Chapter 2. Communication Within and Beyond the Skin Barrier

For me it is a bit too late to start new research projects, yet I still get excited about the possibilities of new ways of understanding literacy suggested by recent neurological research and theory.[1] So in this chapter I am putting out a few thoughts (not even hypotheses) in case anyone sees enough promise and has the resources to pursue them. What I consider specifically in relation to reading and writing may apply in different ways to all forms of human thinking, feeling, and activity, because these suggestions draw on general accounts of human neural organization and activity. Nonetheless, since reading and writing are among some of the more difficult and engaging things humans do and because they are so central to modern life, it may be of special benefit to consider their implications.

Chief among the implications of this line of neurological investigation is that writing capacities might develop differently among different individuals and groups of people within their differing material, cultural, and social circumstances and within their particular experiences. People come to write different things in different ways, having different thoughts to express and different kinds of representations to contribute to communal discussions and projects. To any observer of writing and writers, these differences are self-evidently true, but most psychological, neurological, or sociological accounts of writing do not provide much discussion of the mechanisms by which these differences develop and are expressed. Understanding the nature and development of our neurological systems within their material, social, and semiotic environments may give us clues as to how we as teachers might effectively foster the fuller development of our students as writers and readers. Thus, while these models arise from the needs of neuroscientists to make sense of data, they also have the potential to be useful for writers to make sense of their experiences and to guide their self-management as well as for teachers who might gain from understanding how their students are developing. This potential alignment of models among different groups suggests the robustness of the models as being useful for and consistent with multiple kinds of experiences and evidences (Bazerman, 2018).

The newer accounts of neurological development that seem most promising and consistent with the experiences of writers contrast with the modular versions of cognition and consciousness that have dominated cognitive science until recently. These modular views continue to have great sway in language and writing

1. I would like to thank a reading group of Michael Cole, Maria Falikman, Georg Theiner, Chris Drain, and Tim Djibilaev who helped guide me through current literature in neuroscience and brain development while correcting some of my misunderstandings. The speculations here are, of course, my own fault.

studies, perhaps because they have been quite useful in understanding some of the lower-level literacy processes, such as visual letter processing and alphabetic letter correspondences to phonology as well as related disorders such as dyslexia (as presented for general readers in Stanislas Dehaene, 2009, and Maryanne Wolf, 2007). These earlier modular views consider cognitive activity and the related behaviors as being produced by single-purpose calculative feedback systems largely following the cybernetic logic of computer programming systems. These modular systems are treated as static and stable across humans, except for malformations, damage, or other specific deviations from their ideal configuration. As such they are essentially inborn in humans and are genetically inherited in much the same form across the species. As such they do not require or even imply development based on experience, learning, or instruction, except in very limited ways, such as identifying the particular phonology of a language or the sign forms used to transcribe meanings. In language studies such a special-use modular approach is associated most radically and influentially with Noam Chomsky (1959). Such accounts, sometimes characterized by their adherents as the Swiss Army Knife model of the brain (Tooby & Cosmides, 1992), rely on radical and fortuitous leaps in evolution to explain new capacities. As such, the Swiss Army Knife model of the brain does not solve substantial evolutionary puzzles about how capacities come about, nor does it align well with emerging neurological data (Anderson, 2014). In language development studies, Elizabeth Bates (e.g., 1994) has been particularly trenchant in her critique of modularity.

More recent approaches to neurological evolution, however, rely on the reuse and redeployment of prior capacities for multiple purposes and in alliance with each other, with added reflective layers to expand capacities. They are more realistic in biological and evolutionary terms, seem to be more consistent with brain development data, and seem to provide richer accounts of advanced meaning-making skills in literacy activities. Even the most well-known popularizers of the application of modular research for lower-level reading processes have in their more recent works been more cognizant of upper-level processes where brain complexity, plasticity, and interconnectivity appear to be of greater importance (Dehaene, 2020; Wolf, 2018).

Newer Models, Literacy Development, and Higher Literacy Skills

These newer accounts of neural development are not passive models used only to design and explain experiments, but rather they consider how neural networks arise within each individual's ontogenetic development, responsive to concrete needs, interests, and desires as they arise within the ongoing and changing situations of life to meet practical and often unanticipated challenges. That is, they describe neural networks, the consequent organization of consciousness, and the human expression of conscious thought through language, including through the

historically recent development of writing, as arising in the course of things as organisms go about their lives in their physical and social environments.

These current theories and data about neural organization offer mechanisms for Vygotskian kinds of internalization, suggesting pathways for how advanced creatures' insides can come to coordinate and align with their material and social situations and then become externalized in actions and behaviors to contribute to the unfolding of situations. Humans, in particular, add language and other complex semiotic means to those internalization and externalization processes to transform internalized ways of thinking, uniting spontaneous and scientific thinking as individuals contribute to and transform the sociosemiosphere (Akhutina, 2003; Bazerman, 2012; Vygotsky, 1978, Chapter 1).

These newer models also suggest possibilities for the richness and variety of writing, texts, and text interpretation that we witness in our world, where people write different things, are drawn to different things in each other's texts, and interpret those texts differently to find different meanings. Over time and multiple experiences these differences result in people developing different ways of thinking and making sense of the world they confront in part through their different pathways of reading and writing. While recognizing the importance of biology, evolution, and genetic inheritance, these new lines of thinking avoid undue reliance on biological determinism. Rather they help us understand the individuation of thought and action of people responding to their immediate circumstances and cultural influences, including the institutions, practices, and organizations that advance reading and writing—such as schools, publishing industries, or scriptural religions. People's engagement with their physical, social, and semiotic environments can leave their mark on individuals' neural development and thus the thought within the self. These neural theories recognize the importance of individual development, experience, education, and access to means of life as they may be differentially and inequitably distributed within economic, social, and cultural structures as they evolve across history and regions.[2] Education, experience, individual development, culture, and social institutions play a much smaller role in modular theories of the brain, as they see human thought and action as more determined by human genetic inheritance.

The Neurological Problem of Literacy and the Brain

What happens on the inside as we communicate with the outside world through language, particularly written language? What are the psychoneurological consequences of having read others and of having written ourselves?

Readers and writers use their brains, we hope. As well they use a lot more of their nervous systems while reading and writing. They smile, laugh, twitch, tap

2. From the early years of writing studies Ann Berthoff (e.g. 1978, 1981), following Lev Vygotsky and Charles Sanders Peirce, insisted on the individuality of meaning making.

their fingers, shake their knees, stare upward into space, or focus their eyes on the page. They get headaches or exhilarating chemicals rush through them; thoughts and memories tumble through their head; they picture events and places that they may then try to describe; or their brains feel blocked up. They get exhausted, get excited, feel unsure, feel morose and depressed, or criticize what they have just read or done.

So, even though writing communicates, accomplishes social actions, attends to its audience (even if that audience is the self), and uses languages and inscribed signs that historically emerged within cultures, it is the individual in the moment who works hard internally, overcomes emotional and cognitive challenges, and thoughtfully solves problems of what their reading means or of what words to choose and how to arrange them. Even in collaborative composing or interpreting, each person makes individual contributions, initiated in their thoughts and feelings. Each person does different tasks, proposes different alternatives, critiques and adjudicates each other's choices, and coordinates with co-authors or co-readers.

The Interpersonal, Internal Magic of Writing

From early on I had been interested in how we accomplished the remarkable processes of literacy, one mind speaking to another through words inscribed on paper—symbols only. Writers use language, of course, but writing does not even directly represent things, actions, events, or ideas in the way spoken language does. Writing (at least in alphabetic or syllabic languages) only transcribes the sounds that words make, as Vygotsky pointed out long ago (1978, p. 106). That transcription of sounds, further, is only approximate and often ambiguous—especially in English.

Those sound transcriptions interpretable as recognizable word meanings are composed into complex narratives and lines of reasoning to which the reader must give life. The writer chooses words with aspirations of meaning, but the reader only understands the meaning they can reconstruct from those few clues of transcribed sounds, drawing on their own experiences and impulses to arrive at meanings. Reading itself is a kind of performance, sometimes a halting performance of little children in early grades. But with maturity, reading can take on a depth of eloquence and understanding. Think of the power of meaning at a poetry reading, or a song recital, or as actors bring a script alive in a theater (in collaboration with a director and a backstage team). In modern times, reading is typically performed silently, internally, as the meanings of texts come alive in the minds of readers, whether they are reading a captivating novel or an analytical economic report that compels action. Words take on only as much meaning as the reader can or is willing to construct from the marks on the page or screen. Those meanings can be shared and argued over, whether in a court or a literature course, but more often as not they remain only internal performances from which the readers ingest what they will.

So how do we perform this magic of words? It has helped me to think of the text as being like a music score that has no sound but that can suggest sounds to those who know how to read and perform music. Even correctly produced notes are not yet music unless the performer can interpret those sounds as music—finding the gists, the interests, the motions, the emotions, the instrumental tone colors that make the performed notes come alive and expressive to engage and move the listener. Sometimes, remarkably, an accomplished musician can imagine what the music might sound like from the score alone, but we currently expect every reader of texts to perform the magic of meaning in their heads. Such a performance of meaning must require lots of neural activity that relies on what is already within the reader's neural organization, excited in the moment by the sight of the marks on the page. The greater the excitement of the neural activity, the more of the reader's mind is engaged and drawn into reconstructing the text's meaning. The excitement can even be critical as the reader composes a counter-text, bringing to bear even more cognitive and emotional resources.

An effective writer, in turn, needs to anticipate the reader's state of mind to suggest to them the meanings the writer wants the reader to perform and to keep the reader on the path of reconstructing and inhabiting that meaning. In a sense the writer attempts to create a frame of mind within a text and tries to keep the reader within it. Yet each of these minds are separated by the people's skins, so there is no direct access from one neural system to another. Thus, while it may seem minds are tightly aligned through words, actually they are only approximately connected, following each person's imaginations of what the words signify in the contexted moments of writing and reading. The interpretation of meaning and contexts, and thus how words are connected to the neural communications within each body, is heir to each individual's aggregate experiences over the years during which neural systems develop. The social and linguistic processes of alignment over words are weak and incomplete compared to the rich material specificity, spontaneity, and rapidity of fresh connections within internal neural processing. Though socially imposed coercions and conformity may attempt greater alignment, those pressures themselves add internal resistances or acquiescences that flavor internal interpretations.

Clues Towards Understanding Internal Processes

Over the years, as I have tried to make sense of how people use the social forms of language (particularly writing) to guide their internal understandings and thought (which in turn would have consequence for their material and linguistic actions), my speculations were inspired by Vygotskian theory, introspection, informal observations, and evidence from people's productions (see for examples Charles Bazerman, 1988, 2009, 2012, 2017; Bazerman et al,, 2013, 2104; and Valentina Fahler and Bazerman, 2019). While I looked to psychology for clues, I could find only a few hints in neurological research that seemed to me to illuminate

writing processes. I was, however, intrigued by neural net learning (with biological studies going back at least to the work of Donald O. Hebb, 1949) as biologically more plausible and more matching my experience than cybernetic models that were being applied to writing processes at the time. I was particularly attracted to the idea that perceptions of situations and composing choices, whether choices about tasks, text forms, phrasing, or words, were based on weightings developed through previous experiences and choices. If the writer learned to be attentive to internal perception and feelings about alternatives, one could make choices that were creative, spontaneous, and most likely to succeed. This seemed to reflect better the experience of writers than the cybernetic models of writing processes that were assumed in writing research in the latter decades of the 20th century. While some neuroscientists were working out some of the basic architecture and processes of neural networks, however, their data and findings remained far from the complex skills of writing, and even of language. During this same period, socially focused studies of writing largely remained separate from the individuals participating in the social activities, in order to study the forms of texts and activity structures through which individuals participated. I contributed to this social orientation, but I never lost my interest in the individuals producing those forms and participating in the activities.

The discovery of mirror neurons in the mid-90's (for example Vittorio Gallese et al., 1996; Giacomo Rizzolatti and Laila Craighero, 2004; Rizzolatti et al., 1999) suggested we could emulate the feelings of things we witnessed, such as our adrenalin pumping as we watch a horse race or a football play, or wincing when we witness a painful collision. This to me suggested a mechanism that could account for our common experiences such that reading others' words could make us laugh or bring us to tears or fill us with anxiety and fear. I was already predisposed to the idea that reading might be a form of internal performance of the meanings of words provided by the author. Mirror neurons now seemed to provide a means for us to empathize with characters' events, situation, and feelings. We not only play out the events of their lives, we to some degree can feel their pain or joy along with them and feel deflated or terror when something untoward happens to them. Less personally, narrative forms of reading also depend on us seeing through the author's eyes, responses, and reasoning. Even scientific articles depend on us being able to imagine experiments or other forms of data gathering and reasoning through the consequences of the data, as presented by the author. This helped me think about how when we write we try to evoke thoughts, feelings, visions, states of the world, and so on, to facilitate the reader coming to see the world through our eyes. One mind speaks to another to create and transmit a cognitive meaning, an affect, an environment, a vision of some part of the world, a memory, or an imagined memory.

Research in trauma writing (see James W. Pennebaker, 1997, and Pennebaker and Cindy K. Chung, 2007) gave another window into how writing could impact our emotional states, memories, and organization of experience—even impacting

our autoimmune system, blood cell counts, or blood pressure. The findings in this area reminded me of the insights of Adam Smith (1795) over two centuries ago in his "History of Astronomy" where he compared the psychological panic soldiers feel when they no longer understand what is happening on the battlefield to the disorder scientists feel when their data no longer make sense to them. He noted that both soldiers and scientists are calmed when they can settle on a persuasive story that seems to make sense of the experience, whether or not that story can later be confirmed as an absolute truth (even if such a thing could exist).

Recent Neurological Accounts that Can Help Us Make Sense of Writers' Internal Processes

In recent decades neural research has finally started to suggest some of the physical processes that may tell us more about how we read and write and what reading and writing does to us over time to influence our ways of thinking, perceiving, and acting in the world. These accounts of the mind and brain are tentative with a number of competing and even contradictory versions. Some of these inevitably will be rejected, others may be transformed, and others perhaps may remain viable. Some may even get strong confirming evidence. In total, however, they do transform our ideas about who we are as writing humans, what it is to write, how we write, and how we touch others through our writing, In a sense they reveal the story of how we move beyond the complex internal reasoning of separate individuals with only limited forms of cooperation and mutual alignment (as we might see in birds and mammals, including great apes) to the more complex forms of shared social knowledge, reasoning, and cooperative action we see in humans. These recent accounts make possible for us to conceive how people can engage with, produce, collaboratively construct, interpret, and further develop written statements, which in turn facilitate the complex and varied forms of social organization and activity in which writing has taken such an important place. In fact, writing has been one of the major vehicles through which the complexity of modern social life has been developed, negotiated, participated in, and evolved—and continues to evolve. Writing goes between individuals, goes deeply within each individual, creates the semiosphere which each individual grows up into, and transforms the semiosphere for life going forward.

The currently popular metaphor of the hive mind has some merit to it, based on the collective reasoning of social creatures such as bees and ants in gathering information and forming actions that wouldn't be possible by any one individual. But the hive minds of previous creatures have been limited by their means of communication. The exponential growth of human communicative means has brought about ever more integrated and extensive hive minds—despite conflicts, competitions, misunderstandings, or breakdowns. Talk initially advanced human knowing, thinking, and acting together, but in recent millennia writing has facilitated the negotiation of meaning, the coherence and standards of reasoning, the

spread of knowledge, and the extension of action through time and space (for examples, see Goody, 1986; Bazerman, 1999, 2006; and Brandt, 2001, 2015).

Much of the prior work on the mind and language has taken as a given the difference between mind and body (or at least suspended consideration the relation of these two approaches) and further viewed language largely as part of mind, except for the mechanics of voice production and sound reception. Recent work that goes down to the level of tracing neurons and their activation, however, puts the mind-body question back on the table—requiring us to think about how mind and body are connected and how it cannot be otherwise. That is, mind must arise out of the bodily means we have available, and those bodily means have evolved from other creatures. Unless we take mind and thought to be some ethereal activity not connected to our neural processes (as admittedly many throughout history have done), then every thought (including whatever words we choose to transcribe) must be produced by the materiality in which we exist and somehow play out on the physical, neurobiological stage.

Homeostasis and Allostasis

The models proposed by both Antonio Damasio (1999, 2010, 2018, 2021) and Michael Tomasello (2001, 2010, 2019, 2022) discussed in the previous chapter see homeostasis, or the return to states of equilibrium, as the driving force of individual and group processes in all organisms, including humans, but recently others have augmented this with the concept of allostasis.[3] Allostasis is contemplation and action in anticipation of future changes of the organism or environment that might disrupt homeostasis. This may mean avoiding perceived possible threats to homeostasis or even conceiving a better state providing greater equilibrium or homeostasis in the future (Sterling 2020; Sterling & Eyer, 1988). For example, the autoimmune system in humans and other animals creates antibodies based on contact with previous threats; these antibodies anticipate future threats, so as to rapidly counteract any invading infectants.

Damasio (1999, 2010) has further seen consciousness as arising from neurological monitoring and regulation of the state of the brain and neurological system, just as the neurological system monitors and regulates other bodily states and actions, such as heartbeats, movement of limbs, and signals from the senses. Consciousness, existing among many of the more complex animals, has the additional quality of the organism noticing that monitoring of brain and neurological states, and being aware of it as one's own. The development of consciousness brings allostasis to a new level, as individuals can consciously imagine future threats and avoid them. For example, more than a few animals intentionally build nests high in the trees or other secure locations to avoid nighttime attacks by predators.

3. I would like to thank David Russell for introducing me to the concept of allostasis and directing me to central readings on it.

Human language, however, facilitates communication of these conscious mental contents to others for them to react to, to reflect upon, and to affect their own consciousness. This recognition and exchange of thoughts facilitates communal reasoning and decision making about current needs and allostatically about future threats and possibilities. Human language, for example, facilitates communal work in planning and constructing shelters that avoid multiple threats and increase comfort, far exceeding the capacities of other nest-building animals. Such shelter construction can then lead to architectural planning, construction industries, materials sciences, building codes, projections of costs, among others—all of which allow us to rest securely at night and be comfortable and productive during the day. To this we may add the role of science fiction to help us imagine conditions, needs, and living arrangements as well as avoid undesirable ways of life.

The emergence of group norms and commitments, as Tomasello (2019) has found in young children, but not in chimps, may start as immediate verbal responses to perceived injustices but may transform into more generalized guidelines for equitable behavior with allostatic consequences. Empathic anticipation of future responses of those who might be treated inequitably drive the production of norms of fair behavior and social accountability. Communication through language makes possible the negotiation of cultural expectations to make for group harmony in ways that seem to be beyond the capacity of great apes, although they seem to be as intelligent as humans until the communal consequences of language take hold. We can even see embodied empathic response to perceived disequilibrium when people describe seeing someone violate group norms as making them feel sick, causing their stomach to churn, and being filled with disgust, even if they themselves are not directly threatened by the behavior. That is, the threatened future group disequilibrium posed by violation of norms even effects bodily homeostasis.

The social sphere of group norms elaborates in more enduring adult institutions and written codes (such as scriptural religious prescriptions, or governmental laws, or local office procedures). We can even see advances of communal knowledge and sciences as social allostatic projects to avoid future problems as well as to create better conditions for the harmonious and comfortable continuation of life. Creating better and more persuasive accounts of the world also mitigates the disordered feelings and panic that come from not understanding where one is and what is happening around one, as Smith (1795) described long ago.

Need for an Account of Internalization and Development

As Charles Fernyhough (2005) pointed out, despite Tomasello's detailed picture of sociogenesis of human norms and the role of empathy in communication, he has not yet elaborated an account of ontogenesis through the internalization of group norms communicated through language, although he does at times

mention Vygotsky's concept of internalization. Of course, as a primatologist, Tomasello is concerned with observed behavior; neural formation is not his domain, nor his data. He only imputes internal knowledge and states of mind by observing behavior, such as eye-gaze, interactions with others, or responses to experimental tasks. The consequence of this focus, however, was revealed in his recent book on agency (Tomasello, 2022), where he only considered mechanisms of agency in their fully developed form. He did, nonetheless, through experiments give accounts of the development of the ability to recognize and empathize with the state of knowledge and expectation of others, which leads to self-regulation in order to conform to norms of equitability. This finding, however, does not explain how group expectations then become personal expectations to guide self-understanding and choice making in self-regulation, nor does it explain why self-regulation varies within individuals' distinct lines of personal development. Neither has he provided a way to understand how individuals may become more deeply embedded participants (or more alienated outliers) as they mature into and through adulthood. Of course, his research ended with children of about six or seven years old, where communal self-understanding is just developing. At that age, individuality and complexity of consciousness may not yet be as much in evidence, nor may the consequences of the development of group norms for the internal organization of individual's neurological systems and consciousness. As Vygotsky famously asserted in his first intervention in psychology in 1925 (2000), consciousness transforms our simpler spontaneous reactions, and psychology needs to attend to the ways consciousness can stand between stimulus and response.

Neural Reuse and Neurological Coalitions

Recent accounts of post-partum situational brain activation and development can help elucidate the roles and mechanisms of consciousness in mediating between stimulus and response. Damasio (1999, 2010) got us part of the way there by suggesting a mechanism for the formation of consciousness in the monitoring of brain activity, which potentially allows the organism to control brain operations and thereby to control other actions guided by the brain as they rise to consciousness (Tomasello in his 2022 book hypothesized similar mechanisms based on cybernetic control reasoning). But Damasio has not yet inquired into the formation of the specific contents of consciousness, let alone how consciousness might recognize and be influenced by communications, particularly through language. Such an influence, though, would make possible enlisting the individual into collective modes of attention, thought, and collaborative action.

Michael L. Anderson, in his 2014 book *Beyond Phrenology*, drew on other recent approaches to neural development, both evolutionary and ontogenetic, to propose a new set of research questions for neurological science. His research agenda grew out of what he saw as an emerging consensus about the dynamic

action orientation of our neurological system that reuses prior existing elements to carry out new tasks in the moment. Thus, the brain is best understood in its responses to challenges rather than as a static system at rest. Neural reuse means that neural elements that may have evolved for one purpose may be repurposed in coordination with other neural elements to carry out new functions. Each neural element as it adds to its functions can contribute to multiple coalitions. Each coalition is activated and strengthens when functionally used within the organism's environment, and thus the neural system is not fully pre-wired genetically, but rather emerges post-conception and then post-partum as the need arises for new coalitions, which Anderson called "Transitionally Assembled Local Neural Subsystems (TALoNS)" (p. 94). New alliances are constantly forged as needed by situated brain activations, relying on neural plasticity and strengthened by habitual use and myelination. Some evolutionarily advantageous alliances may become genetically preferred, but even that evolution is gradual and relies on the forging of new functional neural elements situated within activity.

This work suggests to me that new functions (like the use and interpretation of language, and then with writing, the association of visual cues or signs with language) rely and depend on earlier systems, such as those that process visual and aural attention by sensing and interpreting light and sound. Some of these sensory inputs are interpreted as intentional meaningful signs from others. In early ontogenetic development many of these signs will be associated with caregiving functions of providing food and comfort, coordinating with caregivers, and forming joint attention to monitor and interact with the environment and so on, in the manner suggested by Tomasello (2001, 2010, 2019). These social functions increase as the child matures and its life experiences expand. Even more the inputs we get from others through language themselves influence our interpretation of events, environments, and situations inside and outside our bodies, and thus are incorporated into our neural system. This process then leads us to align with the communal understandings embodied in our language and social relations within which language is used, while still maintaining variation of individual sets of experiences and interpretations which have left their marks on our separate neural systems.

The addition of literacy to language includes more information from greater time, spatial, and social distance that we might have to evaluate and select among. Literacy adds greater choices of affiliation, coordination, and participation with a greater range of groups, organizations, or social activities. Literacy also facilitates formulations and evaluations of more complex kinds of evidence and arguments. All these communicative interactions facilitated by socially received language can be internalized into the organization of our neural systems and change our vision of ourselves, our world, our communities, how we relate to them, and how we participate within them.

The peer commentary (Badcock et al., 2016; D'Souza & Karmiloff-Smith, 2016; Guida et al., 2016; Kaplan & Craver, 2016; McCaffrey & Machery, 2016; Parkinson

& Wheatley, 2016; Pasqualotto, 2016; Perlovsky, 2016; Pessoa, 2016; Pezullo, 2016; Shine et al., 2016; Silberstein, 2016; Stanley & De Brigard, 2016; Wang & Bargh, 2016) to Anderson's (2016a) précis of his 2014 book in the journal *Behavioral and Brain Sciences* and his further response (Anderson, 2016b) suggest how research has aggregated around these approaches. Almost all the peer responses accepted as a given some version of neural reuse and widespread brain response to complex situations and tasks requiring complex thinking, such as literacy. The range of neurofunctional accounts in these responses fell on a spectrum at one end of heavy reliance on genetically determined neural elements and fixed systems of alliances among them and at the other end of heavy reliance on emergent structures (neuroplasticity) that see almost all systems as idiosyncratically developed from individual experience, though almost all accounts include some combination of the two. Anderson sees the whole range of comments as fitting within his proposed research program.

Another important aspect of Anderson's (2016a) account is that "Organisms are perception seeking, not passive recipients of environmental stimulation" (p. 6). This means brains are more usefully studied when activated, not when at rest. This also means that we should not think of the brain or memory as creating a neutral image or record of reality. Rather the brain constructs what it needs to know in the moment for the purposes at hand. For sense organs, that means they hear, feel, see, smell, and taste what the organism needs to hear, feel, see, smell, and taste for its homeostatic or allostatic benefit—filtered for salience by the neurological interpretation systems. This action based on needs would also be true both for how we listen to each other and for how we read each other's words through our own needs-based and needs-elaborated interpretive systems. This is consistent both in what I found in studying how physicists read (Bazerman, 1985) and how scientists position their work intertextually within the prior publications of their fields (Bazerman, 1993). Similarly, we would be motivated in what we say and write by our perceived needs to communicate. This needs-based motivation has many implications for epistemology as well as for how we earn our livings and meet our daily needs. Literacy has also created many cooperative social domains, which themselves have transformed how we see the world, how we perceive our needs, and what information we believe would be useful to us, whether in journalism and governance, arts and entertainments, religions and philosophies, finances and law, or sciences and humanities.

One final element of neural development Anderson (2014, 2016a) pointed to is that environments tend to be inherited along with genetics. This means there tends to be a match between genetic endowments and challenges presented by the environment. This also means that each new generation typically has to solve similar problems and thus will tend to develop in similar directions even if the solutions are not determined by genetics. Thus, tropical rodents need to solve problems of staying cool, avoiding threats, and finding sustenance from their ecosystem while arctic rodents must solve problems of staying warm, confronting different sets of threats,

and finding different sources of sustenance in their ecosystem. These adaptations may become genetically preferred, but not necessarily so.

Humans, however, are born into complex environments of language users along with the other environments they inherit. Humans have inhabited diverse natural environments on much of the planet and have reconstructed the physical environment in many different ways. Knowledge passed on through human language conveys information about how to survive and thrive within the particular environment inhabited by parent and child. But language also creates another level of environment that the child needs to learn to navigate in forming social relations with surrounding humans. This *built symbolic environment* requires much puzzle solving that consumes much of the attention of all young humans throughout their formative years, which in recent centuries has extended to include increasing years of schooling and enculturation into different activity worlds that require expanded and purpose-specific uses of language. Even more than other animals that use audible signals, humans need to learn to identify and distinguish among different sounds from their own species, attribute useful meanings to those sounds, and then produce meaningful sounds for others as part of collaborative survival.

With literacy people must associate words with visual signs of word sounds of their languages and dialects (at least in alphabetic and syllabic transcription systems), and of the social activity systems and knowledges that are significant for their lives. The semiosphere each person experiences also evolves rapidly, not only as language changes across generations but also as new spheres of activity, attention, and organization form and transform. In turn the inventions and expansions of each individual and generation contribute to further the rapid change. Additionally, written statements can expand in length, complexity, and potential coherence so that high degrees of expertise are needed to find one's way through legal codes or scientific literatures. This changing semiotic environment challenges neural development in different groups and succeeding cohorts.

While the physical environments humans inhabit have varied as they have migrated and continue to migrate across the planet, the built environment changes even more rapidly from generation to generation. The built symbolic environment changes even more rapidly. Communal and individual cognitive development changes from generation to generation, even within one's lifespan, whether through immigration, education shifts, economic and commercial changes, or changing activities appropriate to different ages. We even now have increasing differentiations of social expectations across different life epochs with more distinct worlds of infancy, childhood, adolescence, college life, young adulthood, maturity, retirees, and elderly. In the last two centuries changing technologies have further sped up changes in our semiotic environment. Semiotic environments change ever more complexly and rapidly, requiring greater flexibility in human cognition and neural response than in any other creature. That is, we are constantly making and remaking our semiotic environment, even as we are

learning to find our way in our perceptions of its changing landscape. Very little of language and literacy use can be pre-wired genetically but rather must be constructed during our lifetimes out of our dispositions, needs, and orientations within our perceptions of our social circumstances and opportunities, drawing on the collected information and skills gathered in previous activities, as encoded in neural and brain chemistry, electrical circuits, and other structural elements, as deployed and recomposed in the moment.

I should mention one other component of Anderson's (2014, 2016a) account, though its implications for literacy seem obscure to me beyond a few speculations. He cited evidence that brain activity is not just controlled by neurons that connect dendritically with each other and send electrical signals, but that chemicals that affect brain activity are also released across the brain. Anderson was not certain of the effect and mechanisms of this chemical wash. Its impact for processing of reading and writing is even more obscure, but it further suggests that the brain system is not fully determined by local processing mechanisms as the modular view would have one believe. This chemical wash may also have something to do with mood and/or emotions in writing, as they might be consistent with more ambient sensations that might accompany writing, facilitate writing, and/or signal certain attitudes or kinds of engagement in writing. For example, one might feel excited, energized, attentive, and focused when thoughts come together, moving one to start writing. Or after finishing some writing one might feel exhausted, depressed, or otherwise dysphoric. But, of course, these are just guesses.

Consequences for Writing Development

If anything like Anderson's (2014, 2016a) account turns out to be viable, it would have many consequences for literacy development and for the way reading and writing may enlist large parts of the neurological system and brain elements. Complexes of feelings, experiences, memories, sensations, or knowledge may contribute to the developing meanings and help us settle on words to convey them, just as many of our complexes of feelings and thought would enter into the reconstruction of meaning prompted by words from others. These connections would be enacted neurologically and consequently would leave their mark on the neural system. As well, reading and writing may excite and connect neural pathways resulting in bodily activity, whether laughing or tapping fingers or shaking legs—or moving one's fingers unthinkingly on the keyboard to transcribe thoughts emerging in words.

Since the neural dendritic connections and myelinated aggregations are a result of a lifetime of firings in response to moment-by-moment situations, experiences, and challenges, these will affect the resources and processes we bring to bear on any new act of reading or writing, just as on any thought or action we take. As well, these neurological networks of meaning built over a lifetime might

define what we are moved to say and how we say it. As a result, the organization of our thoughts and brain may be associated with this ill-defined thing we call voice—that is, some amalgam of the things we have to say and the way we go about saying them. Our preferred word choices, phrases, and syntactic patterns, as well as strategies of analysis and thought, may reflect habituated patterns recorded in neural connections and myelinations as well as emotional moods triggered by some formulations.

These habituated patterns may just come to feel right for us and thus would impact our evaluation of word choices, narrative organization, and social and emotional stance—what we might call personal taste. Further, when we come across authors who find ways of expressing their thoughts and feelings that attract us, it may have something to do with how their expressions resonate with and fulfill emerging connections within us.[4] Such authors seem to think like us, seem to have similar interests, seem to express similar thoughts, perhaps with enough difference to be interesting, but not so much as to sound wrong. We may come to imitate them or be influenced by them in their themes or their modes of expression without conscious awareness, although in some cases we may form conscious affiliation and enthusiasm. In either case, these influences become ever more habituated within us through our engagement, even as they may mix with the influences of other authors.

As we become more experienced writers, these elements of influence become ever more integrated with other impulses arising from elsewhere in our experience. Patterns of style, interests, topics, and knowledge become habituated through increased robustness of the neural alliances we most use, so we tend to think, write and express our thoughts in ever more habituated circuits, further strengthening neural alliances. Nonetheless, we can try out new things and add new ways of working and expressing, but these new ways may require some intentional effort and perhaps strong social support from others to overcome unfamiliarity. These novelties also may not be as durable in their effects as longer standing patterns.

Another major implication of Anderson's (2014, 2016a) approach to understanding our neural system is that writing may participate in alliance with many other parts of our cognition, affect, and imagination within our neural system (as well as be connected to our somatic state and actions). It suggests, for example, that our reading and writing may draw on many other aspects of our lived experience and actions that have left their traces in our neurological capacities. Reading and writing can in turn change our perceptions of the world around us, our internal processes, and our actions as it connects or aggregates experiences, feelings, and knowledge in the words and conceptual terms we use to describe them. It suggests as well that our confusing or conflicted or anxious feelings can be affected

4. This personal resonance with internal audience sense is what Aristotle (2007) might have called enthymematic.

and placed in more acceptable order through our words, which then may impact the chemistry of our emotions, anxieties, and even autoimmune system, as we see in the therapeutic effect of trauma writing (Pennebaker, 1997; Pennebaker & Chung, 2007). As well, our reading of the experiences and literary expressions of others can reach deeply into our feelings or provide us virtual experiences that reconfigure our experiences and expectations. While writing and reading may draw together many different parts of our feelings, sensations, knowledge, identity, and affiliation impulses, they may also reflect or engage our troubled or dysphoric internal states and relations to the world and people around us. In short, writing and reading are whole body and wholly situated responses.

Reading and writing at the same time may create a counterworld for us to distance ourselves from immediacy, as we lose attention to those immediately around us to connect to distant others in fictional or nonfictional worlds and endeavors. These alternative worlds may bring us closer to what we believe is true or important in the world, or they may resonate better with our feelings, or may seem more desirable. Even as we engage in these less proximate worlds, all our emotions, sensations, experiences, and developed neural connections (what some call the connectome, for example Olaf Sporns et al., 2005) are potentially at play and become potential meaning resources. That is, we may be internally responding to things long ago, far away, imagined, abstracted, or persuasive.

The more we understand what is going on with us, the more we can notice introspectively and the better we can accept these processes as natural so we can accommodate and manage them rather than fighting them. If we do not resist the ways our minds, moods, and feelings work, we may engage more fully with literacy processes. In fact, instead of waiting for the muse to grab ahold of us (that is, for inner impulses to overwhelm us), we may be able to notice when the muse starts to stir within us and even invite it through meditative practices, creating conducive work spaces, or finding other ways of opening our minds to what we are impelled to say. By the muse, I mean something like the mind starting to assemble itself into a frame or alliance where impulses, ideas, thoughts, and words emerge. A familiar piece of writing advice that recognizes this importance of finding the right frame of mind is to leave off a day's writing with an easy next task to do that will allow one to get back into the complex effort of what one is working on, assembling that frame of mind or sets of alliances. There is even a common metaphor for this—parking downhill. Conversely, for some kinds of writing closely attached to current circumstances, the right frame of mind may come not from meditative removal but from being surrounded by the physical and textual immediacies of the situation, such as sitting at one's desk in the office, surrounded by project documents and colleagues preparing their contributions to the project.

Similarly, aware of the needs of readers to adopt the right frame of mind, writers typically organize the sections of a book or chapters and the openings of the next to facilitate readers leaving off at one point and then reentering at a

later time, reassembling mentally the gist of the work to know how to interpret or make sense of the next section. As writers, we seek to influence or touch the minds of our readers—the radical fundamental individual differences of interpretation, meaning, and engagement—that our words must mediate. We want to show the readers things, move them to see and feel, to get our meanings, to reconstruct meanings that are close to what we intend but are also important to them. The more we can understand the limited but powerful means we have to communicate, the more we may have an effect.

Consequences for Literacy Education

Understanding internal writing and reading processes can also help us as teachers to support the development of reading and writing of others. Teachers have long been keen observers of their students and have already adopted many of the ideas suggested in this section as they have attempted to connect with and motivate students, making writing important parts of their lives. Accordingly, many of the approaches, techniques, and practices that follow may seem familiar to experienced teachers. Yet it is useful to consider their total impact and some underlying causes that have made them good pedagogic ideas.

The most obvious implication, known by almost every teacher, is that motivation is key to engaging students in learning practices. The approaches presented here recognize that literacy capacities are only engaged in activities that people perceive as beneficial to their way of being. Moreover, the more meaningful these activities are and the more attached they are to students' perceived needs and desires—in other words, the more fully motivated the activities are—the more problem solving will occur in extracting and making meaning and the deeper the engagement for students is. Deeper engagement brings with it greater learning, creativity, and expression. Further, the thinking involved in literacy tasks accumulates over multiple tasks to develop and strengthen neurological alliances and resources. Insofar as tasks bring together similar clusters of cognitive, sensory, and affective elements, the pathways for these kinds of reading and writing become habituated and strengthened.

Yet there are dangers in too much similarity across too many activities over too long a time, as the tasks may become so normalized and specialized that they don't present much challenge to stretch learning or to produce high levels of engagement and creativity. Further, familiar seeming tasks may restrict the range of resources readers and writers may bring to their tasks. Students may benefit from being asked to draw on different kinds of thinking, feeling, sensation, perception, and analysis to broaden the repertoires they can draw on. From an early age we ought to be strengthening the connection between writing and all our senses as well as all aspects of cognition, emotions, cultural and societal knowledge, and action developing within the learner. Writing that describes all the senses—all we see, feel, hear, smell, and taste—and then organizes those sensations may help

build robust alliances among the elements that process words and the senses as well as analytical categorization and sequencing. Similarly, descriptions of bodily actions and sensations may have unanticipated benefits. More deeply, within our emotions, trauma writing and reading about others' difficult experiences, as they become age appropriate or situationally needed, can help individuals bring some satisfactory order to troubling experiences and feelings. Trauma writing may also prevent elements of the mind being compartmentalized, isolated, or suppressed, which restricts the ability to build a variety of neuronal alliances. By practicing trauma writing, then, in all forms of writing one may be able to draw on one's feelings, memories, and meaning impulses more freely.

Along these same lines of building connections among thoughts, sentiments, feelings, experiences, and writing are various meditative activities completed before reading or writing to open up access to connections. These might include writing about dreams, writing imaginatively, playing, even free writing. Reading and writing about relations with others, social observations, observations of the world (including more disciplined observations through experiments and data gathering), or related prior knowledge all draw expanded attention and thinking into writing and help give meaning and order to those things experienced and attended to in writing.

It is also useful to connect writing and reading with action, including participation in socially organized activities, whether family, community, organizations, or eventually professions and careers. Planning and reflecting for oneself—whether analyzing sports, making schedules or to do lists, or reflecting on goals, experiences, affiliations, or identities—can also help establish a sense of who one is and what stance to take in communications with others. Of course, I am listing far too many possibilities for writing here, but the point is early writing should not be limited to just a small number of types or domains. As people mature and identify what is important to their lives, the connections already made between those important themes and literacy can be practiced and strengthened, not only to teach the appropriate forms but to engage and build the kinds of neural alliances that will integrate literacy practices with significant aspects of emerging selves and the building of meaning in lives.

Perhaps most fundamental is not to fight against the modes and practices of expression and interests already developed by the time we meet students, especially in secondary and higher education. The students' processes, practices, and expressive habits are already likely to be embedded in their neurological organization through their years of development and schooling. We can add to their repertoires, open up new vistas and resources, redirect their strengths towards new directions and opportunities. Rarely can we disassemble what is there and already connected, and even if we could, the price would be high. Growth comes from building on existing strengths.

Yet we must recognize that many forms of writing and their associated kinds of thinking are likely not to become introduced or meaningful to students until later

in their development. Academic forms of argument are likely to appear strange and unnatural if they are introduced before students have discovered the force of personal expression. Writing in business and organizational settings is likely not to be meaningful until students actually begin to enter the workplace and experience nonschool settings. Narrative story telling is often the earliest, easiest, and most comfortable mode for reading and writing, and it is often appropriately at the center of early literacy education. But relying exclusively on narrative can also be a trap, as it becomes so habituated that it can be hard for people to read and write in other forms if alternatives are introduced too late. Providing a good mix of text types in age-appropriate ways, supplementing narration with more informative, conceptual, argumentative, evidence-based, or transactional text types can provide the ground for later development. The motive should be to keep expanding and integrating repertoires, to engage students in the reception and production of texts that will become more central to their lives through their years.

Expanding the reading and writing repertoire at an early age can also impact the kinds of spontaneous thoughts students may want to express and the modes of expression that will occur to them as appropriate. As thoughts begin to emerge in a variety of forms, students' interests and expressive engagement will open more opportunities for more varied development and social connection. The techniques discussed earlier of recognizing and engaging the muse and developing voice are equally important for students as they discover what is important for them to communicate, to whom, and how. While teachers can and should provide opportunities for students to recognize and act on their muses, their impulses coming from within that will connect them to those on the other side of the skin barrier, those muses need to be seeded with the beginning resources that might excite lines of meaning, expression, and growth that might not otherwise emerge if no pathways are provided for them.

Coda

I started this set of speculations by saying that recent developments in neuroscience seem to be resonating better with my experiences as a writer and teacher than earlier psychological models of writing processes. It should not be all that surprising that I end by saying that many of the implications of these more recent accounts and research for writing and teaching of writing are consistent with practices and observations familiar to the field I have been immersed in. I admit to circularity in this reasoning. I pursue the approaches that seem consistent with my experiences and lo and behold these approaches confirm the observations and practices from my experience. Yet if science and experience mesh, the ideas gain a kind of plausibility. And such meshing also gives us a way forward to think about our experiences in a more consistent, evidence-based, scientific way, to make us more confident and precise in our observations and practices. This certainly seems a more promising way to go than to either fight against or ignore the sciences that claim to be

finding out about the very neurobiological mechanisms that enable us to be writing creatures. On the other hand, if the mechanisms claimed to be found by scientific investigation turn out to be at odds with our experiences and practices, one side or another or both will have a lot of explaining to do.

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