recall of the motor activities we carry out. Their working assumption is that the mechanism is a somewhat passive process of retrieval that does not require a voluntary memory *scan*. The only intentional component, they hold, is that subjects think back; when they do, items, amply distinct, spontaneously pop into conscious memory devoid of any deliberate search. The automaticity of the process lies in the fact that once started, it does not require any active support. In addition, increasing effort adds nothing to its effectiveness. The efficiency of this automatic process of retrieval is traceable to its power to "stand out" from the "noise" of other memory materials. Performing a motor activity improves on the distinctiveness of a memory material. Thus, in tasks on motor behaviors subjects do, a greater amount of materials is automatically remembered than in tasks on verbal memory formation; of course, these auto-retrieved materials are recalled additionally to those retrieved due to active search.

Zimmer and his colleagues aim at providing experimental data for this high-level effectiveness of the auto-retrieval process in tasks where subjects engage in motor activities. They find that in these tasks there is an extended recency effect, and that the free-recall advantage which these tasks enjoy, majorly rests on the items towards the end of the list. Zimmer (1991) notes that motor activities undertaken recently are incredibly accessible, bereft of any directed search, and that this facilitating effect explains, in part, the greater recall advantage observed in SPTs. (i.e., tasks on recall after engaging in motor activities: motoric encoding). Zimmer opines that, in tasks on recall, following motoric encoding, subjects simply nurse the intention of knowing what they did lately, and that following this general intention to remember, the latest motor activities they carried out of late "pop into conscious memory." This process leads to a substantial extension of the recency effect. Zimmer and his colleagues suppose this extended recency effect to be the outgrowth of an auto-retrieval, which is improved upon by the item-specific information that accompanies our engaging in motor activities. They term this auto-retrieval process a "*pop-out mechanism*".

It is with the above-mentioned understanding and mind-frame that Zimmer and his colleagues (2000) undertake the experiments we are about to relate. They verify whether there is more extension of recency effect in tasks following motoric encoding than in tasks after verbal encoding. Also, they test their supposition that the speculated pop-out mechanism is reflexive and spontaneous, and that it is engaging in motor behavior that occasions its effectiveness. Their first two experiments investigate if the recency effect in tasks after motoric encoding is actually extended. Here, they demonstrate that lists of several lengths show "changed serial position effect." Their third experiment establishes that it is actually performing motor activities, instead of a greater elaborate processing, that brings about the enhancement in recency effect. In the fourth and fifth experiments, they verify whether the free-recall advantage, of memory following motoric encoding, derives from some specific strategies of retrieval (such as the last-in, first-out technique). Here, they demonstrate that a technique of this kind is incapable of generating the effect in tasks after verbal encoding (fourth experiment); they prove too that doing a secondary task in the course of retrieval does not remove the extended recency effect (fifth experiment). In what follows, we present a discussion of their findings in some detail.

To begin with, we reiterate that the aim of the experiments is to demonstrate that the free-recall advantage, which tasks on encoding following self-initiated motor behavior have, is the function of an enhanced auto-retrieval process that Zimmer and his colleagues call the *pop-out mechanism*. This mechanism, rather than being an active search that utilizes relational information, is a passive process. It is believed that when subjects think back to what they had done lately some items pop into conscious memory bereft of any deliberate search for specific memory materials. The susceptibility of any memory material to this *popping-out* is a question of the "quality of its memory trace," a quality that is generated, or at least improved upon, when we engage in motor activities. The motor activities done of late supply memory entries that we can briefly access. Every added item encoding diminishes the distinctiveness of the earlier encoded items. Thus, the pop-out mechanism manifests its highest efficiency at the recency section of a study list; the more removed positions of input are from the end-positions, the lesser the pop-out mechanism.

Given that performing motor activities during memory acquisition improves upon the efficiency of the pop-out mechanism, the recency effect in tasks on memory, following motoric encoding, is understandably more extended than it is in tasks on memory after verbal encoding. These extra recent items we retrieve, contribute heavily to the free-recall advantage of tasks on memory following self-initiated motor behavior. Justifying the predictions of Zimmer and his colleagues, the results of their experiments reveal that, (a) there is a further extension of the recency effect in tasks on memory after motoric encoding, but not in tasks on memory following verbal encoding; (b) this facilitating effect is actually a function of our engaging in motor activities; (c) the effect is not the outgrowth of any specific strategy of active search; (d) the effect is rather automatic.

They find that the extension in recency effect is a common feature in tasks on memory following self-performed motor activities. They notice it in lengths of item-lists (i.e., lists of motor-activity phrases) that definitely exclude any influence of primary effects on the shape of the curve of the serial position in the end-positions. The effect of this mechanism declines the farther away the end-position of the list is; it remains, though, when you count from the last item, till 15 input locations (second experiment). They demonstrate too that what is responsible for the extended recency effect is engaging in motor behavior. Their employing semantic task rather than verbal-surface encoding task to improve on item-elaboration fails to bring about this effect in VT, even as this manipulation shows strong influence on memory performances in Vts. In this experiment, they ask subjects to judge the assertions presented to them, and in the SPT condition, they ask them to perform the motor-activity items in addition. This semantic task should induce a better-elaborated memory acquisition of items than do verbal surface tasks, leading to an improved memory performance. In the third experiment, they discover that manipulating the orienting task, the way they do, does not alter the effect in SPT.

Their fourth and fifth experiments demonstrate that the extension in recency effect is an auto-retrieval effect and that it is not a function of a deliberate search for recent memory materials. Asking subjects to begin recall with the last items in the list (i.e., active or deliberate search,) a strategy of retrieval that ought to be favorable to retrieval of recent items, gives the last item on the list, and it alone, an advantage; it does not enhance the reach of the recency effect (the fourth experiment). Moreover, doing a secondary task in the course of testing (the fifth experiment,) which ought to interrupt an active search, fails to affect the shape of the recency effect. They still observe the extension in recency effect in tasks on memory following subject-performed motor activity (SPT). In the light of these results, Zimmer and his colleagues (2000) rightly conclude that the mechanism responsible for the extended recency effect in SPTs is an automatic process of retrieval that does not require any active assistance as it runs.

In the end, Zimmer and his colleagues (2000) attempt an explanation of the fundamental processes that make up the pop-out mechanism. They speculate that item representation could better be understood as the particular feature-set that is active in the course of memory acquisition, arguing that these features go on to form our episodic memory representation. For us to experience the “original set” as a memory episode at retrieval, it needs sufficient reestablishment. This involves a reactivation of the “correct features” and a binding-together of these features to an episode. The only way this differs from the memory acquisition phase is that at retrieval the features issue from memory instead of from perception. Thus, the retrieval of an item is dependent on whether its constituents are accessible as well as on whether the correct features are put together among all those that are active. What is more, they believe that performing a motor activity occasions a temporary increase in the accessibility of its constituents, and that it activates extra motor-activity components that intensify the binding of the features involved.

Their sense is that feature-sets that had been coupled in intentional motor behaviors carried out of late, could occasion an automatic reestablishment of the original episodes in the absence of external cues, when the "conjunctions" are unique enough to "pop out from the noise" of irrelevant mental materials. This automatic retrieval, they hold, is responsible for the pop-out mechanism. Hence the effectiveness of this process of popping-out relies on how unique the memory units are, rather than on how available the retrieval cues are. A unique unit has a high probability of its constituents recombining with materials from the same memory unit, and a lesser probability of its constituents combining with constituents from other units.

Researches, they point out, indicate that carrying out motor activities during study enhances item-specific information; thus, performing motor activities improves upon the distinctiveness of units of memory. This gives motor-activity items carried out during study their acclaimed advantage in the pop-out process. So it is that *the memory-facilitating factor in SPT is connected with performing motor activities and this factor favorably affects recall efficiency through the enhancement of the process of popping out.*

Engelkamp & Zimmer (2002) investigate the issue whether the free recall advantage of personally doing motor activities (movement behavior), over merely listening to their verbal descriptions, is traceable to better relational encoding of self-performed tasks (SPT) than of verbal tasks (VT). They discover a clear self-performed-task effect in free recall that is independent of the type of encoding. They report that the significant increase in free recall in self-performed tasks (SPTs) does not result from better relational encoding in SPTs relative to VTs. In all, their experiments reveal that the effect of personally performing motor activities (movement behaviors: SPTs) follow from the fact that self-performed motor behaviors provide "motor information" and yield "good item-specific encoding" (Engelkamp & Zimmer, 2002, 95&96).

Engelkamp, Seiler & Zimmer (2004) point out that differentiating item specific from relational information serves to explain explicit memory. Item-specific information describes the information that is specific to a particular item and that permits the item's reintegration into and discrimination from others. Contrastingly, relational information denotes the association among items. It aids memory search processes. These two forms of information subserve explicit memory performance. Klein and his associates (1989) show that we can simultaneously measure relational and item information by calculating gains and losses in a multiple recall procedure. Their experiment proves that an increase in item encoding manifests itself in an increase in the amount of item gains, while an increase in relational encoding slims down the quantity of item loses. Item gains, say Engelkamp and his colleagues (2004), denote the quantity of item one remembers in the real trial but which one had not been able to remember in the earlier test trial. Item loses, on the other hand, stand for the amount of items one leaves out in the real trial but which one had remembered in the earlier test trial.

The assumption is that good relational information yields consistent retrieval instead of fluctuations in loses from trial to trial. It is also assumed that focusing attention on an item yields rich and far-reaching sets of features. This gives rise to items that are richly encoded and that have suitable memory strength, which in turn leads to increased item gains.

Engelkamp and his companions (2004) remark that the celebrated advantage that SPTs have over VTs is traceable to the proposal that SPTs have greater item-specific information than VTs. A principal explanation for this is that *carrying out motor activities compels subjects additionally to focus on individual items* much more than any verbal learning could ever pressurize them. Thus, tasks on encoding, following self-performed motor activities (SPTs,) should proffer enhanced item-specific information and greater item gains than tasks on encoding following verbal learning (VTs).

Engelkamp and his collaborators (1991) propose that in activities not related to one another, enactment inhibits the establishment of inter-item associations. In SPTs, subjects concentrate on individual items; they need to carry out the motor activities distract them away from relational encoding. VTs, on the contrary, make better room for participants to flexibly allocate their attention to the processes of relational and item encoding. Subjects in VTs tend to use strategies of active processing and make active searches for inter-item associations (Engelkamp, 1998). Given that in SPTs performing motor activities make it difficult for subjects to associate activities not related to one another, encoding in SPTs is not fitting to yielding relational encoding of items that are not related to one another.

Thus, Engelkamp and Seiler (2003) judge that this prospect for VTs to have increased relational processes should result in a lesser amount of item loses in a VT encoding than in a SPT encoding, when we employ the multiple recall technique. They find credible evidence confirming their judgment in three experiments, where they employ multiple free recall testing that uses gains and losses of items as manifestations of item-specific memory formation and content-based relational memory acquisition. Working with action phrases that are not related to one another, they observe higher item gains following SPTs than following VTs (i.e., greater item-specific encoding after SPTs than after VTs) and higher item loses following SPTs than following VTs (i.e., weaker relational encoding after SPTs than after VTs).

Engelkamp and his colleagues (2004) also attempt to ascertain the extent to which items that fit into the same category are remembered together (i.e., in a cluster: clustering). Engelkamp and Zimmer (1996) explain that presenting motor-activity phrases that fit into the same category (e.g., ‘enter the car;’ ‘switch-on the ignition’) side by side their particular motor-activity concept, gives rise to an automatic activation of their “categorical superordinate concept” (e.g., driving). Engelkamp and his colleagues (2004) argue that this process of reflexive activation-spread should evenly boosts clustering in SPTs and VTs.

The suppositionis that relationally processing “categorical relations” rests on knowledge acquired prior to experiments, and happens automatically. Relational processing of items that are not related to one another, on the other, is believed to rely on inter-item associations we generate in the course of attending to the episode at hand, and this goes with the processes of strategic encoding (Engelkamp, 1998). This explains why working with unrelated lists of items leads to lesser losses in VTs than in SPTs. It as well clarifies why clustering scores with categorically related lists of items, show no difference in SPTs and VTs.

It is against this backdrop that Engelkamp, Seiler, & Zimmer (2004) deploy the multiple recall approach to investigate the place of relational and item information in memory for actions, by way of calculating the quantity of item loses and item gains in a number of trials. They intend to establish if clustering scores and item loses give uniform outcomes, when we work with lists of items that are categorically structured. They believe that the clustering effects and the amount of losses in SPTs and VTs would not differ, with categorically related lists. They predict higher item gains and greater free recall in SPTs than in VTs, given the better item encoding in SPTs than in VTs.

They report observing the well-know SPT effects in their experiments. They observe that free recall in tasks on encoding following subject-performed motor activities (SPTs) is higher than free recall in tasks on encoding after verbal learning (VTs). They find that SPTs yield higher item gains than VTs. This finding corroborates the view that SPTs provide more elaborate item-specific information than VTs. They also find no difference in the amount of item loses in SPTs and Vts. Again, this finding indicates that SPTs and VTs evenly yield relational information. They observe no difference in clustering scores between SPTs and VTs, when the structure of the list of items is obvious, such as when they present the items of every category in blocks; but they record clustering differences between the two when the structure of the list is not instantly noticeable, such as when they present the items of the lists randomly. In the later cases, clustering scores in SPTs are higher than those in VTs.

Concerning item-specific information, their working assumption was that given that performing motor activities induced a surge in processes considered to be action specific, which enhanced the memory trace of an item, the demand to carry out actions would improve upon item-specific encoding in comparison to verbal tasks. The demand compels the subjects to understand the action, to make it concrete so as to be enabled to plan and ultimately carry out the action. A demand of this kind does insures a rich conceptual encoding (Zimmer & Engelkamp, 1999). It also makes the brain’s motor system become active. This proposition does explain the SPT effect (the advantage motoric encoding has over verbal encoding). Engelkamp, Seiler, & Zimmer (2004) had predicted that item-specific encoding should be richer in SPTs than it is in VTs, and that, thus, one should see greater item gains in SPTs than one finds in VTs. They plainly and unmistakably find this pattern in their first and second experiments.

In the end, they suggest that verbal tasks mostly make room for processes of encoding that are flexible and that they match strategic relational processes of memory acquisition. Thus, with action phrases, verbal tasks permit additional flexible and strategic relational processes of memory acquisition than do motoric tasks that compel subjects to concentrate on processing individual items and rely principally on automatic relational processes of memory formation.

Engelkamp, Seiler, & Zimmer (2005) demonstrate that intentional relational memory acquisition could be more effective in verbal tasks than in subject-performed tasks and affects the level of clustering. If the structure of the list is not immediately noticeable, prompting intentional memory acquisition by displaying the labels of the categories before the exhibition of the list and requesting participants to utilize this prior information raises clustering in verbal tasks rather than in subject-performed tasks. Devoid of prior information, clustering scores of verbal learning tasks and motoric encoding tasks do not vary; with prior information, clustering scores become greater in verbal tasks than in motor tasks. The major implication of this investigation is that participants in verbal tasks gain more from being aware of the labels of categories well ahead of time than do participants in motor tasks when category-structures of lists of items are not immediately clear, such as when one randomly shows them the lists of items. Whenever there is this type of prior notice, clustering scores in verbal tasks become greater than those in motor tasks. This finding agrees with the proposal that verbal tasks make for superior intentional relational memory formation than do motor tasks. The fallout is that clustering scores are greater in verbal tasks than in motor tasks when we let participants see the

labels of categories well ahead of time and ask them to put these into use.
Concerning free recall, two findings of the investigation by Engelkamp, Seiler, & Zimmer (2005) stand out clearly. Firstly, unconstrained by lists and changes in instructions, they consistently observe a motor-encoding effect (SPT effect). Secondly, raising clustering scores by prior notice of the categorical structure of the lists of items does not improve or raise recall scales. The first observation is traceable to the highly effective item-specific encoding in memory formation following the carrying out of motor behaviors. This is so superior that the greater relational memory formation in verbal learning is not enough to offset it. This observation has a direct bearing on the second discovery that an increase in clustering in verbal tasks does not improve free recall.

G. Movements, Memory, and Learning

Henderson and his associates (2005) note that faces are the most pivotal and salient of visual stimuli that humans encounter. Faces, they opine, are at the center of our social interaction, affording us with crucial information concerning the identity, intention, and emotional state of others. They also note that many a cognitive, perceptual, and motor task reveals a coupling in real-time between the movements of the eye and the ongoing processing of perception and cognition. Against this backdrop, Henderson and his companions undertake to study the role of eye movement in face learning. They partition their experiment into learning and recognition sessions. The learning session consists of two blocks: unrestricted looking learning block and restricted looking learning block. In the unrestricted looking learning block, subjects move their eyes naturally while learning a couple of novel faces. In the restricted looking learning block, they restrict their gaze to the center of the faces. Henderson and his associates then test recognition of faces learned in both conditions. They record eye movements in both unrestricted looking learning condition and recognition. Whereas they record a higher recognition accuracy in the unrestricted looking learning condition, they observe a “clear deficit” in the restricted looking learning block. This demonstrates, they submit, that moving the eyes (saccadic eye movement) does play a functional role in face learning. (Saccadic eye movements are the quick movements of the eyes by which we transfer the gaze from one point of fixation to another).

One other strong experimental evidence that movement influences memory is the finding that secondary tasks that require the movement of the eye or of the limb (and by extension, any spatial movement at all) interrupt spatial working memory, resulting in significant loss of memory for locations. Lawrence and his colleagues (2001) perform three experiments to examine the functional role of eye and limb movements in the retaining of information in spatial working memory. Their study shows that some movements negatively influence working memory for spatial locations but not memory for verbal information.

The results of their first experiment show that reflexive saccades (reflexive eye movements) interfere with the maintenance of information on location in working memory but does not interfere with memory span for letters (verbal working memory.) The second experiment replicates this finding. It reveals that other forms of eye movements (especially saccades and pro-saccades, and to some extent anti-saccades) also do significantly affect spatial working memory. This experiment shows the extent of the interference effects in spatial working memory to be independent of the form of eye movement performed. Furthermore, in all three forms of eye movement, working memory span for spatial locations prove to be a lot more affected than working memory for verbal information. The results of the third experiment demonstrate that limb movements also interrupt spatial working memory. In this experiment, limb movements subjects do while maintaining fixation, yield as much interruption of spatial working memory as does saccadic eye movements.

In all, these findings indicate that interference issues from a “common property” that spatially oriented movements share. They also suggest that the effects of this common property are to be found principally in the visuospatial sketchpad. (The visuospatial sketchpad is a subsystem of the working memory said to be responsible for the temporary maintenance of visuospatial information in working memory. Furthermore, although one of the eye movement forms (anti-saccades) entails the inhibition of reflexive saccades, Lawrence and his comrades curiously observe that their experiments show no significant dissimilarities in the extent of interference in all three. The absence of inhibition effects on spatial working memory and the “relative insensitivity” to eye movements of the working memory for verbal information, all indicate, so Lawrence and his collaborators, that these movements bring their effects to bear to a greater extent on the visuospatial sketchpad and lesser on the central executive. (Thought to be associated with inhibitory control, the central executive component of the working memory is held to be an “attentional control mechanism,” charged with selecting information to be temporarily retained in and assigning resources within the working memory network.

Lawrence and his colleagues remark that the revelation that the different eye movement forms affect the retaining of information on spatial locations in working memory would agree with the proposal by Bradley in 1986 that eye-movement-based rehearsals subserve the retaining of information on spatial locations in working memory. In other words, it is possible that secondary tasks that entail the movement of the eyes interfere with rehearsal, giving rise to loss of information on spatial locations. Be it as it may, argue Lawrence and his colleagues, the finding of the third experiment, where a secondary task that entails the movement of the limb also interrupts working memory for spatial locations, hardly lets itself be explained away by such eye-movement-based rehearsal processes. In addition, citing more recent studies in psychology (Washburn & Astur, 1998) and neuroscience (Fuster, 1995)[68] they contend that visuospatial information must not be rehearsed to be retained in memory; contrary to the eye movement rehearsal view that requires rehearsal in order to retain information in working memory.

Thus, it makes sense to associate the mechanism responsible for the interference by eye and limb movements with the possibility that both types of movement interrupt activity in the positive feedback loop between the posterior and prefrontal cortices that sub-serves the maintenance of spatial information in working memory. In the opinion of Lawrence and his colleagues, this mechanism seems to be a credible explanation in that it involves a shared property of all spatially directed movements, instead of relying on properties specific to one movement form or the other (Lawrence et al., 2001, 443).

The effects of shifting attention on spatial locations and of having to plan spatially directed movements, could also be possible mechanisms responsible for interference with memory for spatial locations. Shifts in attention on spatial locations could interfere with memory, given that they intrude upon a rehearsal process based on attention, or merely for the reason that we need to pay attention so as to retain spatial information in working memory. It could also be that movement planning interferes either in some direct way by disrupting rehearsal, or in an indirect manner given that such planning entails shifts in spatial attention. For Lawrence and his colleagues, whatever the mechanism implicated, their studies reveal that spatially directed movements affect working memory principally by interfering with processes in the visuospatial sketchpad (Lawrence et al., 2001, 443).

Alternatively, experimental evidence that saccadic eye movements influence memory positively could be found in the work of Robert Althoff and his colleagues (1999). They observe shifts in patterns of eye movement for items subjects had earlier on seen. These shifts in eye movement patterns, they propose, offer evidence that earlier exposure to items on which subjects would be tested changes the nature of the perceptual processing subjects accord those items later on. They show that monitoring eye movements could be drawn upon to indirectly measure on-line shifts in the processing of stimuli resulting from earlier exposure. The pattern of eye movements to different regions of a repeated stimulus, they explain, yields information on the representation of that material in the viewer's memory. One does not need the viewer's oral reports or explicit memory judgment to ascertain this fact.

In another study, by letting their subjects look at novel scenes, repeated scenes, and earlier experienced but doctored scenes, Althoff & Cohen (1999) employ measurements of eye movements to acquire information on the manner of our representation of the "changing world." Using indirect measures acquired through monitoring eye movements, they explore the extent and magnitude of viewers' representation of the world, seeking to know to what detail we represent the changing world as we look at it. The central measure in their experiment is to ascertain to what extent their subjects' eye movements are attracted to the "critical regions" of the *doctored* scenes.

They let their subjects watch a monitor while they present series of real-world scenes. In one of the experiments, subjects answer questions relating to two objects in the scene on display. In another experiment, they simply study the scenes and recall them later on. The experimenters, while repeating some scenes and their corresponding questions across blocks, display some scenes only once. In a final block, the experimenters *doctor* a half of the repeated scenes (adding or removing some elements of the originals).

Their results show earlier exposure to the scenes producing changes in on-line processing. They observe eye-movement-based memory effects in the series of scenes that had been repeated. They record a "relational manipulation effect" in the eye movements of subjects for scenes that were *doctored* in the final block. They observe that subjects direct an increased amount of their overall fixations to the *doctored* region, in comparison to the way other subjects look at the same region when no doctoring had taken place.

They report that their subjects required maintaining detailed representation of the scenes over a period of time for one to observe the relational doctoring effect in the final block. The results of the experiments indicate, they opine, that people do indeed form and retain detailed representations of their world in memory; to the extent that when that world is altered, the movements of their eyes are directed towards the location of that alteration. It would seem our eye movements are naturally attracted to changes in our memory representations, making tracking eye movements a reliable technique for identifying changes in our world.

Thus, Althoff and Cohen (1999) identify eye-movement-based memory effects with a change in the nature of processing that derives from attempts by viewers to optimize information extraction through the saccadic movement of the eyes. In two experiments, in a range of various processing tasks, they demonstrate an eye-movement-based memory effect as subjects employ different patterns of eye movements to process novel (non-famous faces) and repeated (famous/familiar faces) stimuli. Analyzing eye-movement behaviors, they examine how subjects look at faces, and how this varies as a function of previous exposure to familiar faces. The results reveal an eye-movement-based memory effect that demonstrates changes in the manner we look at items we had previously experienced, in comparison to new items. They observe that the effects of previous exposure ensue in spite of the kind of processing task involved. Such findings, they assert, lend credence to the notion that the dissimilarities one finds in the eye-movement behavior between novel items and familiar ones echo an "obligatory consequence" of earlier exposure, or put differently, previous processing of familiar materials. They describe this as a "reprocessing effect" issuing from re-engaging on many occasions the analyzers of our visual-pattern and the machinery of the brain that processes faces.

They report the effects of previous exposure in many aspects of eye movement behavior in the various variables of their experiments. They establish a shift in the sampling behavior we utilize in searching for information. They report that sampling behavior for *searching through* unfamiliar faces appears adapted to optimizing the extracting of information. In comparison to looking at familiar faces, searching through novel faces goes with additional sampling, with increased regions being sampled, reduced symmetric searching, and an increased constrained and intense sampling of the internal face features. Indicating that it is a strategy of sampling, the effects of previous exposure surface early enough in viewing non-familiar faces (inside the first five fixations). Remarkably, the fact that this eye-movement-based memory effect surfaces early in viewing, indicates that it influences even the very initial phases of face processing.

Dissimilarities in the sampling behavior of viewers provide evidence of dissimilarities in the manner we process new and repeated information. Measuring eye movement behavior helps us explore such changes, so Althoff and Cohen. They observe that viewers direct a significantly greater level of fixation to the internal features of non-familiar faces than they do to familiar ones. This heightened dependence on internal face-features for *searching through* non-familiar faces, they explain, belongs to a rather larger pattern of searching behavior in looking at non-familiar faces. Its relevance lies in the pertinence of the internal face features for identifying one by one's face. *Searching through* non-familiar faces calls for a greater efficient sampling of the features of the face. In the light of the basic human face symmetry, asymmetric searching is the greater "efficient sampling strategy" (e.g., having already sampled the right eye, one would fish out more relevant quick information by sampling the mouth or nose straightaway, instead of sampling the left eye too).

Mary Smyth and her colleagues have carried out a couple of studies on space, movement and working memory. Their experiments reveal that encoding (visually) observed movement of someone else demands visuo-spatial processing, and *recall entails motor activity*. Nonetheless, to encode an entire movement pattern of the body is influenced differentially by secondary tasks on patterned movements and spatial (sequencing) movements. This differential effect does not affect memory formation on movements directed towards spatial targets.

Smyth and her comrades (1988,) thus, distinguish between movements (e.g., motioning someone to a chair) where the goal of the activity is to locate a target in space, and movements (e.g., generating a certain dance pattern or choreography) where the goal is the pattern or configuration of parts of one's body. The former is basically spatial; the latter, primarily configurational, they hold. They argue for the possible presence of resources employed in recalling configured movement that may differ from those we apply in recalling positions in space. They discover that their subjects moving to spatial locations while viewing body movements, does not affect the amount of body movements they recall. Thus, spatial movement does not interrupt the encoding of configurations of the body. Configured movements (choreography), on the contrary, do influence the encoding of body configurations. Hence Smyth and his colleagues propose that memory for configured movements may entail applying a "body-centered rehearsal mechanism" to retain seen positions in working memory till we recall them.

Smyth and her associates (1990) study the rehearsal of movement patterns (of the type mentioned above) and the way we recall them over intervals engaged with intervening tasks or those free from any intervening preoccupation. They find that when subjects perform, watch, or encode a sequence of social locations as they attempt to maintain movement patterns in memory, recall of those movements are not affected. Inversely, when subjects perform, watch, or encode a set of patterned movements while attempting to retain movement patterns in memory, there is a drop in the quantity of movements they are able to recall. Nonetheless, whereas looking at movements to series of spatial positions during intervening moments affects memory information on order placements, looking at patterns of movement during intervening moments does not affect memory for series of positions in space.

Put simply, the results of the experiments by Smyth and her colleagues (1990) reveal that whereas similar tasks interfere with rehearsal, dissimilar ones do not. Until interference patterns show up, distinguishing between similar and dissimilar tasks is impossible, though. *Both configurational and positional tasks entail spatial processing during encoding and movement during recall.* Viewing somebody change his body's configuration requires visuo-spatial processing, yet this hardly affects recall of spatial locations. Spatial positions, Smyth and her colleagues explain, do seem to be retained in a system of rehearsal that the processing of novel spatial stimuli does not affect. In contrast, viewing additional movement configurations affects maintaining configured movement in memory. It is possible that these movements are retained in a system that the outgrowths of spatial evaluation of the body shape access directly. This kinesthetic-spatial system, say Smyth and her colleagues, may be the underlying factor in movement imitation.

Again, authors of children's literature, dance teachers, and movement therapists show that teaching through dancing and movements turn out having tremendous positive effects on memory. Salome Swaim (1997) reports a process of effectively teaching pre-kindergarten girls by incorporating teaching materials (such as myths and stories) into dances and movements. Her *dancing a storing* describes a method of weaving movement patterns into storytelling that, by individually stimulating children's "multiple intelligences," maximally accesses their imagination, optimizes their cognitive functioning, and "impacts very positively" on their memory.

She reports a process of telling stories to kindergarten children, "who then rework and dance" the stories, extracting their relevant underlying pedagogical implications. She reports that weaving patterned movements into teaching materials in this way, dancing stories, leads to a comprehension and "long-lasting memory" of advanced language and literature, a boost in elegance and physical control of the body, improvement on the power to energetically and effectively but safely interact with fellow children, and affords a handle on expressing feelings safely, creatively and appropriately.

Yawkey (1979) does a study involving two hundred and forty infants in private day care, Kindergartens and primary schools, between the ages of five, six and seven. He discovers that employing play forms such as "body action movements" and puppets in rehearsing story contents is an "extremely effective way" to develop the learning of language and reinforce memory in infants. His study reveals that in contrast to non-play situations, in (motoric) play situations, both self-acting and puppet play as well as rehearsing in the course of and after storytelling become highly effective in facilitating aural language understanding and recall.

His results show that five-year Olds perform better on aural language learning and recall when they use puppets during storytelling and self-action subsequently to rehearse the story. Manipulating puppets for rehearsals in the course of the storytelling maintains attention better and offers five-year Olds more information bits for recall. Besides, his six and seven-year Olds recall more correct words than the five-year Olds. Notably, children who rehearse his stories play-acting (moving around) recall more correctly than those who do not play and *move around the stories.* He concludes that incorporating playful movements into storytelling does seem to be more effective than mere discussions in rehearsing the contents of stories and enhancing aural language learning and recall.

Not only that movement has a facilitating effect on learning and memory, but also information acquired from the use of “kinesthetic stimulation” by applying persistent pressure on the joint, enhances *learning and retention* of motor skills. In Jarus and Loiter (1995,) forty healthy women, aged between twenty and thirty, learn a gross motor skill where they use their two legs one after the other to kick a football, not letting it touch the ground. Each of them throws the ball in the air, kicks it with the right foot, and with the left, and then catches it with the hands. Divided into two groups, those in the kinesthetic stimulus group learn the task while an elastic load is fastened to both of their knee joints with elastic bandages.

Jarus and Loiter report that participants in the kinesthetic stimulus group perform better than those in the non-kinesthetic group. They observe that the kinesthetic stimulus appears to facilitate the learning of the task at the skill acquisition phase. They report that the kinesthetic stimulus seems to facilitate not only motor task performance, but also the “acquisition and retention of the task.” Those in the kinesthetic stimulus group, they note, seem to do better in learning the task as they practice with kinesthetic stimulation and seem to carry out the task better when the stimulation is later taken away than their non-kinesthetic stimulation counterparts. The encoding and retention of the kinesthetic information in memory seems richer with the kinesthetic stimulation.

H. Retrieval and Motor Information Acquired during Memory Formation

Studies in functional brain imaging, Nyberg and his companions (2001) point out, show that sensory-specific areas of the brain that become active during perception/memory acquisition of sensory-specific materials also get active during memory retrieval of those same materials. Indications are that reactivations of some of the memory formation activities rather than being due to some selective attention, could be actual retrieval effects. Findings from studies by Persson & Nyberg (2000) and Nyberg *et al*. (2000) taken together, indicate that sensory-specific areas of the brain become active during memory acquisition as well as during memory retrieval of sensory-specific items.

In the positron-emission tomography study by Nyberg *et al*. (2000), when subjects remember that visual words had been matched with sounds during memory acquisition, some of the auditory areas of the brain that were involved during memory acquisition become active. Following word-sound encoding, they also observe that auditory brain areas become active during recognition of visual word, even when retrieval of auditory information is not required. Collectively, these findings extend evidence that retrieving specific event information has connection with reactivation of some of the areas that were engaged at the encoding of this information. They provide support for the idea that sensory features of multi-sensory information on events could be stored in some of the brain regions that get active during memory formation. This, argue Nyberg and his colleagues, could be one more evidence for the power of reintegration, that is, the ability of part of an encoded complex of stimuli to evoke the entire experience. Importantly, it offers one more instance of where the processes of memory formation and memory retrieval meet in our brains.

PET (positron emission tomography) and fMRI (functional magnetic resonance imaging) are hemodynamic techniques that estimate the activity of the brain by measuring changes in blood flow. Researchers employ them to investigate the functional neuroanatomy of cognitive functions. Again, cognitive theories of episodic memory maintain that some form of synchrony between memory acquisition and retrieval is important for an efficient memory performance. Thus, Persson and Nyberg (2000) employ PET to study the overlap in the processes of memory acquisition and retrieval. Precisely, they investigate the overlap in brain activation patterns for memory acquisition and retrieval of item information, spatial information, and temporal information. They aim at ascertaining if some areas of the brain become active during memory acquisition as well as during retrieval of specific event information. Although they do not observe overlap in the same regions for the three types of event information, analyses of their overall findings reveal overlap in patterns of activation for all three categories of event information.

Conclusion

On a more general note, Nyberg and his colleagues submit that their recording of differences in activity patterns in the motor regions, as memory explicitly retrieves specific information on events, provides further evidence that some types of implicit memory, for instance learning motor sequence, have links with motor brain regions. Put together, these findings indicate that motor regions of the brain take part in some non-motor cognitive operations. To sum up, Nyberg and his colleagues disclose that their results tally with the reactivation hypothesis that certain regions of the brain that are activated at the perception and encoding of sensory information become active again as we retrieve the same information (Damassio, 1989 & James 1893). This principle, they hold, appears to hold water both for the activities of the brain relating to perceptions that are sensory-induced and for brain activities relating to imaginary and real motor activity (Nyberg et al., 2001,527-528).

If a phenomenon as fundamental as motor behavior does influence memory this much what impact would this have on our addressing questions and issues? What meaning would terms such as objectivity, fidelity, accuracy, truth, impartiality, and the like have for humans whose cognitive operations have much to do with a memory system whose efficiency could be consequent upon circumstantial matters as whether motor activity or mere verbal encoding is involved?

References

Bugelski, B. R (1987) *Memory*. In Raymond, J. Corsini (Ed), *Concise Encyclopedia of Psychology* (Pp. 701-703). New York: John Wiley & son.

Backman, L., Nilsson, L, G., & Chalom, D. (1986). New Evidence on the Nature of the Encoding of Action Events. *Memory & Cognition,* 14(4), 339-346.

Backman, L., (1985). Further Evidence for the Lack of Adult Age Differences on Free Recall of Subject Performed Tasks: The Importance of Motor Action. *Human Learning, 4,* 76-87.

Binkofski, F., Dohle, C., Posse, S., Stephen, K.M., Hefter, H., Seitz, R.J & Freund, H.J. (1998). Human Anterior Intraparietal Area Subserves Prehension: A Combined Lesion and Functional MRI Activation Study. Neurology, 50(5), 1253-1259.

Buccino, G., Binkofski, F., Fink, G.R., Fadiga, L., Fogassi, L., Gallese, V., Seitz, R.J., Zilles, K., Rizzolatti, G, & Freund, H.-J. (2001) Action Observation Activates Premotor and Parietal Areas in a Somatotopic Manner: An fMRI Study. *European Journal of Neuroscience, 13,* 400-404.

Bugelski, B. R. (1987) *Memory*. In Raymond, J. Corsini (Ed), *Concise Encyclopedia of Psychology* (pp. 701-703). New York: John Wiley & son.

Chao, L.L. & Martin, A. (2000). Representation of Manipulable and Man-Made Objects in the Dorsal Stream. *NeuroImage*, 12, 478-484

Cohen, R.L. & Steward, M. (1982). How to Avoid Developmental Effects in Free Recall. *Scandinavian Journal of Psychology, 23,* 9-16.

Cohen, R.L. (1985) On the Generality of the Laws of Memory. In L.G. Nilsson & T. Archer (Eds.), *Animal Learning and Human Memory* (pp. 247-277), Hillsdale, NJ: Erlbaum.

Engelkamp, J. & Zimmer, H.D. (1996). Organization and Recall in Verbal Tasks and Subject-Performed Tasks. *European Journal of Cognitive Psychology, 8,* 257-273

Engelkamp, J., Seiler, K. & Zimmer, H.D. (2004). Memory for Actions: Item and Relational Information in Categorical Lists.*Psychological Research, 69,* 1-10

Fisher, D.F. (1987),*Memory*. In Raymond, J. Corsini (Ed), *Concise Encyclopedia of Psychology* (pp. 703-704). New York: John Wiley & son.

Fisher, D.F. (1987), *Memory.* In Raymond, J. (Ed), *Concise Encyclopedia of Psychology* (Pp. 701-703). New York: John Wiley & son.

Goldstein, E.B. (2000), *Wahnemungspsychologie.* Berlin: Spektrum Akedemischer Verlag.

Grèzes, J.& Decety, J. (2002). Does Visual perception of Objects afford Action? Evidence a Neuroimaging Study. *Neuropsychologia,* 40 (2), 212-222.

Förster, J. and Strack, F. (1996). The Influence of Overt Head Movements on Memory for

Valenced Information: A Case of Conceptual-Motor Compatibility. *Journal of Personality and Social Psychology*, 71, 421-430.

Knopf, M. (1991). Having Shaved a Kiwi Fruit: Memory of Unfamiliar Subject-Performed Actions.*Psychological Research*, 53, 2003-211.

Lawrence, B. M., Myerson, J., Oonk, H. M. & Abrams, R. A.(2001). The Effects of Eye and Limb Movements in Working Memory. *Memory, 9* (4/5/6), 433-444.

Lotze, M., Montoya, P., Erb, M., Hülsmann, E., Flor, H., Klose, U., Birbaumer, N., & Grodd, W. (1999). Activation of Cortical and Cerebella Motor Areas During Executed and Imagined Hand Movement: an fMRI Study. J. Cogn. Neurosci., 11, 491-501.

Moscovitch, M. (1994). Memory and working with Memory:Evaluation of a component process Model and Comparison with Other Models. In D.L Schacter & E. Tulving (Eds), *Memory Systems* (pp. 269-310). Cambridge, MA:MIT Press.

Mecklinger, Axel, Gruenewald, C., Weiskopf, N. & Doeller, C. (2004). Motor Affordance and its Role for Visual Working Memory: Evidence from fMRI Studies. *Experimental Psychology*, 51 (4), 258-269.

McDaniel, M.A., Robinson-Riegler, B., & Einstein, G.O. (1998). Prospective Remembering: Perceptually Driven or conceptually Driven Processes. *Memory & Cognition*, 26, 121–134

Miki, H., Setou, M, Kaneshiro, K., & Hirokawa, N. (2001). All Kinesin superfamily protein, KIF, genes in mouse and human. *PNAS*, 98 (13), 7004-7011.

Moscovitch, M. (1994). Memory and Working with Memory: Evaluation of a Component Process Model and Comparison with Other Models. In D. L. Schacter & E. Tulving (Eds.), *Memory Systems* (pp. 269-310). Cambridge, MA: MIT Press.

Nilsson, L.G., Nyberg, L, Klinberg, T., Åberg, C., Persson, J., & Roland, P.E. (2000). Activity in Motor Areas While Remembering Action Events. *NeuroReport, 11* (10), 2199-2201.

Nyberg, L.-G, Petersson, K.M., Nilsson, L.G., Sandblom, J., Åberg, C., & Ingvar, M. (2001). Reactivation of Motor Brain Areas During Explicit Memory for Actions. *NeuroImage, 14*, 521-528

Rizzolatti, G., Luppino, G. & Matelli, M. (1998). The Organization of the Cortical Motor System: New Concepts. *Electroencephalogr Clin Neurophysiol*, 106, 283-296.

Schubotz, R.I. and Von Cramon, D.Y. (2001). Functional Organization of the Lateral Premotyor Cortex: fMRI Reveals Different Regions Activated by Anticipation of Object Properties, Location and Speed. *Cognitive Brain Research*, 11 (1), 97-112

Setou, M., Nakagawa, T., Seog, D., & Hirokawa, N. (2000) Kinesin superfamily motor protein KIF17 and mLin-10 in NMDA receptor-containing vesicle transport. *Science*, 288, 1796-1802.

Wilson, M. & Emmorey, K. (1997). A Visuospatial “Phonological Loop” in Working

Memory: Evidence from American Sign Language. *Memory & Cognition*, 25, 313-320.

Wong, R.W., Setou, M., Teng, J., Takei,Y., Hirokawa, N. (2002). Overexpression of Motor Protein KIF17 Enhances Spatial and Working Memory in Transgenic Mice. *PNAS*, 99 (22), 14500-14505.

Wong, R.W., Setou M., Teng, J., Takei, Y., Hirokawa, N. (2002). Overexpression of Motor Protein KIF17 Enhances Spatial and Working Memory in Transgenic Mice. PNAS, 99 (22), 14500-14505.

Zimmer, H.D. (1991). Memory After Motoric Encoding in a Generation-Recognition Model. *Psychological Research*, *53*, 226-231

Zimmer, H.D., & Engelkamp, J. (1996). Routes to Actions and their Efficacy for Remembering. *Memory*, 4 (1), 59-78.

Zimmer, H.D., & Engelkamp, J. (1999). Levels-of-Processing Effects in Subjects Performed Tasks. *Memory and Cognition*, *27*, 907-914.

Zimmer, H.D., Helstrup, T. & Engelkamp, J. (2000). Pop-out into Memory: A Retrieval Mechanism that is Enhanced with the Recall of Subject-performed Tasks. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 26 (3), 658-670.