Contents

Maria Pachalska and Michel Weber (Eds.)
Neuropsychology and Philosophy of Mind in Process

P R O C E S S   T H O U G H T

Edited by

Nicholas Rescher • Johanna Seibt • Michel Weber

Volume 18

Maria Pachalska and Michel Weber (Eds.)

Neuropsychology and Philosophy of Mind in Process

Essays in Honor of Jason W. Brown

ontos verlag

Frankfurt | Paris | Lancaster | New Brunswick

Bibliographic information published by Deutsche Nationalbibliothek
The Deutsche Nastionalbibliothek lists this publication in the Deutsche Nationalbibliographie; detailed bibliographic data is available in the Internet at http://dnb.ddb.de

North and South America by
Transaction Books
Rutgers University
Piscataway, NJ 08854-8042
trans@transactionpub.com

United Kingdom, Eire, Iceland, Turkey, Malta, Portugal by
Gazelle Books Services Limited
White Cross Mills
Hightown
LANCASTER, LA1 4XS
sales@gazellebooks.co.uk

Livraison pour la France et la Belgique:
Librairie Philosophique J.Vrin
6, place de la Sorbonne ; F-75005 PARIS
Tel. +33 (0)1 43 54 03 47 ; Fax +33 (0)1 43 54 48 18
www.vrin.fr

P.O. Box 15 41, D-63133 Heusenstamm
www.ontosverlag.com

ISBN 978-3-86838-010-1
2008

Printed on acid-free paper
ISO-Norm 970-6
FSC-certified (Forest Stewardship Council)
This hardcover binding meets the International Library standard

Printed in Germany
by buch bücher **dd ag**

Camerado, this is no book...
Who touches this touches a man.

Walt Whitman

Contents

Foreword

Jason's Brown contribution to neuropsychology and philosophy of Mind

MARIA PACHALSKA, MICHEL WEBER

The present volume both is and is not a Festschrift for Jason Brown – a paradox which Jason himself will surely appreciate. Like any Festschrift, it is a look back: a group of authors who in one way or another have known Jason personally, or at least have known his work and been influenced by it, have been invited to contribute essays in his honor. Several of the authors have stated (either expressly in their papers, or in correspondence with the editors) that they have written *for him* in a very particular way, knowing that he will read the paper, and thus addressing some or all of their remarks to him as the consummate Reader. Many have also included personal tributes to Jason, commenting on how his work and (not at all infrequently) his personality have influenced their own thinking. Some have undertaken the somewhat grander task of assessing his role in the development of contemporary thinking about what we may call very generally the brain/mind problem. To paraphrase Lincoln at Gettysburg, this is "altogether fitting and proper."

In another and perhaps more fundamental way, however, the intention of this book is to look forward. To begin with, Jason Brown's career is far from over: we all await with a feeling of anticipation the next essay, the next paper, the next book. Unlike the recipient of a more typical academic Festschrift, Jason Brown is not and never has been the holder of an endowed chair at a major research university, surrounded by fawning doctoral students and collecting large research grants. To be sure, he is Clinical Professor of Neurology at the New York University Medical Center, which is no small distinction, and he has promoted several important doctorates in his career. But the model of "Herr Professor" does not suit him; indeed, he often unwittingly grimaces when the honorific title is used in his presence. His is rather the model of the Romantic poets he so much admires: consumed by an overarching idea, he sits in the park or in a concert hall and writes, writes, writes, continually pushing the Idea yet a little further. After each successful book, he proclaims himself exhausted and the work finally completed, the Idea fulfilled – until his restless mind takes him back to his favorite Central Park bench to start the next one. The Idea is far from exhausted, the story is far from over, and it would be premature to try to sum it all up now.

Even more fundamentally, however, Jason Brown's microgenetic theory is the yeast in a dough that has only just begun to rise. What began as a dissenting voice in behavioral neurology, a protest against what was then (and, alas, largely remains) an orthodoxy dominated by a connectionist, modularist, reductionist, strictly materialist and substantialist theory of brain work, has slowly but surely become a Grand Theory in its own right. For decades, to be sure, Jason Brown has been recognized in several different fields as a brilliant and original thinker, invited to important conferences, published in the best journals, appointed to editorial boards and program committees. What has only just begun to happen, however, is for larger numbers of working neurologists, psychiatrists, psychologists, and neuroscientists to take his theory seriously. Perhaps they simply did not understand it; or perhaps (and this seems more likely) taking microgenetic theory seriously means doing neuroscience very differently, which is always a highly unwelcome thought for those who may have spent their careers doing the wrong things.

Not surprisingly, then, the impact of Jason Brown's work has sometimes been felt sooner and more deeply in a variety of disciplines that may be more or less remote from behavioral neurology or neuropsychology. This includes in a very particular way the philosophy of mind, where the fundamental issues of cognition, its mechanisms and objects, are as old as ancient Greece and as contemporary as the latest publications. There are obvious and acknowledged analogies between Jason Brown's microgenetic theory (which, as he often and insistently reminds us, was born in clinical work) and process thinking in the tradition of Peirce, Bergson, and above all Whitehead. At the same time, cracks are beginning to appear in the once imposing facade of cognitivism, so that now, finally, there is an opening for microgenetic theory and Jason Brown's work in the fields where it all began: neurology, psychiatry, neuropsychology. Is there a good way out of the mind/brain conundrum that does justice to neuroscience without falling into the "mindless" materialism touted by those who criticize Descartes's putative "errors" without really having much an idea of what he actually said? Perhaps there is, after all. It is becoming increasingly apparent that Jason Brown's dissent was not really heresy at all, but rather a Grand Idea that appeared just a little before its time. And that time has now finally come.

The fact that the present volume is co-edited by a neuropsychologist (MP) and a philosopher (MW) is itself an indication of the breadth and diversity of Jason Brown's writing and interests. This is even more clearly indicated – even before one begins to read – by the list of authors (with their varied institutional affiliations or lack thereof) and the titles. Even a cursory glance at the papers themselves will only support the impression that Jason Brown's influence has been both surprisingly wide (across many disciplinary boundaries) and surprisingly deep.

Perhaps Jason himself is the only reader who will be able to read every one of these papers without feeling at certain moments intimidated by some of the terms, concepts, and methods that belong to "foreign" fields. That is the inherent danger of truly interdisciplinary work. There is a temptation to water things down, making the material palatable for the non-specialist – but at the cost of oversimplifying and trivializing. A safe course must be steered between the Scylla of obscure jargon and the Charybis of making scientific music into muzak. The authors have been encouraged to bear in mind a reader who is interested, intelligent, well-educated – but not necessarily in the writer's own field. Our fondest hope is that this approach (*Bildung* in von Humboldt's sense) has borne good fruit, that most readers will get something out of most of the papers, if they are willing to make the effort. The greatest rewards may be found there where they are least expected.

The editors' original intention was to group the papers in sections along disciplinary or thematic lines, and indeed many of the authors were originally recruited with this division in mind. In the end result, however, this proved to be a Gordian knot. On the one hand, there is so much diversity in this collection that a reader who is not well acquainted with the richness and complexity of Jason Brown's thought may wonder how one person could have inspired such disparate kinds of work. Some authors quote ancient Greek philosophers in the original, others produce results from laboratory tests or clinical research, and some manage to do a bit of both. Apart from this great diversity, however, which seems to call for some scheme of organization that would group together papers of interest or not of interest to particular groups of potential readers, there are deep threads of unity that would be threatened by any such division. Perhaps it is just too easy, too comfortable, to gravitate at once to the familiar company of those we know, those who use the professional jargon we are used to using and hearing, who take up a discourse that we have already followed for some time. This would be fundamentally false, however, to the thought of Jason Brown – and, it must be said, to his personality as well. Jason is not the kind of person who habitually seeks the company of those who make him feel good; if anything, he is somewhat more inclined to search for a worthy opponent.

Finally, then, we made the decision to use Alexander the Great's legendary solution to the problem of the Gordian knot, where our metaphorical "sword" is that bane of all systematic thinkers, so roundly (and perhaps rightly) condemned by Mortimer Adler: alphabetical order. Let the reader think of this as one of those pragmatic devices sometimes used by hapless hosts at a dinner party in a desperate effort to break up the little clusters of the same old friends huddled in the corners, and force their guests to actually meet someone new. Thus no implicit or explicit claim is made here that the juxtaposition of papers in this collection points to or somehow creates intertextual bonds between them. At sometimes surprising moments the bonds appear by themselves, of various kinds and in various directions. Some creative bonds will of course be more apparent to certain readers than to others, but that, after all, is the nature of theory. The reader is invited, then, to take the papers as they come, and see what happens, especially when in this way one "accidentally" ventures into some area of thought that was previously hostile territory, or no-man's land, or at best *terra incognita*.

***

Harald Atmanspacher, from the Institut für Grenzgebiete der Psychologie und Psychohygiene at the University of Freiburg (Germany), and Jack Martin, from the Department of Psychology at Simon Fraser University (Burnaby, British Columbia, Canada) have contributed a paper whose title ("An authentic life for process thinking") and content are inspired by Jason Brown's latest book, *Process and the Authentic Life*. The accident of alphabetical order places this paper first, but, as Shakespeare put it, "there is a destiny that shapes our ends [and beginnings, addition ours], rough hew them how we will." Atmanspacher and Martin begin their paper with a summary and appreciation of Jason Brown's intellectual odyssey from clinician to philosopher, before introducing four main lines of argument that emerge directly from his recent work. The first of these involves the nature of time and its essential significance for any kind of serious process thinking; the authors stress irreversibility and temporal holism. Inherent in the very existence of a fourth dimension of objects is the next problem, that of *instability and transiency*: how do account for the fact that things change, and yet there is a continuity, without which nothing would make any sense at all? If we reject a mechanical determinism, what are the truly viable alternatives? This leads in turn to the problem of personhood, the existence of an object endowed with consciousness, in which the paradox of stability and instability becomes particularly acute. The authors insist in this context on combining two aspects of personhood, biological and cultural, that are typically subordinated one to the other, depending on the disciplinary affiliations and loyalties of particular authors. Atmanspacher and Martin finally argue for what they call a "*domain-relative ontology*," which avoids currently fashionable tendencies to reduce all domains of reality to one, as Thales wanted to claim that all things are water. This has always been an essential point in microgenetic theory: that exploring the evolutionary and developmental aspects, the prehistory and history of mental states, should not be approached as an attempt to bypass the higher realms of thought in order to reduce art, philosophy, and science to the grunts of animals. It is not easy to maintain the dialectic between the biological and the cultural, the primitive and the civilized, but if the tension is relieved by unstringing one end or the other, we have lost the most important point.

The next contribution, by David Bradford (Austin, Texas), admirably illustrates many of the points made by Atmanspacher and Martin. Mysticism and neuropsychology would not seem to be a good or obvious mix. Mysticism often serves as an alternative to (or escape from) the kind of scientific, empirical and materialistic thinking that characterizes the neurosciences generally. What Bradford does is to search for a way, inspired by the example of Jason Brown, to explore the possibilities of both while transgressing the boundaries they both implicitly observe. There are six sections. The first, fittingly enough, is an overview of mysticism, and is followed by a section that reviews what Brown has written on this topic. The third section deals with the (neuro)psychological phenomenology of asceticism, without either patronizing or bracketing the serious issues involved. In the fourth section the discussion turns to creativity, described and discussed in light of the foregoing. The next section takes up Brown's distinction between the mysticism of nature and the mysticism of god, and argues that despite the differences the goal is the same. The final section applies what has been learned so far to the search for a "perennial philosophy," the philosophical analogue of the unified field theory in physics. All of this is followed by two Addenda, the first of which includes critiques of two currently fashionable neuropsychological explanations of mystical experiences. The second is a kind of mini-glossary of microgenetic terminology with suggestions for further reading.

Hugh W. Buckingham, from the Department of Communication Sciences & Disorders at Louisiana State University (Baton Rouge, Louisiana) and Sarah S. Christman, from the Department of Communication Sciences at the University of Oklahoma (Oklahoma City, Oklahoma), need no introduction to those familiar with neurolinguistics. Their paper, entitled "Sublexical phonological processing and paraphasia: Recent topics in the neurolinguistics of production in aphasia," reminds us that microgenetic theory essentially began with aphasia, and the problem of language remains a central one. Of all the aspects of language, however, perhaps the least attention in process thinking has been devoted to phonology, which to the uninitiated often seems a purely mechanical, and thus rather trivial problem. Buckingham and Christman begin by discussing some recent developments in neurolinguistics on the phonemic level, or more precisely: tonemes. This last concept has made it possible to consider prosody in a more systematic manner than previously. The interesting conclusion reached from this work is that prosody is not specific to left or right hemispheres, but requires their interaction. This in turn leads to the problem of paraphasias, i.e. the pathological substitution of phonemes or lexemes. The paper suggests what many neurolinguists have long suspected, that the taxonomy of paraphasias in general use is faulty and confusing, once we properly understand the complex relationship between sound and meaning in language. The problem is particularly vexing in the so-called "fluent" aphasias, where the old disconnection hypothesis (that there is a mechanical problem in connecting what Wernicke called the *Wortbegriff* to a specific sound string that symbolizes it) does not very well explain what actually occurs. In this way Buckingham and Christman approach from a different direction the problem of the "Freudian slip," which once again shows that phonology is not after all so easily divorced from semantics. The paper concludes with some important remarks on aphasic neologisms (i.e. the use of non-existent words that the speaker uses as though they were endowed with meaning).

The paper by John B. Cobb (Claremont Graduate University), among the central figures of contemporary process theology, is in itself a lucid and very useful overview of process thought, which places microgenetic theory in a larger context. It is often remarked in process thought, sometimes rather ruefully, that thanks to such figures as Hartshorne and Cobb, the legacy of Alfred North Whitehead has had more impact in theology than in philosophy. This observation is more a judgment on philosophy, however, than on the value of either process thinking generally or theology in particular. It may perhaps be possible to reconcile a certain kind of theology with the revolt against metaphysics that characterized Western philosophy through the 20th century, but it seems on the face of it an odd theology indeed, which would have to make of God either a material entity or a play on words. At the same time, however, process thinking is likewise a challenge for more traditional theologies in either the Thomist or Calvinist tradition. Cobb's paper explains how microgenetic theory, based as it is on evolutionary theory and brain studies, may indeed be difficult to reconcile with fundamentalist pieties of various sorts, but enriches process theology in unexpected ways.

Mark Germine, a practicing psychotherapist from Mt. Shasta, California, takes the discussion in yet another direction, writing on “The microgenesis of antisociality: a process-relational perspective.” The problem of whether antisocial (including criminal) behavior is a symptom of a disease or indicative of a character defect is an old one, but no less pressing today than ever. Existing theories tend to explain the undesirable behavior away without addressing the more fundamental issues, which seem to lie beyond the competence of specialists. Germine argues that acquired sociopathy or antisociality is caused by damage to the orbitofrontal cortex (not in itself a new idea, of course), leading to reactive aggression manifested at an early stage in the microgenesis of behavior, which includes social behavior, i.e. the application of socially generated norms to private behavior. Genetic factors seem to play a role in the hypoactivity of the prefrontal cortex, but abuse and neglect in early childhood are mediating or triggering factors. Germine goes beyond the familiar studies of frontal lobe involvement in antisocial behavior, however, to argue for a relational view of intersubjectivity that develops in ontogeny and microgeny, with the caregiver/infant relationship as a background and model for an expanding web of social relationships, the root from which the tree grows.

The next author, Bozydar L.J. Kaczmarek, professor of psychology at the Marie Curie-Sklodowska University in Lublin, Poland, is a well-known neurolinguist and neuropsychologist, most of whose work to date has focused on the frontal lobes (including some important studies of the relationship between criminal behavior and frontal lobe damage). In the present paper, however, entitled “The brain and the mind,” Kaczmarek broadens his scope considerably, to reflect on one of the basic problems of neuropsychology, the philosophy of mind – and microgenetic theory. The paper begins with the important observation that recent advances in neuroimaging technology have actually weakened, rather than strengthened, the

Let's face it! Phonagnosia[1] happens, and voice recognition is finally familiar

Diana Sidtis & Jody Kreiman

To appear in:

M. Pachalska & M.Weber. (Eds.). Neuropsychology and Philosophy of Mind in Process. Essays in honor of Jason W. Brown. Process Thought VI, Frankfurt / Lancaster, Ontos Verlag, in press.

Although an adult, and nothing like a duck, one of us (DS) underwent imprinting in the Lorenzian sense, during a particular event some 30 years ago, not by a visual stimulus but by an Idea, and the day and time remain as vivid as a flashbulb memory. On an unexceptionally beautiful, sunny afternoon in Los Angeles, California, Jason Brown and DS were chatting over coffee in the UCLA Medical School Cafeteria, exchanging talk about work, interests, and friends. The mysteries of Tourette's disease, Capgras syndrome, and variously newly discovered neurobehavioral disorders were popular themes of the day, as were provocative presentations of aphasia reflecting left hemisphere specialization for speech and language. Like everyone else, we were doing dichotic listening studies. We must have strayed into talk about the new kid on the block[2], right cerebral hemisphere function. In the neuropsychology of the time, the "non-dominant" hemisphere was just emerging from its second-tier status, now receiving laud and honor for attentional and visual-spatial abilities, especially face recognition.

Jason suddenly and pointedly announced the Idea: it seemed to him that voice information constituting personal identity is similar to visual information signaling facial

[1] Deficit in voice perception ability. This may involve familiar and/or unfamiliar voices.
[2] E.g., Kinsbourne, 1970, 1974.

recognition, and therefore, that voice recognition, like face recognition, might well be a right hemisphere function. The notion was revolutionary. Notwithstanding the gleam in his eye, he stated that he, himself, did not plan to pursue such studies. He suggested that someone with an interest in phonetics might want to investigate this question. He encouraged this. We discussed how faces and voices are indeed patterns, by then thought to be the essence of right hemisphere specialization. Given the fixed belief of the time that speech and language resided exclusively in the left hemisphere, this was truly a radical idea, for it proposed that part of the speech signal is shunted off to the traditionally "nonverbal" hemisphere for routine processing.

In 1977, a few years after this day, having completed the doctoral degree and gone on to postdoctoral studies at Northwestern University, one author (DS) remembered the intriguing Idea, and, with the help of a strong mentor in the Department of Communicative Disorders, Jerry Canter, took up the study of brain substrates underlying familiar voice recognition. Jerry liked the idea immediately. We coined the term "phonagnosia" and joked about how it was about to become a household word. From his clinical experience, Jerry was highly sensitive to the latent abilities and overt disabilities of stroke patients, and he was expert in experimental design. These qualities guided us in setting up the first study (Van Lancker & Canter, 1982[3]). On returning to Los Angeles, the other author, JK, then an escapee doctoral student (that is, in absentia) from the Linguistics Department at the University of Chicago, was ready to pursue her doctoral research, and together, with benefit of a New Investigator Award from NIH, we proceeded to study perception and recognition of familiar and unfamiliar voices in normal and unilaterally brain-damaged subjects through the early 1980s at the UCLA Phonetics Laboratory.

After the first few years of intriguing findings, we tried repeatedly to obtain funding to continue the work, but were unsuccessful. At the time there was no field of familiar voice recognition, and the approach appeared alien to the prevailing perspective. In fact, there was very little familiarity research at all (some practical reasons for which are offered below). We designed spectacular projects such as voice recognition by

[3] We acknowledged Jason's contribution by thanking him for "titillating us" into voice research.

members within a university fraternity compared with listeners from two different fraternities, and dichotic listening of famous voices compared with recognition of the words spoken in those voices. At one point we teamed up with Immanuel Schegloff (1979), prominent sociolinguist, with an elaborate plan to record incoming phone calls to a hospital stroke ward, which would allow us to document the process of familiar-intimate voice recognition in comparison to our familiar-famous protocols. But addressing personally familiar stimuli appeared to excite loathing bewilderment in serious scientists. What prevailed was, as Brown has noted, an "anti-subjectivism," such that the consideration of personal familiarity, emanating necessarily from the first person perspective, was not "a respectable starting point for scientific study" (2002, p. xlii). While our luck with familiar voice recognition grant proposals never clicked, JK joined Bruce Gerratt to study voice quality in normal and disordered voices in great depth and detail (Kreiman, 1987; Kreiman & Gerratt, 1998), while DS turned to affective prosody for consolation (Van Lancker, 1980).

We've seen an increase in familiar voice recognition studies in the past several years, in part due to the rise of functional brain imaging, but undoubtedly also because internet and digital computer technology make auditory stimulus preparation much easier. We like to think that our earlier work belatedly inspired some of these current studies (Belin & Zatorre, 2003; Kriegstein & Giraud, 2004, Schweinberger, 2001) Recently we have revisited it all to produce a book entitled Voices and Listeners (Kreiman & D. Sidtis, in preparation). This chapter presents a birds'eye overview of these historical and current studies, along with our emergent model of human processing of familiar and unfamiliar voices.

Background

That differences in function of the two cerebral hemispheres in humans "cannot be accounted for readily in terms of the manner in which sense organs project to, and motor organs receive innervation from contralateral and ipsilateral hemispheres" has long been known (Neff ,1962, p. 196). One must consider both the functional and physical characteristics of the sound stimulus when considering hemispheric specialization. Physiological studies have shown that the basic auditory elements, frequency, intensity, timing, and quality (timbre) are processed by a symmetrically crossed and uncrossed auditory pathway in animals and humans transversing through subcortical nuclei, leading and contributing actively the formation of auditory "percepts" at the level of the cortex. Intensity is does not appear to be lateralized in any form. Complexity plays a role in specialization of the other sound elements. While pure tones (fundamental frequencies free of overtones) are not lateralized, complex tones, which include overtones providing pitch information as well as voice quality or "timbre," are lateralized to the right hemisphere (J. Sidtis, 1980; Zatorre, 1988; Zatorre & Samson, 1991) and timing, made up of complex relationships of short and longer elements, is specialized in the left hemisphere in humans (Schirmer, 2004; Zatorre & Belin, 2001), supporting the left hemisphere specialization for language.

A question arises about brain processing of pitch contrasts in tone languages such as Thai or Standard Chinese. Where are these linguistically structured pitch patterns processed? In the "language" hemisphere or in the "pitch pattern" hemisphere? Early dichotic listening studies suggested that, although pitch patterns are generally processed at the right temporal cortex, such patterns could be functionally "allocated" for use in the linguistic system, which is lateralized to the left hemisphere (Van Lancker & Fromkin, 1973). The linguistic use of pitch, forming a discrete number of contrastive elements that do not require the high-resolution pitch information used in music, governs the laterality effect, and left hemisphere specialization for tonal contrasts is seen in speakers of tone languages (Van Lancker, 1980). This finding has been corroborated by subsequent lesion studies for Thai, (Gandour & Dardarananda, 1983), Chinese (Naeser & Chan, 1980; Liang, 2006; Liang & van Heuven, 2004), Norwegian (Ryalls & Reinvang, 1986), and in English noun phrase level contrasts such as "green house," "green house" (Blumstein & Goodglass, 1972). Left hemisphere linguistic use of pitch has been seen normal subjects using functional brain imaging techniques (Gandour, Wong, Hsieh, Weinzapfel, Van Lancker & Hutchens, 2000; Klein, Zatorre, Milner, & Zhao, 2001). The permutability, or systematic nature of prosodic elements, and their function in a contrastive linguistic system, are qualities that determine lateralization to the left hemisphere. Tones in a tone language are discrete and linguistically structured and take a position at one side of a left-right continuum, while familiar voice patterns, having no capacity for decompositionality or permutability of elemental features, appear toward the other side, are associated with right hemisphere specialization. (Figure 1)

Figure 1 here

Other facts about functionality of the hemispheres contribute to the model of voice recognition. The right hemisphere more efficiently mediates emotional experiences (Van Lancker, 2000; Borod, 1993; Bowers, Bauer, & Heilman, 1993; Brown, 2002; Myers, 1998; Young, 1983). This supports processing of emotional associations in the voice pattern and facilitates voice recognition. It is specialized in processing configurational patterns (Benowitz, Finkelstein, Levine, & Moya, 1990), and we will see that the voice is best viewed as an auditory pattern of the Gestalt variety. While patterns can be discerned in any auditory-acoustic signal, our use of "Gestalt" entails that the perceived entity cannot be decomposed into aggregate elements and retain its identity as the perceptual object. In this view, as expressed in the microgenetic model, "wholes are not sums and parts are not mere constituents," as their relations must be taken into consideration (Brown, 2002, p. xli). Our perspective on familiar voices is particularly resonant with the process model of brain function in that configurations play a major role as original status of the content (Brown, 1998b). The content is "not constructed like a building," but unfolds from "preliminary configurations [that] are implicit in the final object" (Brown, 2002, p. 8).

The right hemisphere also modulates the acquisition and maintenance of personally relevant phenomena (Van Lancker, 1991), further supporting the acquisition and retention of a large repertory of personally known voices. The attribution of the familiarity sense itself is a specialized neuropsychological process, affecting cognitive processing of faces, voices, surroundings, pets and handwriting (Bradshaw & Nettleton, 1983; Heckmann, Lang, & Neudörfer, 2001); it is associated with right hemisphere function. A "pure" failure of the recognition sense, often present in right hemisphere damage,presents as a striking condition called Capgras syndrome, in which patients insist that family member, or sometimes a pet, has been replaced by an imposter (Cutting,1990; Young, Reid, Wright & Hellawell, 1993).

There is an obvious interplay between emotional and familiarity processing. Personally familiar phenomena carry packets of associations—history, images, facts, impressions, experiences, as well as thoughts and feelings about them. This has been demonstrated in studies of biographical memory (Cimino, Verfaelie, Bowers, & Heilman, 1991). Deficient emotional associations and impoverished report of personally familiar phenomena are seen following right hemisphere damage. When culturally known (personally familiar) persons and landmarks were rated on familiarity and emotionality, these two parameters were correlated but not identical for the items rated (Van Lancker & Ohnesorge, 2002). A related finding showed higher familiarity ratings for rapidly presented familiar and unfamiliar faces when the faces were smiling (Baudouin, Gilibert, Sansone & Tiberghien, 2000).

These known specialties of the right hemisphere: enhanced emotional experiencing, and acquisition and maintenance of personal familiarity, in tandem with superior pattern processing, are mutually cooperative competences that serve to support familiar voice recognition. We must emphasize the pervasive role of affect in familiarity perception. Here, again, process theory as articulated by Brown (2002; 1998b) provides a foundation in maintaining that affect is universally generated through conceptual systems, and that affect arises through cerebral regions other than the limbic system. These perspectives, formerly brilliantly exploreed by Zajonc (1968, 1980), were otherwise seriously neglected in earlier years, but have been recently resumed (Panskepp, 2008; Shanahan, 2007). In voice recognition performance, we see a strong relationship between familiarity and affect, which themselves form the essence of familiar voices.

In summary, sounds are processed in the brain according to their acoustic-physiologic properties on a scale from simple to complex and according to the preferred functionality of the cerebral hemispheres. These streams of influence—physiologic and functional—converge differently for different sounds and different uses of sounds. Within the sequential-analytical properties of speech, using high-granular temporal information, the left hemisphere rises to the task. Complex pitch, given its virtues as an auditory pattern (less reliant on temporal cues), receives superior processing at the right hemisphere auditory areas. However, when complex pitch information is linguistically structured into permutable units, as in language, a left hemisphere specialization is imposed. [4] Personal vocal signatures, forming a huge repertory of unique, complex patterns, are consigned to right hemisphere function.

We must confess that we are handicapped in our desire, however intense, to characterize the voice pattern in a truly revealing way. This caveat is represented in Figure 1, where it is noted that tones, tonemes, speech can be transcribed and written down. Voice patterns, as dynamic, intricately interwoven perceptual objects, cannot be written down. Of course, anything can be deconstructed and decomposed. Phonetics descriptions for voices have been developed (Laver, 1980; Nolan, 1983). These are a very large set of physical parameters applicable to many voices, but they fail to provide a unifying system for distinguishing different voices. Proper study of brain processing of familiar voice patterns demands a "vigorous defense of the primacy of the subjective"(Brown, 2002, xliii). The process model, which emphasizes the contribution of mental life to perceptual experience, provides a compatible context for describing familiar voice recognition. According to Brown, in the "microgenetic view…sensations do not provide the 'raw material' of percepts or cognitions, but constrain or 'sculpt' mind to represent sensory events" (Brown, 1988, p. 15). Any other account of human ability to process a large repertory of unique familiar voice patterns that attempts to utilize acoustic building blocks in the explanation is likely to fall short of satisfaction. A quote adapted from Brown fits well here: Trying to characterize a single voice pattern, or the repertory of voices known to someone, and/or the process of recognizing a familiar voice "would be like trying to illustrate the flow of a river with a set of bricks" (2002, p. xxxvi).

Neuropsychology of face and voice processing

Jason's original observation was that voices are like faces, and since this insight, the human voice has indeed been described in recent work as an "auditory face" (Belin, Fecteau, & Bédard, 2004). Although voice identity information occurs within the speech signal, arising from the acoustic-auditory energy that is speech, we foster the view in this paper that voices are more like faces than they are like speech. Voice identity information

[4] Tonal tokens in tone languages also contain temporal, intensity, and voice quality cues.

and speech information, although interwoven in the same signal, have radically different characteristics.[5]

How do speech and voice information differ? Speech is sequential, having a regular correspondence to discrete units (Sawusch, 1986); crucial contrasts, such as stop consonants, occur within very small units of time, on the order of tens of milliseconds. Speech can be decomposed into a small, finite set of elements (phonetic units and phonemes); it has describable structure (syllable shapes, consonants and vowels, regularly occurring voiced and voiceless portions, and so on). In the acoustic material cueing vocal identity, longer portions (1-3 seconds) (identification can occur in shorter periods) form the basis for identification. This corresponds to Pöppel's notion of the "specious present" of about two seconds. The pertinent elements are not usefully decomposable in the search to understand voice recognition; the characteristics "sequential" or "regularly analyzable into component parts" do not usefully pertain to the vocal pattern.

While many acoustic correspondences in speech are known (but see Footnote 5), efforts to isolate and identify parametric elements constituting the voice pattern, in ways that explain our prodigious perceptual competence, have not been successful. Faces also constitute a nondecomposible pattern. For identification, different and idiosyncratic aspects (relation of eyes to nose, mouth shape, closeness of eyes) in thousands of possible combinations come into play. In these ways, voices and faces are more similar to each other than are voices and speech.

Besides both forming patterns that lose their unique quality when decomposed, a further laundry list of similarities between voices and faces can be easily enumerated. Both are used to communicate personal, affective, and social information. They both surround us in familiar and unfamiliar guise. They are "indexical," in that they signal personal

---

[5] These extreme perspectives on voices compared with speech are breaking down. We are aware that the phonological segmentation tradition as representing "recurrent sames" in spoken language is being challenged (Port & Leary, 2005; Port, 2007; Pisoni, 1993; Palmeri, Goldinger, & Pisoni, 1993), in favor of a dynamic process (Goldinger & Azuma, 2003;) called "adaptive resonance theory." At the PisoniFest in Bloomington, Indiana, in May, 2006, a conference on speech perception, we intended to argue that voices are more like faces than they are like speech, until we heard the new story in speech perception that speech is a great deal like voices.

information, such as age, gender and mood, and a very large number can be instantly recognized. Both can be intentionally altered through disguise techniques. Voices and faces are similarly important in ontogenetic and phylogenetic survival: the offspring and the species learn to rely on vocal and facial signals to discern friend from foe and to recognize family members. A main difference between vocal and facial phenomena, beyond the dimensional (temporal versus spatial) one, is that voices can be heard by the fetus, suggesting deep evolutionary origins of this behavior, another perspective which is compatible with microgenetic theories of brain function, in which behaviors unfold as part of a long, whole brain evolutionary process (Brown, 1988, 1998a, 2002).

Given the characteristics shared by faces and voices, riding tandem through the social world with so many matching properties and functionalities, it was surprising to observe the asymmetry in neuroscience research, with many, many studies published for faces, and very few for voices (see Kreiman & D. Sidtis, to appear). To our minds, the explanation lies in relative convenience; facial stimuli, visuospatial entities, can be photocopied, carried in a briefcase, and displayed across a table for scientific inquiry, while voices, ephemeral, invisible, and transient, have a less accessible physical existence, and require electrical equipment throughout stimulus preparation and delivery.

Examination of personally familiar material introduces an additional set of challenges, as it brings in precisely those features that scientists previously avoided: subjective judgments, personal biases, idiosyncratic performance, and a demand for specialized stimuli for individual subjects (Van Lancker, 1991). Thus it is understandable, given the perspective, why many studies of facial perception, and later, studies on voices, utilized unfamiliar voices in discrimination tasks[6]. Construct validity in stimulus selection is severely threatened if the test materials are variably—not uniformly—familiar to the subjects; the difficulty of achieving such uniformity in personal familiarity across any number of subjects is obvious. We labored to overcome these hindrances with a number methodological inventions, including using stimuli

---

[6] To complicate the matter, the term "recognition" was applied where non-familiar faces or voices were used in the study. In a number of studies of "proposagnosia" (poor performance on facial stimuli) it is not clear whether familiar or unfamiliar faces are the object of the study.

generated by a cohort of our test subjects and posttest surveys to establish endorsement of known voices.

The comparison of familiar-intimate with familiar-famous materials—a topic of neuropsychological interest-- presents an additional special challenge, because two sets of familiar exemplars must be accumulated, each having comparable levels of familiarity to the subjects. We have not attempted this in voices, although a correspondence in auditory recognition of names corresponding to familiar-famous as well as familiar-intimate faces in globally aphasic patients, who were unable to recognize spoken or written common nouns, was found (Van Lancker & Nicklay, 1992). These differences have barely been addressed in face research, and have only begun to be touched upon in the realm of voices. It is curious that such aspects of human life that we especially care about—recognizing those individuals close to us–are avoided in scientific research.

The prevailing "componential accounts" of behavior associated with localization models of the brain have contributed to the dearth of familiarity research (Brown, 2002). In these accounts, behaviors common across persons are decomposed into components or modules that are supposed to be correlated to localized areas of the brain. In contrast, the process model of brain function describing microgenetic unfolding of perceptual experience, involving the whole brain, lends itself to a coherent discussion of personally familiar phenomena. Brown advocates "a theory of a mind sensitive to physical constraints but centered in the subjective" (2002, p. 20). This approach is essential for an authentic characterization of the intimate listener-speaker dyad inherent in familiar voice processing.

Familiar face and voice recognition

Considering the number of family, friends, colleagues and famous persons in our physical midst and calling us up on the telephone, it is clear that we potentially recognize many voices, but how well do we recognize them? How many, and under what conditions? Design problems abound for this type of study. Little information has been available for voices, although some such questions have been asked and answered for faces. Something about the extent of this ability, despite changes in age, facial hair, expression, and other local details was first demonstrated for faces in 1975 (Bahrick,

Bahrick & Wittlinger, l975), using high school yearbooks going back as far as 50 years. Subjects recognized familiar persons (in arrays including nonfamiliar faces) at very high rates. Studies identified no upper limit to the number of faces individuals can accurately recognize as "familiar" throughout their lives (Bruck, Cavanaugh, & Ceci, 1991). Aging does not noticeably affect face recognition competence (Baeckman, 1991), although some decrement for more recent faces may occur (Wahlin, Backman, Mantylea, Herlitz, Viitanen, & Winblad, 1993).

The case for lifelong retention of a repertory of familiar voices is likely similar, but more difficult to demonstrate formally (due to the “inconvenience” factor mentioned above). It is daunting to consider assembling a test set of past familiar-intimate voices. Therefore, although everyone has a large repertory of voices that they recognize as familiar, actual recognition rates are difficult to come by. Yet casual observation suggests that when they recognize and (less often) name the person who produced a voice sample, humans perform extremely well compared to the recognition abilities demonstrated, for example, by penguins, monkeys, or bats, who, at most, recognize a small set of individual familiar members (see Kreiman & D. Sidtis, in preparation).

As can be imagined, there are two approaches to the topic. In the first, researchers study speakers and listeners who are familiar with each other through daily contact (familiar/intimate voices), including an individual’s friends and family members. This has been attempted only rarely. Ladefoged and Ladefoged (1980) examined the ability of a single highly expert listener (Peter Ladefoged) to recognize the voices of 53 speakers (29 familiar, 13 somewhat familiar, and 11 unfamiliar). In a difficult “open set” task, the expert correctly named 31% of the speakers from a single word ('hello’), compared to 66% when the stimulus was a sentence. The overall false identification rate equaled 11%. A small number of other studies (Schmidt-Nielsen & Stern, 1985; Rose & Duncan, 1995; Wagner & Köster, 1999; Lavner, Gath & Rosenhouse, 2000), using single words or sentences as challenge stimuli spoken by persons of varying degrees of personal familiarity, report success rates for listeners of from 4% to 100%, depending on task and voice samples.

Another approach to evaluating the extent of human recognition abilities uses familiar/famous voices. Thanks to the mass media, this approach is much simpler to implement, because many listeners are familiar with the voices of similar sets of actors, politicians, newscasters, and other celebrities. The examiner can enhance uniformity of the known voices in listeners by pre- and posttesting: first, a survey can be used asking a demographically matched cohort to generate names of famous persons whose voices they know, and/or by, following testing, having the listeners themselves rate the voices in the listening set for familiarity. In studies, listeners perform decently when asked to identify a famous voice in an open-set task (where the speaker could be anyone, living or dead): 27% of the speakers presented with a 4-second voice sample without context were named (Van Lancker, Kreiman & Wickens, 1985), and 48% from a 20-second sample, even when voices were recorded across 5 decades (Meudell, Northern, Snowden & Neary, 1980;). Recognition rates increased when speakers were provided with a closed set of choices, with pictures, and/or with a list of speakers' names. More recently, Schweinberger et al. (1997) played listeners samples of famous voices varying in duration from 250 ms to 2 sec. Listeners heard longer and longer samples until they categorized the voice as "famous" or "unfamiliar." Accuracy was very close to 0 at 250 ms, but increased rapidly with duration up to 1 sec. For the longest durations, listeners correctly responded "famous" 68% of the time, with a false alarm rate of 33%. These limited data give some idea of range of competences across listeners and listening environments, but more studies of human voice recognition competence are needed.

Effects of brain damage on face and voice recognition

Prosopagnosia was first described by Joachim Bodamer in l947 as agnosia (loss of meaning) for the recognition of faces and expressions, without disturbance of perception of the parts of the face[7]. Viewing a photograph of his wife, the victim of prosopagnosia can report that he is seeing a face and he can describe the face in detail, but he cannot "recognize" or identify it (Benton, l980). In real life, the prosopagnosic patient must rely on

[7] Later studies uncovered separate cognitive processes for familiar face recognition, unfamiliar face discrimination, and recognition of facial expression. Failure to define and distinguish between these different neuropsychological functions has often led to confusion in the scholarly literature.

known items of clothing, the sound of his wife's voice[8] or other extraneous props, to recognize her (Damasio, Damasio, & Van Hoesen, 1982).). Viewing the face does not evoke a feeling of familiarity.

A failure to recognize familiar faces is associated with a lesion in the right hemisphere, often a parietal-occipital lesion (Whitely and Warrington, l977; Yin, l970; Vilkki & Laitinen, l976). Many studies report that a left hemisphere lesion is also present, and that bilateral damage is required for prosopagnosia (Meadows, l974; Damasio, Damasio & Van Hoesen, l982; Hamsher, Levine, & Benton, 1979). From the beginning, predominant side of lesion was not clear (Brown, 1972). Some of these observations may be explained by the notion, as mentioned previously, that both hemispheres are able to perceive and identify faces, but they do so using different processes (Gazzaniga & Smylie, 1983). Cases of prosopagnosia have been associated with single right hemisphere lesions based on CT-scan evidence (Landis, Cummings, Benson, & Palmer, l986; DeRenzi, l986) and PET results showing hypometabolism (less than normal metabolism) in the right temporal lobe (Evans, Heggs, Antoun, & Hodges, 1995). While a lesion in the left hemisphere may enhance the disability, reports of familiar face recognition deficits following unilateral right hemisphere damage suffice to suggest an important role of that hemisphere in familiar face recognition.

Both hemispheres perceptually process familiar and unfamiliar faces and names, according to different procedures (Damasio, Damasio, & Van Hoesen, 1982), but only the left hemisphere is proficient in famous name production (Semenza & Zettin, 1988). This was dramatically illustrated in a study of callosal-sectioned ("split-brain") subjects, who identified pictures of familiar persons and landmarks presented to either hemisphere. As expected, subjects verbally named only the stimuli presented to the left hemisphere. The especially interesting finding is that right hemisphere presentation yielded nonverbally accurate responses that were more intense than left hemisphere (Sperry, Zaidel, & Zaidel,

---

[8] We have noted such comments several times in the neuropsychological literature on prosopagnosia, anecdotally and indirectly implying a dissociability of voice and face in the recognition repertory, but also indicating a failure to acknowledge a status of voices as a comparable neurocognitive category. This neglect has persisted in neuropsychology (cf Bauer & Rubens, 1985; Duchaine, 2006). This also reflects the dominance of the visual modality in neurobehavioral thought.

1979). A reasonable proposal is that both hemispheres can identify visual stimuli; the right hemisphere has a more emotional, personally familiar response, while the left hemisphere makes the identification and can produce a verbal response. A study using split-visual techniques combined with evoked response measures over left and right hemispheres, whereby faces and names were presented, produced a sustained negative wave in the hemisphere contralateral to the stimulated visual hemi-field (Schweinberger, Sommer, & Stiller, 1994). This indicated that hemisphere resources are allocated to both tasks. Yet the clinical data indicate hemispheric differences in quality of processing.

Recognition versus discrimination of voices and faces

The term "recognition" has various meanings in psychological studies. One sense of the term is categorize, so that a subject "recognizes" that an object is (or is not) a member of a category, such as the category of faces, animals, and so on. Another version of familiarity studies, the "train-to-familiarity" technique, also differs from studies of personally familiar, or personally relevant items, such as family members, politicians, and movie stars. These approaches train subjects to acquire into memory a set of faces or voices, and then test how well they recognize these trained stimuli in a larger set including untrained items. In personally familiar voice and face recognition, two variants are familiar-famous (culturally known persons and places) and familiar-intimate (family, friends, neighborhood places).

Discrimination tasks are generally understood to involve new or unfamiliar objects or material, although personally familiar voices can be mounted in an ABX-type matching-to-sample discrimination task. This has been performed in trained-to-familiar studies, but we know of no such studies using personally familiar voices. Generally, for discrimination tasks, people discriminate between two or more objects, judging them as same, different, or having certain features in common. Early studies examining brain-injured subjects suggested that discriminating between unfamiliar faces and recognizing familiar faces engage different cerebral mechanisms (Young, Newcombe, de Haan, Small, & Hay, 1993; Benton & Van Allen, 1972; Benton, 1980). Malone, Morris, Kay and Levin (l982) reported a double dissociation between discrimination and recognition of faces in two patients who could achieve one but not the other task, and they mention four cases of prosopagnosia in whom unfamiliar face discrimination was preserved. These differences once were identified as apperceptive (unfamiliar-discrimination) and associative (familiar-recognition) forms of prosopagnosia (De Renzi, Faglioni, Grossi, & Michelli, 1991). Warrington and James (l967) claimed that a right parieto-occipital lesion corresponded to a recognition deficit, while a right hemisphere temporal lobe lesion was associated with face discrimination deficits

Studies comparing familiar and unfamiliar face recognition tasks in a large group of unilaterally brain damaged subjects reported that although right sided damage affected all tasks, performance on familiar faces was independent of other perceptual disorders (Carlesimo & Caltagirone, 1995). In contrast, 39 subjects performed at a 22% decrement (compared to normal subjects) on a facial discrimination task following temporal or frontal lobectomy on either side (Brown, Denault, Cohen, & Rouleau, 1994). Nachson (1995) proposed a specific, "domain specific" mechanism in the brain for processing of faces. Studies of brain electrical activity using surface and depth electrodes also reported different responses to familiar and novel faces (Seeck, Mainwaring, Ives, Blume, Dubuisson, Cosgrove, Mesulam, & Schomer, 1993). Grafman, Salazar, Weingartner & Amin (l986) found a similar double dissociation between performance on familiar and unfamiliar faces in persons with penetrating brain wounds.

Electrophysiological correlates of face discrimination and other visual tasks, in the form of early and middle evoked responses, suggested the presence of category-specific streams of processing in bilateral, inferior extrastriate and temporal cortex (Allison, McCarthy, Nobre, Puce, & Belger, 1994). In studying a range of percepts, including numbers and colors, as processed in secondary visual cortex, discrete regions for face stimuli were found (Allison, Ginter, McCarthy, Nobre, Puce, Luby, & Spencer, 1994). Separate chronically implanted electrode placements across subjects, during evaluation for surgery as treatment for epilepsy, suggested that discrete regions for face recognition may differ between individuals.

Several approaches to face and voice processing in the brain refer to the notion of two distinct cortical streams: a medial stream (for object recognition) and a lateral stream (for perceptual processing) (Elgar & Campbell, 2001). For auditory input, dorsal and ventral streams are described, said to process the "what" and "where" of the stimuli.

Functional imaging studies proposing to examine networks within the brain utilize these notions for both left and right hemispheres. So, for example, Knösche, Lattner, Maess, Schauer, & Friederici (2002) show separate processing streams for phonemic and voice identity information. Other brain imaging studies attempt to identify cortical areas forvoice recognition. As many as three distinct voice areas have been proposed to exist for familiar stimuli in right temporal lobe. The authors attempt to accommodate this observation to the standard two-stream hypothesis, by claiming that the anterior ventral (toward the underside) stream originating in the superior temporal sulcus identifies a specific person, while the posterior dorsal (toward the upper side) stream processes voices as acoustic targets (Kriegstein & Giraud, 2004). This is not in full agreement with Belin, Zatorre, Lafaille, Ahad & Pike (2000), who identify the midanterior superior temporal sulcus as responsible for spectral analysis, while both posterior and anterior areas emphasize voice processing over linguistic analysis of speech. But functional connections to adjacent temporal areas during voice recognition are proposed. Lattner, Meyer, & Friederici (2005) using magnetic field studies of the brain found that voice information was processed bilaterally, but that pitch and voice analysis formed a Gestalt-like function in the right temporal lobe.

While we are pleased that brain function underlying voice recognition—especially subjectively, personally familiar voices-- has finally become a topic of serious scientific study, we suspect that the localizationist model, especially as utilized in brain activation paradigms, is inadequate. This shortcoming is compounded by the uncertainties of the meaning of activation signals in functional imaging (J. Sidtis, 2007). The elementary and primordial nature of the ability, arising out of deep evolutionary processing, as revealed in the ubiquitous and varying versions of familiar voice recognition instinctual behaviors in animals, suggests a whole-brain participation in the process, which is better described as a brain state beginning with a configuration, possibly, as Brown (2002) describes, in the brain stem, and resonating through limbic and basal ganglia systems to neocortical areas. A recent finding of brain stem processing of linguistic pitch contrasts makes a small beginning in supporting the view of multiple brain processes underlying these complex auditory behaviors (Krishnan, Xu, Gandour, & Cariani, 2005).

Studies reviewed in this chapter implicate the right parietal lobe as end-station processing area for the unfolding of personally familiar voice recognition (see Figure 2).

Figure 2 here

How instinctual, or inborn, are these processes that help us recognize faces and voices? In reviewing learning and recognition studies of face processing, Farah (1996) concluded that face discrimination and recognition are "special" in cognition, in that humans are uniquely adapted to processing facial stimuli. This view was supported by observations in an individual with prosopagnosia (meaning, here, failure to recognize known, familiar faces), who performed disproportionately poorly on other face processing tasks, in comparison with perception of objects (Farah, Levinson, & Klein, 1995). A single case of developmental prosopagnosia suggested that face recognition is domain specific (and not a general visuospatial competence), in that the deficit occurred only for upright facial stimuli (Duchaine, Yovel, Butterworth, & Nakayama, 2006). More evidence that neural tissue is innately dedicated to face recognition arose from studies of a child with a severe, acquired face recognition deficit without object perception problems, who sustained brain damage shortly after birth (Farah, Rabinowitz, Quinn, & Liu, 2000). The common observation that inverted faces elicit better discrimination performance in some persons with prosagnosia has been brought forth to support the notion of modularity in that ability (Farah, Wilson, Drain, & Tanaka, 1995). These authors have provided evidence that proposagnosia occurs as a genetic disorder in familial groups. The demonstrated inborn status of human voice recognition certainly supports a genetic origin of this ability.

Recently the notion of "face blindness" has caught the popular imagination, with internet surveys available for people to fill out, intending to earmark people with deficient familiar facial recognition in everyday life. The budding analog is "voice blindness," revealing individuals who are deficient in recognizing the voices of their conspecifics. This disability is less noticeable than face blindness. We received a letter from an adult male who acknowledged a failure, through his earlier life, to appreciate that human voices are distinguishable. He described being agnostic to differences between voice patterns. He eventually became aware only because of complaints from friends and family, when he consistently identified himself to them on the telephone, and by his inability to know, by the voice itself, who was calling him. Such individuals likely use verbal strategies on the telephone to identify callers, and in social situations, focus on visual cues to identify acquaintances.

Face and voice processing are both likely genetic endowments, but with different maturational schedules in the developing child. Infants learn to recognize their mothers' voice before birth, and respond significantly more to her than other maternal voices immediately after birth (de Casper & Fifer, 1980), implying acquisition in utero. This finding has been amply supported by later findings. In contrast, while infants preferentially track face-like shapes and faces more often than other visual stimuli, they do not recognize their mothers' faces until several months after birth (Fantz, 1961; Johnson, Dziurawiec, Ellis, & Morton, 1991). For voice perception, a dissociated, specialized, domain-specific cognitive ability has also been proposed. In their review of recent neuroimaging studies, Belin, Fecteau and Bedard (2004) claim that vocal identity information is processed in cortical pathways partially segregated from linguistic and affective information in speech. They draw on the lessons of face research, and suggest that the analogy for voices as specialized is justified. However, the emphasis on modularity for such cognitive functions fails to take into account the pervasive contribution of several brain areas. The notion of modules renders static structure to conceptual objects and events that are better viewed as dynamic processes (Brown, 1998a, b).

A historical view of phonagnosia studies

The earliest published studies of voice perception in brain-damaged patients used unfamiliar voices, but the purpose, to understand abilities to discern different voice patterns, approached the bona fide recognition question[9]. Judgments of male, female, or child, and detection of foreign accents in a set of unfamiliar female voices were used, resulting in a greater tendency for right sided damage (compared to left sided damage) to

[9] We don't know if Jason Brown was familiar with Assal's work when he proposed the Idea. In Brown, 1972, he outlined a battery of tests for auditory agnosia, which included these stimuli: male vs female voice, young vs old voice, foreign languages, and English with nonnative accents.

interfere with successful discrimination (Assal, Zander, Kremin & Buttet, l976). These authors inferred from patients' performance on a same/different voice discrimination task that "the right temporal/parietal region seems to play a key role in vocal recognition" (Assal, Aubert & Buttet, l981, p. 256). This early statement strikingly foretells the story of voices that unfolded.

At Northwestern University in 1977, examination of recognition of personally familiar (famous) voices in brain-damaged subjects began (Van Lancker & Canter, l982). At the time, most famous people were male, so we opted to stay with that gender for the stimulus array. We explored how best to obtain target voices. As one proposed strategy, we wrote to Rich Little, well known impressionist, and asked whether he would cooperate with the study. A spokesperson declined our request. As an alternative, we recorded voices of famous male media persons and entertainers from various sources (e.g., radio and television interviews and shows, audiocassettes of old radio programs, phonograph recordings of comedians), and edited the material to eliminate background noise and revealing content. Using the same multiple choice format adopted for the voice recognition test, we designed a pretest with written samples. Any test item significantly often "guessed" from the written text was removed or altered. This was to ensure that correct identification could be made from voice alone with no benefit of linguistic content. Seven samples of 9-14 seconds in length were played to 30 unilaterally brain damaged subjects (21 left brain damaged and 9 right brain damaged) who had sustained single lesions from stroke. Responses were made by pointing to one of four photographs. Response options for each choice included the written and spoken name, so that selective deficits in face recognition, auditory comprehension, or reading would not interfere with the results. As an incidental finding from observing our normal control subjects, we saw that recognition was accomplished in less than 3 seconds of presentation of the voice samples[10].

[10] This informal observation was later supported by evoked response potential (ERP) studies. Effects of priming on familiar voices were observed within 200 milliseconds (Schweinberger, 2001). In studies monitoring brain electrical activity through scalp and implanted electrodes, brain responses on the familiarity judgment occurred from 50-90 milliseconds (Seeck, Michel, Mainwaring, Cosgrove, Blume, Ives, Landis, & Schomer, 1997). When stimuli presented in increasing durational steps from 0.25 seconds up to a maximum of 2 seconds, famous voice recognition improved with duration (Schweinberger, Herholz, & Sommer, 1997).

Most exciting were the findings that right hemisphere damage significantly interfered with recognizing familiar voices, whereas left hemisphere damaged patients recognized voices, in many cases, as well as normal listeners. Even severely aphasic patients, who could neither speak nor understand what was being said, recognized with ease who was saying it. One person diagnosed with global aphasia, a complete disability in language function affecting all modalities, recognized all the voices, and when she heard the voice of Jack Benny, she performed a gesture that was his signature (leaning chin on hand, other hand cupping elbow). Her family members, accustomed to her severe communication deficit and seeing this gesture, were heartened and impressed to see her cognitive response to a cultural icon.

In retrospect, the finding of a right hemisphere specialization for familiar voice recognition might have been expected, insofar as recognizing voices is much like recognizing faces: both are complex patterns (one auditory, one visual) and the right hemisphere is superior at some forms of pattern recognition. From another point of view, however, the early right hemisphere finding for voice recognition was surprising, because voice quality is carried in the speech signal, previously believed to be processed exclusively in the left hemisphere.

Later, in Los Angeles, with the advent to the UCLA Phonetics Laboratory of a coauthor of this article (JK), the studies continued. We seized an opportunity to describe our voice studies to Freda Newcombe[11], a prominent British neuropsychologist, who visited the UCLA Department of Linguistics somewhere around this time. She reminded us that brain processing underlying voice perception might differ for familiar and unfamiliar voices. We are grateful for her suggestion, drawn from her studies on prosopagnosia. A new and improved protocol was designed to test clinical subjects with damage to either the left or the right cerebral hemisphere on two kinds of voices: personally-familiar and unfamiliar (Van Lancker & Kreiman, l986; l987). Using the knowledge gained from the previous study, shorter voice signals (four-second samples) of 25 familiar voices were prepared, along with 4 choices vertically aligned on response sheets. To compare familiar voice recognition with discrimination of unfamiliar voices, JK adapted a listening test from her dissertation research. Unfamiliar voices were 26 pairs of 4-second samples of 10 age-

[11] Freda Gladys Newcombe died in Holton, Oxfordshire on April 6, 2001.

and dialect-matched male college students. These were prepared for a same/different discrimination paradigm. (Kreiman, 1987). Forty-five normal-control listeners, matched in age and education to the clinical population, were tested, and 40 clinical patients received both discrimination and recognition protocols.

Results for familiar voices replicated the previous study: right brain damage interfered with voice recognition performance, while left brain damaged subjects, even those with severe aphasia, performed as well as normal listeners. However, unfamiliar voices brought different findings. No unilateral side of lesion was exclusively associated with poor performance. Damage to either hemisphere lowered performance on discrimination between unfamiliar voices (Van Lancker, Kreiman & Cummings, 1989).

Review of individual patients' performance led to the conclusion that voice recognition and voice discrimination are separate and unordered abilities: we saw that brain lesions can interfere with one competence, but not the other. In addition, these selected disabilities were unordered, in that they occurred in either "direction": Some patients could recognize familiar voices, but could not discriminate between unfamiliar voices, and others showed the opposite pattern. At first glance, it might appear that familiar voice recognition is more complex or occurs at a higher cognitive level than unfamiliar voice discrimination, and that therefore, if performance on familiar voices is good, one can expect good performance on unfamiliar voices. However, this was not the case. Voice recognition and discrimination are not dependent on each other, and do not form an implicational series, but are functionally independent, and have different neuroanatomic substrates (Van Lancker, Cummings, Kreiman & Dobkin, 1988).

With the help of behavioral neurologist Jeffrey Cummings, radiographic data were used to determine sites of damage associated with familiar and unfamiliar voice perception difficulties. Patients were considered deficienton either task if they scored more that 1.5 SD below the mean of the normal-control group. All patients with familiar-recognition deficits had right parietal lobe lesions; two others had additional right frontal or occipital damage. Patients with unfamiliar-discrimination deficits had lesions involving either the right or left temporal lobe, with the lesions extending beyond the temporal lobe in two thirds of the cases. These differences were significant using a Chi square analysis. Areas in the inferior and anterior parietal lobes have been identified as "heteromodel" or cross-modal association areas (Benson, 1994). The voice as perceptual object is a constellation of auditory, visual, and tactile features along with elements of declarative and procedural memory. This implies that successful identification of a personally familiar voice involves cross modal associations.

Later studies using patients with unilateral brain lesions lent support to the earlier studies of the 1980s and carried them a step further (Neuner & Schweinberger, 2000). Patients' performance indicated that neuropsychological impairments in face, voice, and name recognition, following discretely located brain damage, are dissociable from one another. In four patients, a selective impairment of voice recognition was seen; voice recognition scores were at chance levels, while face, name, and sound recognition were preserved. A number of patients with impairment of familiar voice recognition were able to discriminate unfamiliar voices, supporting the view that familiar recognition and unfamiliar voice discrimination are dissociated neuropsychological abilities; of these, two had unilateral right hemisphere damage, lending support to an important role of the right hemisphere in familiar voice recognition. Person recognition deficit was associated with bilateral or right hemisphere damage in 9 of the 10 subjects having this difficulty, further supporting the notion of personal relevance as residing in the human right hemisphere (Van Lancker, 1991).

A Model of Brain Processing for Voice Perception

All the structures of the brain identified in voice and face discrimination and recognition exist bilaterally. The temporal lobes, which contain the auditory receiving areas, the hippocampi, which are crucial to learning and memory of auditory events, the amygdala, which, as part of the encircling limbic system, react to emotionally laden stimuli, are all nearly identical in size and shape in each cerebral hemisphere. The small interhemispheric morphological differences identified for a few structures have not been shown to have consistent functional implications (Geschwind & Galaburda, 1985). Yet the convergence of findings from different scientific paradigms leads to the conclusion that the acoustic material of speech is processed preferentially in the left hemisphere, while the acoustic material for voice recognition is preferentially processed in the right hemisphere.

Some exceptions to these general outcomes arise from functional imaging studies, where considerable bilateral activation for many language and cognitive tasks is reported. The reasons for activation signals in the right hemisphere for language tasks, for example, are not well understood (J. Sidtis, 2007; Van Lancker Sidtis, 2007). They may be attributable to a large set of possible explanations including tandem blood flow, passive responses, and so on. Since many of these signals are difficult to explain, caution in interpretation is indicated.

A convergence of findings from neuropsychological studies leads to a model of the brain which describes the right hemisphere as a superior Gestalt pattern recognizer, whereas the left hemisphere excels at detailed, analytic tasks. For voices, this model accommodates the notion that voices are processed by the interplay of two processes, Gestalt-recognition and feature analysis. It further specifies that bilateral temporal lobes specialize in detailed auditory processing, whereas the parietal lobe, as association cortex, performs cross-modal matches and higher integration of sensory input. Finally, the right hemisphere has a key role in personal relevance processing by storing "packets" of associated information for a very large repertory of unique, known persons, places, objects, and events; this information includes faces and voices. The packets include biographical information and emotional associations.

Familiar voices are recognized as Gestalt-like patterns, not as an additive list of specifiable parameters or features. In the microgenetic approach. we can say that configural properties of the content are actualized (Brown, 2002, p. xxxiv). As mentioned previously, processing a voice sample involves an interplay between the holistic, synthetic Gestalt process (whereby a pattern is apperceived and the compositional elements are not systematically attended to), and perception of vocal parameters. In this view, familiar voice recognition depends both on the idiosyncratic, distinctive salience of a cue or set of cues and on the context of the other cues present in a voice. To characterize listeners' recognition of known voices in general, it is not useful to specify a single set of parameters that universally underlie voice quality judgments. We agree with Brown that: it is "failed logic [to assume] that a behavior is explained when it is fractionated into constituent operations that are separately interpreted and then reunited" (2002, p. 16).

The cues to a particular speaker's identity logically depend on both the listener and on the complete vocal pattern in which the individual cues operate. Recognition depends on the particular listener, because familiarity is a function of both the voice and the listener (what is known and the person who knows it). Without subjectivity in this formula, the point is lost, or in Brown's words "Subjectivity is the inner dynamic of any object…the entity into which it actualizes" (2002, p. xlix).

Support for this view comes from behavioral studies of normal listeners. When 45 famous voices were played to listeners backward or with the speaking rate altered, some voices were easily recognized despite the alteration but others could not be identified (Van Lancker, Kreiman & Emmorey, 1985; Van Lancker, Kreiman & Wickens,1985). Intuitively, it seemed likely that voices of speakers who were notable as fast or slow talkers would be most affected by rate alterations, and that recognition of the voices of speakers with strong foreign accents would be most impaired by backwards presentation. However, this was not the case. No matter how extreme a voice was on some dimension, the importance of that dimension as a cue was determined by the other characteristics that the voice had, not just on that cue alone. For example, actor Maurice Chevalier had a strong French accent when speaking English, but also a rather low pitched, breathy voice, distinctive syllable rates and "different sounding" vowel qualities; his voice was easily recognized backwards. Other actors with similarly salient accents were not recognizable when their voices were played backwards. These data suggest that recognition depends both on the relative salience of a cue or set of cues, and on the context of the other cues present in a voice. The simple feature-based model of familiar voice recognition assumed by most research cannot accommodate these findings, because the values of individual cues, as if forming part of a fixed repertory of cues, are not adequate to predict whether or not a voice will be recognized. These data suggest that familiar voices are recognized as complex, Gestalt-like patterns, not as additive lists of a known, finite set of features.

Data from priming experiments (Schweinberger, Herholz, & Sommer, 1997) also point to this conclusion. In one of these studies, listeners heard famous and unfamiliar voices, and were asked to respond 'famous' or 'not famous' as quickly as possible. Reaction times to famous voices were significantly faster when listeners had previously heard a different exemplar of a famous voice, but no similar advantage was observed for unfamiliar voices. Because the priming effect was produced by a different sample of each voice, it appears that the benefit derives from the complete voice pattern, not from the specific details of a given sample, consistent with the view that familiar voices are processed as patterns, and not as bundles of features.

Gestalt doctrine—the notion that much of perception involves establishment of schemata or patterns – (Corcoran, 1971; Reed, 1972; Neisser, 1976) is generally accepted. This ability is held to be "wired-in" or innate (Pomerantz, 1986). It remains a problem how to define this process. Patterns and aggregates of features differ essentially. Features can be notated and written down. But patterns are best represented in toto, or as unique caricatures, and notational systems have not proven adequate or useful. Structure can be imposed on voice patterns, and features can be listed, but this is a case of imposing stasis on the dynamic of process (Brown, 2002, p. 25), during which the essence of the object is distorted.

We are aware that parameters can be listed for certain vocal attributes, such as fundamental frequency, breathiness, and foreign accent, but these do not adequately account for the huge repertory of known voices even in a single individual. Both featural-analytic and holistic-configurational approaches have been demonstrated in studies face perception (Farah, Hammond, & Mehta, 1989; Farah, Levinson, & Klein, 1995; Schwaninger, Lobmaier, Collishaw, 2002), indicating that task demands can elicit both perceptual approaches. Equal performance on tasks emphasizing part-analysis and holistic recognition is not achieved until adolescence (Davidoff & Roberson, 2002).

Gestalt and microgenetic theory each offer a vocabulary and a context for describing voice perception. It is said for pattern recognition that an emergent feature or features serve to identify the pattern; this, then, constitutes the salient property (Pomerantz, 1986), but it is obvious that both the configurational pattern and the idiosyncratically identifying feature coexist. Somewhat similarly, in microgenesis, the recognition process can be conceived as occurring in phases from whole-to-parts specification leading to an "independent existence" as the "becoming terminates" in the actuality, the recognized voice (Brown, 1998a, p. 82). The voice object arises as "a process of momentary actualization" –the known voice--with progressive specification of parts arising from it.

The temporal dimension is retained in this description of voice perception. The voice pattern arises as a "concrete image in the mental space" of the listener, even though "change is intrinsic to the actualization." For voices, in is intensely useful to acknowledge that "the replication is never exact" as described in microgeny (Brown, 1998a, p. 85). And further, as specified by microgenic perspectives, the stability of objects, such as our vast repertory of known voices, has been achieved through a long evolutionary processes, which is easy to support by surveying the prevalence and variety of familiar voice recognition capacities across species.

This phenomenological view of voice patterns implies, for voices familiar to the listener, that the individual voice pattern alone provides the appropriate cue to itself. Applicable here is Brown's notion of patterns externalizing into their featural elements. This microgenetic view represents our model better than any compositional approach, in which the voice pattern is "built up" out of additive, elemental ingredients. In our view, the configural properties of the voice are reproduced as part of the interactional process of talker and listener. It follows that different instantiations of the voice pattern, affected by background noise, aging, or mood, to mention a few, suffice to represent the voice phenomenon. Each occurrence of the familiar voice object, in a sense, is novel, as described for mental states in microgenesis. Each entity in thought is novel in view of its temporality and its change across micromoments (Brown, 1998b). Yet the brain forms categories, leading to an allusion of stability. This conceptualization of mental processes accommodates the very large number of known voice objects, each of which occurs in changing, "novel," and dynamic form, and yet each belongs to a single, unique category (her voice or his voice). This dynamic, process approach to familiar voice perception offers an accounting that is lacking in compositional analysis of a static entity.

A view of microgenetic processing for voice, where the pattern is newly and instantaneously actualized in a dynamic unfolding, also provides a context for understanding the acquisition of familiar voices. We have argued elsewhere (Kreiman & D. Sidtis, in preparation) that inducting a voice pattern into one's pantheon of personally familiar voices does not enjoy a learning curve. Acquiring a personally relevant voice pattern is the result of a whole brain response that involves the auditory processing of the temporal lobes, short-to-long term memory shunting by hippocampi, the emotional valences of the limbic system, executive oversight of the frontal lobes, and coordination across parietal lobe association cortices (see Figure 2). This is best viewed as a phasic process.

The voice perception model proposed here makes the basic assumption that all voices constitute auditory patterns. The voice is not usefully reducible to componential constituents; like any pattern, no list of ingredients or parameters can reasonably thought of to "add up," in space or time, to the total voice pattern. In the case of familiar voices, very little predictable featural analysis may enter into the recognition process; rather, a few idiosyncratic, salient cues, occurring within a unique context, provide adequate information for identification. As previously described, studies of normal listeners' recognition of acoustically altered (backwards presentation, slowing rate, and increasing rate) familiar voices showed that a large variety of salient characteristics (e.g., breathiness, nasality, clipped consonants, rate) are important to different voices, suggesting that listeners do indeed recognize each familiar voice as a unique pattern; they do not extract a constant set of auditory features (Van Lancker, Kreiman, & Emmorey, l985; Van Lancker, Kreiman & Wickens, l985).

In matching or evaluation tasks for discrimination of unfamiliar voices, use of elemental feature analysis and comparison plays a greater role. Matching unfamiliar voices engages featural analysis. In addition to perceiving the unfamiliar voice as an overall auditory pattern, the listener "extracts" elementary acoustic features such as pitch, vocal quality, and rate, and perceptual features such as masculinity, and uses them for comparison. In fact, normal listeners' performance on unfamiliar voices, in discrimination and long-term memory studies, suggests that both general characteristics and distinct features are utilized to compare and remember unfamiliar voice patterns (Kreiman, l987).

The clinical findings for voice perception reviewed above indicates that an intact right hemisphere was needed for voice recognition, and that both hemispheres were needed to successfully discriminate between unfamiliar voices. The voice perception model proposes that pattern recognition abilities of the right hemisphere are required for both kinds of voice perception, but the analytic abilities of the left hemisphere are needed for successful performance on unfamiliar voices. Furthermore, familiar recognition is a cross-association pattern matching involving information packets, utilizing parietal lobe association areas. In the right cortical hemisphere, cognitive functions are believed to be diffusely represented. Voice recognition involves a vertical and systemic process from brain stem through limbic structures and temporal lobes to an end station at the right parietal lobes. Unfamiliar voice discrimination is more "purely" an auditory skill involving primarily auditory receiving areas of temporal lobes on either left or right hemisphere.

Despite the discrepant backgrounds in research on voices and faces, tentative generalizations about the comparative neuroanatomical substrates for discrimination and recognition are possible. First, for both faces and voices, it is clear that discrimination and recognition are separate abilities. Secondly, a predominance, overall, of the right hemisphere for all these abilities has been reported, but some left hemisphere involvement for both face and voice processing has been observed. For faces, the left hemisphere has also been implicated in recognition, especially when names are involved; for voices, the left hemisphere has been implicated in discrimination. Naming may be less strongly associated with recognition of voices. For faces, a verbal component has been invoked to account the left hemisphere participation in familiar face recognition, while an analytic sub-strategy has been invoked to account for evidence of left hemisphere involvement in unfamiliar voice discrimination.

The model of voice perception presented here is in harmony with other known attributes of the right hemisphere: processing of social context, emotional meanings, complex patterns, and personal relevance (Bradshaw & Mattingly, 1995; Myers, 1998; Van Lancker, 1991, 1997). This model of voice processing in the brain fits well with other discoveries about the role of the right hemisphere in prosodic function. Information about the speaker revealed in the speaker's voice includes emotional state, personality, socioeconomic status, geographic history, mood, attitude toward the listener, and, of course, personal identity. All of this is interwoven in the speech signal, in a complex auditory pattern, the prosodic pattern. Much is automatically processed by the listener. Judgments about the speaker and about the importance of his/her message are inferred from the voice information. This information is, in a way, "more elemental" than the verbal content (Bolinger, l964, 1972), probably because subcortical limbic systems are engaged more directly. Brown's view of emotion being present at all levels of processing is particularly pertinent here (1972). As he later states, "There is an affective element in every act and object [forming]…part of their structure and their description" (2002, p. 149). It is impossible to describe familiar voice recognition without accommodating affect to the description. This perspective is compatible with recent shifts in language study to social and pragmatic communication, which must be viewed subjectively (Shanahan, 2007). Panskepp (2008) argues that human language development is crucially dependent on emotional processes arising throughout the basal ganglia. This is even more pertinent in considering acquisition and processing of personally familiar voices. In neuroscience, a similar shift to the role of affect and emotion in evolutionary development and in all of cognitive processing is underway.

Given that voice perception utilizes both featural and configuration modes of processing; considering the large array of potential vocal parameters available for each voice; and taking into account the psychological differences inherent in familiar compared with unfamiliar voices, we propose a model of brain processing of voice patterns that accommodates all these facts. A set of familiar voices, each with unique, distinctive cues to identify (and these vary with listener), is likely to be more heterogeneous than a set of unfamiliar voices, which are not yet established as unique memorable patterns. The more homogeneous and unfamiliar the voice set, the more likely featural comparison will be used; the more heterogeneous and familiar the voice set, the more likely Gestalt-closure processes will be engaged. Distinctive cues and ad hoc combinations of cues will suffice to identify the familiar voice; this process is the idiosyncratic emergence of features in patterns (Pomerantz, 1986). The two modes, featural and configurational, are associated with left and right hemisphere processes respectively. In this model, similarity (homogeneity) and dissimilarity (heterogeneity) are psychological properties of the listener, correlating roughly with a (high or low) familiarity factor (Figure 3).

Figure 3 here

For over a century, it was held that the left hemisphere was the sole arbiter of communication through the medium of speech and language. In its strictest interpretation, this fact has been borne out by continuing studies. However, much more is known about right hemisphere involvement in communication, especially in the realm of pragmatic function. This review of voice and face perception and recognition studies has shown that persons with aphasia, having intact right hemispheres, are likely well aware of the identity of the familiar-intimate and familiar-famous voices and faces around them, along with much of the attitudinal, affective, personal, and pragmatic patterns provided by intonation and facial expression. Results from studies of familiar voice recognition and prosody suggest that the left hemisphere knows what is being said, and at the same time, the right hemisphere is considering how, and by whom, the message is expressed.

We close this excursion through the wonderland of voices and listeners with a nod of thanks to Jason Brown, who shared his creative Idea with us during a coffee break thirty years ago. As is obvious, it left quite an impression, and it continues to provide satisfaction and enchantment, reflecting, as do the other papers in this volume, Jason's great fecundity of thought and generosity of spirit.

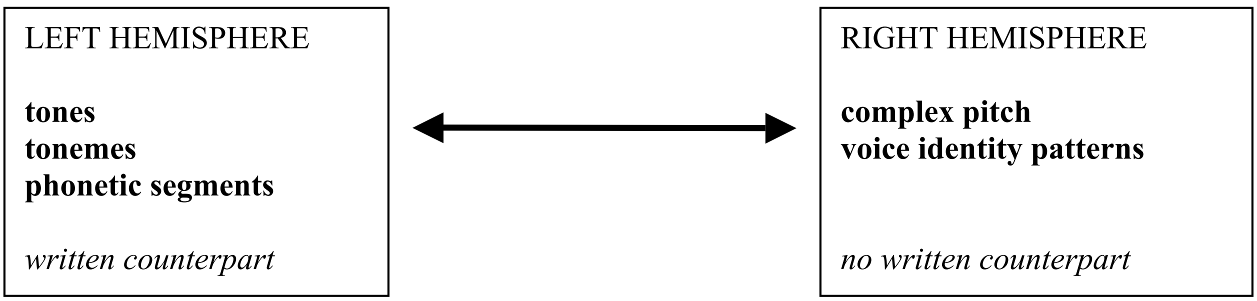

Figure 1. Prosodic functions associated with left or right hemisphere.

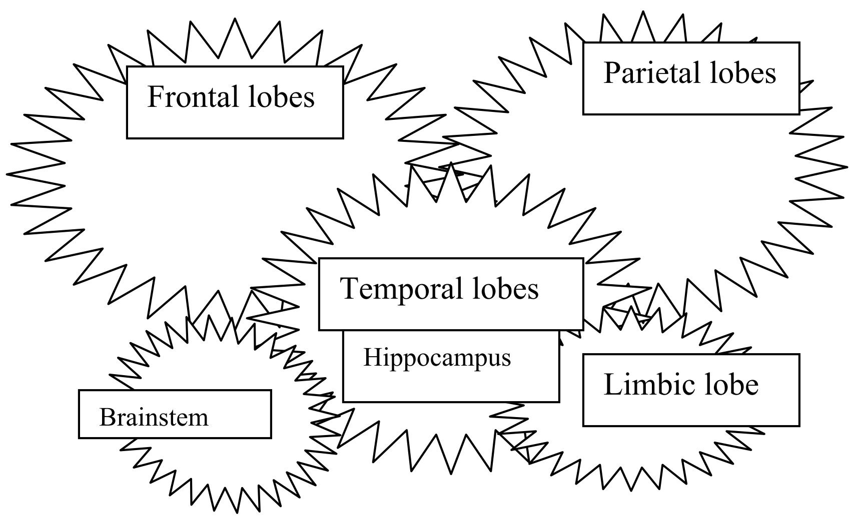

Figure 2. Brain areas involved in acquiring and processing familiar voices. The whole brain participates.

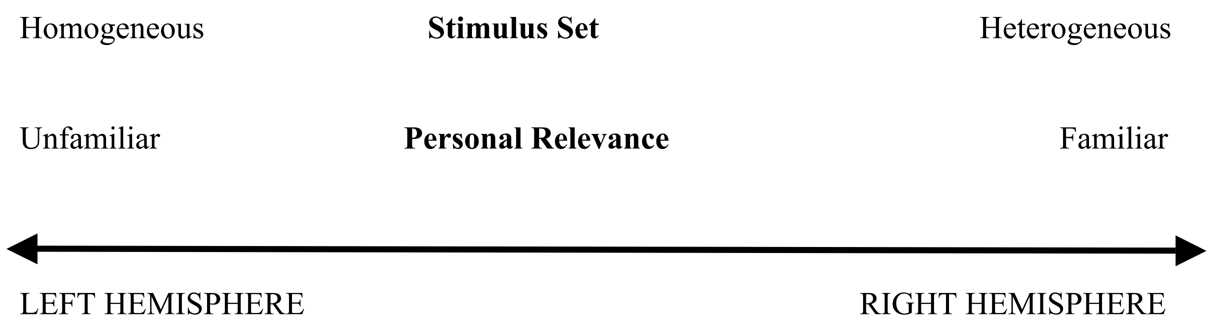

Figure 3. Stimulus parameters determining preferential processing of left and right hemisphere. Unfamiliar voices are perceived as more homogeneous and are processed by feature comparison processes of the left hemisphere. Familiar voices are perceived as a more heterogeneous set and are preferentially processed by the right hemisphere.

References

Allison, T., Ginter, H., McCarthy, G., Nobre, A. C., Puce, A., Luby, M., & Spencer, D. D. (1994). Face recognition in human extrastriate cortex. Journal of Neurophysiology, 71 (2), 821-825.

Allison, T., McCarthy, G., Nobre, A., Puce, A., & Belger, A. (1994). Human extrastriate visual cortex and the perception of faces, words, numbers, and colors. Cerebral Cortex, 4 (5), 544-545.

Assal, G., Aubert, C., & Buttet, J. (1981). Asyme'trie ce're'brale et reconnaissance de la voix, Revue Neurologique (Paris) 137, 255-268.

Assal, G., Zander, E., Kremin, H., & Buttet, J. (1976). Discrimination des voix lors des le'sions du cortex ce're'brals, Archives Suisses de Neurologie, Neurochirurgie, et de Psychiatrie 119, 307-315.

Baeckman, L. (1991). Recognition memory across the adult lift span: the role of prior knowledge. Memory and Cognition, 19 (1), 63-71. No decrement with age

Bahrick, H., Bahrick, P., & Wittlinger, R. (1975). Fifty years of memory for names and faces: A cross-sectional approach. Journal of Experimental Psychology: General, 104, 54-75.

Baudouin, J.Y., Gilibert, D., Sansone, S., & Tiberghien, G. (2000). When the smile is a cue to familiarity. Memory, 8(5), 285-292.

Bauer, R. & Rubens, A. B. (1985). Agnosia. In K. M. Heilman & E. Valenstein (Eds). Clinical Neuropsychology. New York: Academic Press, pp. 187-284 (2nd Edition).

Belin, P., & Zatorre, R. J. (2003). Adaptation to speaker's voice in right anterior temporal lobe. NeuroReport, 14, 2105-2109.

Belin, P., Fecteau, S., & Bedard, C. (2004). Thinking the voice: neural correlates of voice perception. Trends in Cognitive Sciences, 8(3), 129-135.

Belin, P., Zatorre, R.J., Lafaille, P., Ahad, P., & Pike, B. (2000). Voice-selective areas in human auditory cortex. Nature, 403, 309-312.

Benowitz, L. I., Finkelstein, S., Levine, D. N., & Moya, K. (1990). The role of the right cerebral hemisphere in evaluating configurations. In C. B. Trevarthern (Ed.). Brain circuits and functions of the mind. Cambridge: Cambridge University Press, pp. 320-333.

Benson, D. Frank. (1994). The neurology of thinking. Oxford: Oxford University Press.

Benton, A. L. & Van Allen, M.W. (l972). Prosopagnosia and facial discrimination. Journal of Neurological Science, 15(2), 167-72.

Benton, A.L. (1980). The neuropsychology of facial recognition. American Psychologist, 35, 176-186.

Blumstein, S. & Goodglass, H. (1972). The perception of stress as a semantic cue in aphasia. Journal of Speech and Hearing Research, 15.4, 800-806.

Bolinger, D. (1964). Around the edge of language: Intonation. Harvard Educational Review, 34, 282-296. Reprinted in Bolinger, Intonation: Selected Readings, Harmondsworth, Penguin Books.

Bolinger, D. (1972). Intonation: Selected Readings. Harmondsworth, Penguin Books.

Borod, J.C. (1993). Cerebral mechanisms underlying facial, prosodic, and lexical emotional expression: A review of neuropsychological studies and methodogical issues. Neuropsychology, 7, 445-463.

Bowers, D., Bauer, R.M., & Heilman, K.M. (1993). The nonverbal affect lexicon: Theoretical perspectives from neurological studies of affect perception. Neuropsychology, 7, 433-444.

Bradshaw, J.L. & Nettleton, N. C. (l983). Human Cerebral Asymmetry. Englewood Cliffs, New Jersey: Prentice-Hall.

Bradshaw, John L. & Mattingly, Jason B. (1995). Clinical neuropsychology: Behavioral and brain science. New York: Academic Press.

Brown, C. M., Denault, C., Cohen, H., & Rouleau, I. (1994). Discrimination of facial identity and facial affect by temporal and frontal lobectomy patients. Brain and Cognition, 24 (2), 198-212.

Brown, J. W. (1998a). Morphogenesis and mental process. in C. Pribram & J. King (Eds.) Learning as self organization. Mahwah, NJ: Lawrence Erlbaum, pp. 295-310.

Brown, J. W. (1998b). Foundations of cognitive metaphysics. Process Studies, 21 (1-2), pp. 79-92.

Brown, Jason W. (1972). Aphasia, apraxia and agnosia: Clinical and theoretical aspects. Springfield: Charles C. Thomas.

Brown, Jason W. (1988). The life of the mind: Selected papers. Hillsdale, NJ: Lawrence Erlbaum.

Brown, Jason W. (2002). The self embodying mind. Barrytown: Station Hill Press.

Bruck, M., Cavanagh, P., & Ceci, S.J. (1991). Fortysomething: recognizing faces at one's 25th reunion. Memory and Cognition, 19(3), 221-228.

Carlesimo, G. A., & Caltagirone, C. (1995). Components in the visual processing of known and unknown faces. Journal of Clinical and Experimental Neurpsychology, 17 (5), 691-705.

Cimino, C.R., Verfaellie, M., Bowers, D., & Heilman, K.M. (1991). Autobiographical memory: Influence of right hemisphere damage on emotionality and specificity. Brain and Cognition, **15**, 106-118.

Corcoran, D. W. J. (1971). Pattern recognition. Middlesex, England: Penguin books.

Cutting, J. (1990). The right cerebral hemisphere and psychiatric disorders. Oxford: Oxford University Press.

Damasio, A.R., Damasio, H., & Van Hoesen, G.W. (l982). Prosopagnosia: Anatomic basis and behavioral mechanisms. Neurology, 32, 331-341.

Davidoff, J., & Roberson, D. (2002). Development of animal recognition: A difference between parts and wholes. Journal of Experimental Child Psychology, 81, 217-234.

De Casper, A.J., & Fifer, W.P. (1980). Of human bonding: Newborns prefer their mothers' voices, Science 208, 1174-1176.

De Renzi, E. (1986). Prosopagnosia in two patients with CT scan evidence of damage confined to the right hemisphere. Neuropsychologia, **24**, 385-389.

De Renzi, E., Faglioni, P., Grossi, D., & Michelli, P. (1991). Apperceptive and associative forms of prosopagnosia. Cortex, **27**, 213-221.

Duchaine, B. C. (2006). Selective deficits in developmental cognitive neuropsychology: An introduction. Cognitive Neuropsychology, 23, 675-679.

Duchaine, B., Yovel, G., Butterworth, E., & Nakayama, K. (2006). Prosopagnosia as an impairment to face-specific mechanisms: Elimination of the alternative hypotheses in a developmental case. Cognitive Neuropsychology, 23 (5), 714-747.

Elgar, K., & Campbell, R. (2001). Annotation: The cognitive neuroscience of face recognition: Implications for developmental disorders. Journal of Child Psychology and Psychiatry, 42(6), 705.

Evans, J. J., Heggs, A. J., Antoun, N., & Hodges, J. R. (1995). Progressive prosopagnosia associated with selective right temporal lobe atrophy. A new syndrome? Brain, 118, pt. 1, 1-13.

Fantz, R. (1961). The origins of perception. Scientific American, 204, 66-72.

Farah, M.J. (1996). Is face recognition 'special'? Evidence from neuropsychology. Behavioural Brain Research, 76, 181-189. Yes

Farah, M.J., Hammond, K.M., & Mehta, Z. (1989). Category-specificity and modality-specificity in semantic memory. Neuropsychologia, **27**, 193-200.

Farah, M.J., Levinson, K.L., & Klein, K.L. (1995). Face perception and within-category discrimination in prosopagnosia. Neuropsychologia, 33(6), 661-674.

Farah, M.J., Rabinowitz, C., Quinn, G.E., & Liu, G.T. (2000). Early commitment of neural substrates for face recognition. Cognitive Neuropsychology, 17(1-3), 117-123.

Farah, Martha J., Wilson, Kevin D., Drain, H. Maxwell, & Tanaka, James R. (1995). The inverted face inversion effect in prosopagnosia: Evidence for mandatory, face-specific perceptual mechanisms.Vision Research, 35 (14), 2089-2093.

Gandour, J., & Dardarananda, R., (1983). Identification of tonal contrasts in Thai aphasic patients. Brain and Language, 18, 98-114.

Gandour, J., Wong, D., Hsieh, L., Weinzapfel, B., Van Lancker, D., & Hutchens, G. A. (2000). A crosslinguistic PET study of tone perception. Journal of Cognitive Neuroscience, 12:1, 207-222.

Gazzaniga, M.S. & Smylie, C.S. (1983). Facial recognition and brain asymmetries: Clues to underlying mechanisms. Annals of Neurology 13 (1983), 536–540.

Geschwind, N. & Galaburda, A.M. (1985). Cerebral lateralization: Biological mechanisms, associations and pathology: I. A hypothesis and program for research. Archives of Neurology 42, 428-459.

Goldinger, S. D. & Azuma, T. (2003). Puzzle-solving science: the quixotic quest ofr units in speech perception. Journal of Phonetics, 31, 305-320.

Grafman, J., Salazar, A. M., Weingartner, H., & Amin, D. (1986). Face memory and discrimination: an analysis of the persistent effects of penetrating brain wounds. International Journal of Neuroscience, 29, 125-139.

Hamsher, K., Levin, H.S., & Benton, A.L. (1979). Facial recognition in patients with focal brain lesions. Archives of Neurology, 36, 837-839,

Heckmann, J.G., Lang, C.J.G., & Neundörfer, B. (2001), Brief communications: Recognition of familiar handwriting in stroke and dementia. American Academy of Neurology, 57, 2128-2131.

Johnson, M.H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. Cognition, 40(1-2), 1-19.

Kinsbourne, M. (1970). The cerebral basis of lateral asymmetries in attention. Acta Psychologica, 33, 193-201.

Kinsbourne, M. (1974). Lateral interactions in the brain. In M. Kinsbourne & W.L. Smith (Eds.), Hemispheric disconnection and cerebral function. Springfield, IL, pp. 239-259.

Klein, D., Zatorre, R.J., Milner, B., & Zhao, V. (2001). A cross-linguistic PET study of tone perception in Mandarin Chinese and English speakers. Neuroimage, 13 (4), 646-653.

Knösche, T.R., Lattner, S., Maess, B, Schauer, M., & Friederici, A.D. (2002). Early parallel processing of auditory word and voice information, Neuroimage, 17, 1493-1503.

Kreiman, J. & Sidtis, D. (in preparation). Voices and listeners. Oxford; Blackwells.

Kreiman, J. (1987). Listening to voices: theory and practice in voice perception research. In K. Johnson and J. W. Mullinex (Eds.). Talker variability in speech processing. New York, NY: Academic Press, pp. 85-108.

Kreiman, Jody & Gerratt, Bruce R. (1998). Validity of rating scale measures of voice quality. The Journal of the Acoustical Society of America, 104(3),1598-1608

Kriegstein, von, K. & Giraud, A.-L. (2004). Distinct functional substrates along the right superior temporal sulcus for the processing of voices. Neuroimage, 22, 948-955.

Krishnan, Ananthanarayan, Xu, Yiseng, Gandour, Jackson, & Cariani, Peter. (2005). Encoding of pitch in the human brainstem is sensitive to language experience. Cognitive Brain Research, 25, 161-168.

Ladefoged, P., & Ladefoged, J. (1980). The ability of listeners to identify voices. UCLA Working Papers in Phonetics, 41, 41-42.

Landis, T., Cummings, J. L., Benson, D. F., & Palmer, E. P. (1986). Loss of topographic familiarity. Archives of Neurology, 43, 132-136.

Lattner, S., Meyer, M. E., & Friederici, A. D. (2005). Voice perception: Sex, pitch, and the right hemisphere. Hum.Brain.Mapp., 24, 11-20.

Laver, J. (1980). The phonetic description of voice quality. Cambridge, UK: Cambridge University Press,

Lavner, Y. Gath, I. & Rosenhouse, J. (2000). The effects of acoustic modifications on the identification of familiar voices speaking isolated vowels. Speech Commun. 30:9-26,

Liang, J. (2006). Experiments on the modular nature of word and sentence phonology in Chinese Broca's patients. Trans 10. Utrecht, The Netherlands: LOT.

Liang, J., & van Heuven, V.J. (2004). Evidence for separate tonal and segmental tiers in the lexical specifications of words: A case study of a brain-damaged Chinese speaker. Brain and Language, 91, 282-293.

Malone, D. R., Morris, H. H., Kay, M. C., & Levin, H.S. (l982). Prosopagnosia: a double dissociation between recognition of familiar and unfamiliar faces. Journal of Neurology, Neurosurgery, and Psychiatry, 45, 820-822.

Meadows, J.C. (1974). The anatomical basis of prosopagnosia. Journal of Neurology, Neurosurgery and Psychiatry, 37, 4898-501.

Meudell, P. R., Northern, B., Snowden, J. S., & Neary, D. (1980). Long term memory for famous voices in amnesic and normal subjects, Neuropsychologia 18, 133-139.

Myers, P. (1998). Right hemisphere damage. San Diego: Singular Publishing.

Nachson, I. (1995). On the modularity of face recognition: the riddle of domain specificity. Journal of Clinical and Experimental Neuropsychology. 17(2), 256-275.

Naeser, M.A., & Chan, W.-C.S. (1980). Case study of a Chinese aphasic with the Boston Diagnostic Aphasia Exam. Neuropsychologia, 18, 389-410.

Neff, W. (1962). Differences in the functions of the two cerebral hemispheres. In V. Mountcastle (Ed.), Interhemispheric relations and cerebral dominance. Baltimore: The Johns Hopkins University Press, pp. 196-198.

Neisser, U. (1976). Cognition and reality: Principles and implications of cognitive psychology. San Francisco: W. H. Freeman & Co.

Neuner, F., & Schweinberger, S.R. (2000). Neuropsychological impairments in the recognition of faces, voices, and personal names. Brain and Cognition, 44, 342-366.

Nolan, F. (1983). The phonetic bases of speaker recognition. Cambridge, UK: Cambridge University Press.

Palmeri, T. J., Goldinger, S. D., & Pisoni, D. B. (1993). Episodic encoding of voice attributes and recognition memory for spoken words. Journal of Experimental Psychology: Learning, Memory, and Cognition, 19, 309-328.

Panksepp, Jaak (2008). The power of the word may reside in the power of affect. Integr.Psych. Behav., 43, 47-55.

Pisoni, D.B. (1993). Long-term memory in speech perception: Some new findings on talker variability, speaking rate, and perceptual learning. Speech Communication, 13, 109-125.

Pomerantz, J. R. (1986). Visual form perception: An overview. In E. C. Schwab and H. C. Nusbaum (Eds.). Pattern recognition by humans and machines. San Diego:

Port, Robert and Adam Leary (2005) Against formal phonology. Language, 81 (4), 927-964.

Port, Robert F. (2007). The graphical basis of phones and phonemes. In Murray Monro & Ocke-Schwen Bohn (Eds.). Second-language speech learning: The role of language experienced in speech perception and production. Amsterdam: Benjamins Publishing Co., pp. 349-365.

Reed, S. (1972). Pattern recognition and categorization, Cognitive Psychology 3, 382-407.

Rose, P. & Duncan, S. (1995) Naive auditory identification and discrimination of similar voices by familiar listeners, Forensic Linguistics 2(1): 1-17.

Ryalls, J., & Reinvang, I., (1986). Functional lateralization of linguistic tones: Acoustic evidence from Norwegian. Language and Speech, 29, 389-398.

Sawusch, J. R. (1986). Auditory and phonetic coding of speech. In E.C. Schwab & H. C. Nusbaum (Eds.). Pattern recognition by humans and machines: Speech perception, Volume 1. New York: Academic Press, (pp. 51-88).

Schegloff, E. A. (1979). Identification and recognition in telephone conversation openins. In G. Psathas (Ed.). Everyday language studies in ethnomethodology. New York, NY: Irvington, pp. 23-78.

Schirmer, A. (2004). Timing in speech: A review of lesions and neuroimaging findings. Brain Res Cogn Brain Res., 21, 269-287.

Schmidt-Nielsen, A. & Stern, K. (1985) Identification of known voices as a function of familiarity and narrow-band coding. Journal of the Acoustical Society of America, 77, 658-663.

Schwaninger, A., Lobmaier, J.S., & Collishaw, S.M. (2002). Role of featural and configural information in familiar and unfamiliar face recognition. Lecture Notes in Computer Science, 2525, 643-650.

Schweinberger, S. R. (2001). Human brain potential correlates of voice priming and voice recognition. Neuroposychologia, 39, 921-936.

Schweinberger, S. R., Herholz, A., & Sommer, W. (1997). Recognizing famous voices: influence of stimulus duration and different types of retrieval cues. Journal of Speech, Language and Hearing Research, 40, 453-463.

Schweinberger, S.R., Sommer, W., & Stiller, R.M. (1994). Event-related potentials and models of performance asymmetries in face and word recognition. Neuropsychologia, 32(2), 175-191.

Seeck, M., Mainwaring, N., Ives, J., Blume, H., Dubuisson, D., Cosgrove, R., Mesulam, M.M., & Schomer, D.L. (1993). Differential neural activity in the human temporal lobe evoked by faces of family members and friends. Annals of Neurology, 34(3), 369-372.

Seeck, M., Michel, C. M., Mainwaring, N., Cosgrove, R., Blume, H., Ives, J., Landis, T., D., & Schomer, D.L. (1997). Evidence for rapid face recognition from human scalp and intracranial electrodes. Neuroreport, 8(12), 2749-2754.

Semenza, C., & Zettin, M. (1988). Generating proper names: A case of selective ability. Cognitive Neuropsychology, 5, 711-721.

Shanahan, John. (2007). Language, feeling, and the brain: The evocative sector. New Brunswick, New Jersey: Transaction Publishers.

Sidtis, J. (1980). On the nature of the cortical function underlying right hemisphere auditory perception. Neuropsychologia, 18, 321-330.

Sidtis, J. J. (2007). Some problems for representations of brain organization based on activation. Brain and Language, 102, 130-140.

Sperry, R.W., Zaidel, E. & Zaidel, D. (1979). Self-recognition and social awareness in the disconnected minor hemisphere. Neuropsychologia, 17, 153-166.

Van Lancker Sidtis, D. (2007). Does functional neuroimaging slove the questions of neurolinguistics? Brain and Language, 102, 200-214.

Van Lancker, C., & Ohnesorge, C. (2002). Personally familiar proper names are relatively successfully processed in the human right hemisphere, or, the missing link. Brain and Language, 80, 121-129.

Van Lancker, D. & Nicklay, C. (1992). Comprehension of personally relevant (PERL) versus novel language in two globally aphasic patients. Aphasiology, 6, 37-61.

Van Lancker, D. (1980). Cerebral processing of pitch cues in the linguistic signal. Papers in Linguistics: International Journal of Human Communicaiton, 13, 201-277.

Van Lancker, D. & Fromkin, V. A. (1973). Hemispheric specialization for pitch and 'tone': Evidence from Thai. Journal of Phonetics, 1, 101-109.

Van Lancker, D. (1991). Personal relevance and the human right hemisphere. Brain and Cognition, 17, 64-92.

Van Lancker, D. (1997). Rags to riches: Our increasing appreciation of cognitive and communicative abilities of the human right cerebral hemisphere. Brain and Language, 57, 1-11.

Van Lancker, D. (2000). Brain structures in verbal communication: A focus on prosody. Topics in Stroke Rehabilitation, 7(1), 1-23.

Van Lancker, D., Kreiman, J. & Wickens, T.D. (1985). Familiar voice recognition: Patterns and parameters. Part II: Recognition of rate-altered voices, Journal of Phonetics 13, 39-52.

Van Lancker, D., & Kreiman, J. (1986) Preservation of familiar speaker recognition but not unfamiliar speaker discrimination in aphasic patients. Clinical Aphasiology, 16, 234-240.

Van Lancker, D., & Canter, J. (1982). Impairment of voice and face recognition in patients with hemispheric damage. Brain and Cognition, 1, l85-l95.

Van Lancker, D., & Kreiman, J. (1987). Voice discrimination and recognition are separate abilities. Neuropsychologia, 25(5), 892-834.

Van Lancker, D., Cummings, J., Kreiman, J. & Dobkin, B.H. (1988). Phonagnosia: A dissociation between familiar and unfamiliar voices. Cortex 24, 195-209.

Van Lancker, D., Kreiman, J. & Cummings, J. (1989). Voice perception deficits: Neuroanatomic correlates of phonagnosia. Journal of Clinical and Experimental Neuropsychology, 11, 665-674.

Van Lancker, D., Kreiman, J., & Emmorey, K. (1985). Familiar voice recognition: Patterns and parameters. Part I: Recognition of backward voices, Journal of Phonetics 13, 19-38.

Vilkki, J. & Laitinen, L.V. (1976). Effects of pulvinectomy and ventrolateral thalamotomy on some cognitive functions. Neuropscychologia, 14, 67-78.

Wagner, I. & Köster, O. (1999). Perceptual recognition of familiar voices using falsetto as a type of voice disguise. Proceedings of the XIVth International Congress of Phonetic Sciences, San Francisco, 1381-1385.

Wahlin, A., Backman, L., Mantylea, T., Herlitz, A., Viitanen, M., & Winblad, B. (1993). Prior knowledge and face recognition in a community based sample of healthy, very old adults. Journal of Gerontology, 48 (2), 54-61.

Warrington, E.K., & James, M. (1967). An experimental investigation of facial recognition in patients with unilateral cerebral lesions. Cortex, 3, 317-326.

Whiteley, A.M., & Warrington, E.K. (1977). Prosopagnosia: A clinical psychological, and anatomical study of three patients. Journal of Neurology, Neurosurgery, and Psychiatry, 40, 395-403.

Yin, R. K. (1970). Face recognition by brain-injured patients: a dissociable ability? Neuropsychologia, 8, 395-402.

Young, A.W. (Ed.). (1983). Functions of the right cerebral hemisphere. London: Academic Press.

Young, A.W., Newcombe, F., de Haan, E.H., Small, M., & Hay, D.C. (1993). Face perception after brain injury. Selective impairments affecting identity and expression. Brain, 116(4), 941-959.

Young, A.W., Reid, I., Wright, S., & Hellawell, D.J. (1993). Face-processing impairments and the Capgras delusion. British Journal of Psychiatry, 162, 695-698.

Zajonc, R. B. (1968). Attitudinal effects of mere exposure. Journal of Personality and Social Psychology Monograph, 9(Part 2) l-28.

Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. American Psychologist, 35, 151-175.

Zatorre, R.J. (1988). Pitch perception of complex tones and human temporal-lobe function. Journal of the Acoustical Society of America, 84(2), 566-572.

Zatorre, R.J., & Belin, P. (2001). Spectral and temporal processing in human auditory cortex. Cerebral Cortex, 11(10), 946-953.

Zatorre, R.J., & Samsom, S. (1991). Role of the right temporal neocortex in retention of pitch in auditory short-term memory. Brain, 114(6), 2403-2417.