Epilogue to *The Oxford Handbook of Cognitive Neuroscience*—Cognitive Neuroscience: Where Are We Going?

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The Oxford Handbook of Cognitive Neuroscience, Volume 1: Core Topics
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Abstract and Keywords

This epilogue looks at themes and trends that hint at future developments in cognitive neuroscience. It first considers how affective neuroscience merged the study of neuroscience and emotion, how social neuroscience merged the study of neuroscience and social behavior, and how social cognitive neuroscience merged the study of cognitive neuroscience with social cognition. Another theme is how the levels of analysis of behavior/experience can be linked with psychological process and neural instantiation. Two topics that have not yet been fully approached from a cognitive neuroscience perspective, but seem ripe for near-term future progress, are the study of the development across the lifespan of the various abilities described in the book, and the study of the functional organization of the frontal lobes and their contributions to behaviors (e.g., the ability to exert self-control). This epilogue also explores the multiple methods, both behavioral and neuroscientific, used in cognitive neuroscience, new ways of modeling relationships between levels of analysis, and the question of how to make cognitive neuroscience relevant to everyday life.

Keywords: cognitive neuroscience, emotion, social behavior, social cognition, functional organization, frontal lobes, behaviors, methods, analysis, neural instantiation

Whether you have read the two-volume *Handbook of Cognitive Neuroscience* from cover to cover or have just skimmed a chapter or two, we hope that you take away a sense of the breadth and depth of work currently being conducted in the field. Since the naming of the field in the backseat of a New York City taxicab some 35 years ago, the field and the approach it embodies have become a dominant—if not the dominant—mode of scientific inquiry in the study of human cognitive, emotional, and social functions.

But where will it go from here? Where will the next 5, 10, or even 20 years take the field and its approach? Obviously, nobody can say for sure—but there are broad intellectual themes and trends that run throughout this two-volume set, and a discussion of them can be used as a springboard to thinking about possible directions future work might take.

Themes and Trends

Here we discuss themes and trends that hint at possible future developments, focusing on those that may be more likely to occur in the relatively near term.

What's in a Name?

It is said that imitation is the sincerest form of flattery. Given the proliferation of new areas of research with names that seemingly mimic *cognitive neuroscience*, the original has reason to feel flattered.

Consider, for example, the development of three comparatively newer fields and the dates of their naming: social neuroscience (Cacioppo, 1994), affective neuroscience (Panksepp 1991), and social cognitive neuroscience (Ochsner & Lieberman, 2001). Although all three fields are undoubtedly the (p. 600) products of unique combinations of influences (see, e.g., Cacioppo, 2002; Ochsner, 2007; Panksepp, 1998), they each followed in the footsteps of cognitive neuroscience. In cognitive neuroscience the study of cognitive abilities and neuroscience were merged, and in the process of doing so, the field has made considerable progress. In like fashion, affective neuroscience combined the study of emotion with neuroscience; social neuroscience, the study of social behavior with neuroscience; and social cognitive neuroscience, the study of social cognition with cognitive neuroscience.

All three of these fields have adopted the same kind of multilevel, multimethod constraints and convergence approach embodied by cognitive neuroscience (as we discussed in the Introduction to this *Handbook*). In addition, each of these fields draws from and builds on, to differing degrees, the methods and models developed within what we can now call "classic" cognitive neuroscience (see Vol. 1 of the *Handbook*). These new fields are siblings in a family of fields that have the similar, if not identical, research "DNA."

It is for these reasons that Volume 2 of this *Handbook* has sections devoted to affect and emotion and to self and social cognition. The topics of the constituent chapters in these sections could easily appear in handbooks of affective or social or social cognitive neuroscience (and in some cases, they already have, see, e.g., Cacioppo & Berntson, 2004; Todorov et al., 2011). We included this material here because it represents the same core approach that guides research on the classic cognitive topics in Volume 1 and in the latter half of Volume 2.

	Year term was coined	Approx Age	Google hits
Cognitive Psychology	~1967	~45 yrs	5,910,000
Neuroscience	~1960?	50+	38,600,000
Cognitive Neuroscience	late 70's	~34 yrs	2,750,000

Affective Neuroscience	1991	21 yrs	280,000
Social Neuroscience	1994	18 yrs	290,000
Social Cognitive Neuroscience	2001	11 yrs	370,000

Google hit counts for the names of fields as of April 2012

One might wonder whether these related disciplines are on trajectories for scientific and popular impact similar to that of classic cognitive neuroscience. In the age of the Internet, one way of quantifying impact is simply to count the number of Google hits returned by a search for specific terms, in this case, "cognitive neuroscience," "affective neuroscience," and so on. The results of an April 2012 Google search for field names is shown in the tables at right. The top table compares cognitive neuroscience with two of its antecedent fields: cognitive psychology (Neisser, 1967) and neuroscience. The bottom table compares the descendants of classic cognitive neuroscience that were noted above. As can be seen, cognitive psychology and neuroscience are the oldest fields and the ones with the most online mentions. By comparison, their descendant, cognitive neuroscience, which describes a narrower field than either of its ancestors, is doing quite well. And the three newest fields of social, affective, and social cognitive neuroscience, each of which describes fields even narrower than that of cognitive neuroscience, also are doing well, with combined hit counts totaling about one-third that of cognitive neuroscience, in spite of the fact that the youngest field is only about one-third of cognitive neuroscience's age.

How Do We Link Levels of Analysis?

A theme running throughout the chapters concerns the different ways in which we can link the levels of analysis of behavior/experience, psychological process, and neural instantiation. Here, we focus on two broad issues that were addressed, explicitly or implicitly, by many of the authors of chapters in these volumes.

The first issue is the complexity of the behaviors that one is attempting to map onto underlying processes and neural systems. For example, one might ask whether we should try to map what might be called "molar" abilities, such as memory or attention, onto sets of processes and neural systems, or instead whether we should try to map "molecular" *subtypes* of memory and subtypes of attention onto their constituent processes and neural systems. As alluded to in the Introduction, for most of the abilities described in Volume 1, it was clear as early as 20 years ago that a more molecular, subtype, method of mapping makes the most sense in the context of neuroscience data. The current state-of-theart in the study of perception, attention, memory, and language (reviewed in Volume 1 of this *Handbook*) clearly bears this out. All the chapters in these sections describe careful ways in which researchers have used combinations of behavioral and brain data to fractionate the processes that give rise to specific subtypes of abilities.

This leads us to the second issue, which concerns the fact that for at least some of the topics discussed (p. 601) in Volume 2, only recently has it become clear that more molecular mappings are possible. This is because for at least some of the Volume 2 topics, behavioral research before the rise of the cognitive neuroscience approach had not developed clearly articulated process models that specified explicitly how information is represented and processed to accomplish a particular task. This limitation was perhaps most evident for topics such as the self, some aspects of higher level social cognition such as mental state inference, and some aspects of emotion, including how emotions are generated and regulated. Twenty years ago, when functional neuroimaging burst on the scene, researchers had proposed few if any process models of these molar phenomena. Hence, initial functional imaging and other types of neuroscience studies on these topics had more of a "let's induce an emotional state or evoke a behavior and see what happens" flavor, and often they did not attempt to test specific theories. This is not to fault these researchers; at the time, they did not have the advantage of decades of process-oriented behavioral research from cognitive psychology and vision research to help guide them (see, e.g., Ochsner & Barrett, 2001; Ochsner & Gross, 2004). Instead, researchers had to develop process models on the fly.

However, times have changed. As attested by the chapters in the first two sections of Volume 2, the incorporation of brain data into research on the self, social perception, and emotion has been very useful in developing increasingly complex, "molecular" theories of the relationships between the behavior/experience, psychological process, and neural instantiation.

Just as the study of memory moved beyond single-system models and toward multiple-system models (Schacter & Tulving, 1994), the study of the self, social cognition, and emotion has begun to move beyond simplistic notions that single brain regions (such as the medial prefrontal cortex or amygdala) are the seat of these abilities.

Looking Toward the Future

Without question, progress has been made. What might the current state of cognitive neuroscience research auger for the future of cognitive neuroscience research? Here we address this question in four ways.

New Topics

One of the ideas that recurs in the chapters of this *Handbook* is that the cognitive neuroscience approach is a general-purpose scientific tool. This approach can be used to ask and answer questions about any number of topics. Indeed, even within the broad scope of this two-volume set, we have not covered every topic already being fruitfully addressed using the cognitive neuroscience approach.

That said, of the many topics that have not yet been approached from a cognitive neuroscience perspective, do any appear particularly promising? Four such topics seem ripe for near-term future progress. These topics run the gamut from the study of specific brain systems to the study of lifespan development and differences in group or social network status, to forging links with the study of mental and physical health.

The first topic is the study of the functional organization of the frontal lobes and the contributions they make to behaviors such as the ability to exert self-control. At first blush, this might seem like a topic that already has received a great deal of attention. From one perspective, it has. Over the past few decades numerous labs have studied the relationship of the frontal lobes to behavior. From another perspective, however, not much progress has been made. What is missing are coherent process models that link specific behaviors to specific subregions of prefrontal cortex. Notably, some chapters in this *Handbook* (e.g., those by Badre, Christoff, and Silvers et al.) attempt to do this within specific domains. But no general theory of prefrontal cortex has yet emerged that can link the myriad behaviors in which it is involved to specific and well-described processes that in turn are instantiated in specific portions of this evolutionarily newest portion of our brain.

The second topic is the study of the development across the lifespan of the various abilities described in the *Handbook*. Although some *Handbook* sections include chapters on development and aging, many do not—precisely because the cognitive neuroscientific study of lifespan changes in many abilities has only just begun. Clearly, the development from childhood into adolescence of various cognitive, social, and affective abilities is crucially important, as is the ways in which these abilities change as we move from middle adulthood into older age (Casey et al, 2010; Charles & Carstensen, 2010; Mather, 2012). The multilevel approach that characterizes the cognitive neuroscience approach holds promise of deepening our understanding of such phenomena. Toward this end, it is important to note that new journals devoted to some of these topics have **(p. 602)** appeared (e.g., *Developmental Cognitive Neuroscience*, which was first published in 2010), and various institutes within the National Institutes of Health (NIH) have called for research on these topics.

The third topic is the study of the way in which group-level variables impact the development and operation of the various processing systems described in both Volumes of this *Handbook*. Notably, this is an area of research that is not yet represented in the *Handbook*, although interest in connecting the study of group-level variables to the study of the brain has been growing over the past few years. Consider, for example, emerging research suggesting that having grown up as a member of different cultural groups can dictate whether and how one engages perceptual, memory, and affective systems both when reflecting on the self and in social settings (Chiao, 2009). There is also evidence that the size of one’s social networks can impact the structure of brain systems involved in affect and affiliation, and that one's status within these networks (Bickart et al., 2011) can determine whether and when one recruits brain systems implicated in emotion and social cognition (Bickart et al., 2011; Chiao, 2010; Muscatell et al., 2011). Forging links between group-level variables and the behavior/experience, process, and brain levels that are the focus in the current *Handbook* will prove challenging and may require new kinds of collaborative relationships with other disciplines, such as sociology and anthropology. As these collaborations grow to maturity, we predict this work will make its way into future editions of the *Handbook*.

The fourth topic is the way in which specific brain systems play important roles in physical, as well as mental, health. The *Handbook* already includes chapters that illustrate how cognitive neuroscience approaches are being fruitfully translated to understand the nature of dysfunction, and potential treatments for it, in various kinds of psychiatric and substance use disorders (see e.g., Barch et al., 2009; Johnstone et al., 2007; Kober et al., 2010; Ochsner, 2008 and the section below on *Translation*). This type of translational work is sure to grow in the future. What the current *Handbook* is missing, however, is discussion of how brain systems are critically involved in physical health via their interactions with the immune system. This burgeoning area of interest seeks to connect fields such as health psychology with cognitive neuroscience and allied disciplines to understand how variables like chronic stress or disease, or social connection vs. isolation, can boost or diminish physical health. Such an effect would arise via interactions between the immune system and brain systems involved in emotion, social cognition, and control (Muscatell & Eisenberger, 2012; Eisenberger & Cole, 2012). This is another key area of future growth that we expect to be represented in this *Handbook* in the future.

New Methods

How are we going to make progress on these questions and the countless others posed in the chapters of the *Handbook*? On the one hand, the field will undoubtedly continue to make good use of the multiple methods—both behavioral and neuroscientific—that have been its bread and butter for the past decades. As noted in the Introduction, certain empirical and conceptual advances were only made possible by technological advances, which enabled us to measure activity with dramatically new levels of spatial and temporal resolution. The advent of positron emission tomography, and later functional magnetic resonance imaging (20–30 years ago), were game-changing advances.

On the other hand, these functional imaging techniques are still limited in terms of their spatial and temporal resolution, and the areas of the brain they allow researchers to focus on reflect the contributions of many thousands of neurons. Other techniques, such as magnetoencephalography and scalp electroencephalography, offer relatively good temporal resolution, but their spatial localization is relatively poor. Moreover, they are best suited to studying cortical rather than subcortical regions.

We could continue to beat the drum for the use of converging methods: What one technique can't do, another can, and by triangulating across methods, better theories can be built and evaluated. But for the next stage of game-changing methodological advances to be realized, either current technologies will need to undergo a transformation that enables them to combine spatial and temporal resolution in new ways or new techniques that have better characteristics will need to be invented.

New Ways of Modeling Relationships Between Levels of Analysis

All this said, even the greatest of technological advances will not immediately be useful unless our ability to conceptualize the cognitive and emotional processes that lie between brain and behavior becomes more sophisticated.

At present, most theorizing in cognitive neuroscience makes use of commonsense terminology for describing human abilities. We talk about memory, (p. 603) perception, emotion, and so on. We break these molar abilities into more molecular parts and characterize them in terms of their automatic or controlled operation, whether the mental representations are relational, and so on. Surely, however, the computations performed by specific brain regions did not evolve to instantiate our folk-psychological ideas about how best to describe the processes underlying behavior.

One possible response to this concern is that the description of phenomena at multiple levels of analysis allows us to sidestep this problem. One could argue that at the highest level of description, it's just fine to use folk-psychological terms to describe behavior and experience. After all, our goal is to map these terms—which prove extremely useful for everyday discourse about human behavior—onto precise descriptions of underlying neural circuitry by reference to a set of information processing mechanisms.

Unfortunately, however, many researchers do not restrict intuitively understandable folk-psychological terms to describe behavior and experience, but also use such terms to describe information processing itself. In this case, process-level descriptions are not likely to map in a direct way onto neural mechanisms.

Marr (1982) suggested a solution to this problem: Rely on the language of computation to characterize information processing. The language of computation characterizes what computers do, and this language often can be applied to describe what brains do. But brains are demonstrably not digital computers, and thus it is not clear whether the technical vocabulary that evolved to characterize information processing in computers can in fact always be appropriately applied to brains. Back in the 1980s, many researchers hoped that connectionist models might provide an appropriate kind of computational specificity. More recently, computational models from the reinforcement learning and neuroeconomic literatures have been advanced as offering a new level of computational specificity.

Although no existing approach has yet offered a computational language that is powerful enough to describe more than thin slices of human information processing, we believe that such a medium will become a key ingredient of the cognitive neuroscience approach in the future.

Translation

In an era in which increasing numbers of researchers are applying for a static or shrinking pool of grant funding, some have come to focus on the question of how to use cognitive neuroscience to solve problems that arise in everyday life (and therefore address the concerns of funding agencies, which often are pragmatic and applied).

Research is often divided into two categories (somewhat artificially): “Foundational” research focuses on understanding phenomena for its own sake, whereas “translational” research focuses on using such understanding to solve a real-world problem. Taking cognitive neuroscience models of abilities based on studies of healthy populations and applying them to understand and treat the bases of dysfunction in specific groups is one form of translational research. This will surely be an area of great future growth.

Already, a number of areas of psychiatric and substance use research have adopted a two-step translational research sequence (e.g., Barch et al., 2004, 2009; Carter et al., 2009; Ochsner, 2008; Paxton et al., 2008). The first step involves building a model of normal behavior, typically in healthy adults, using the cognitive neuroscience approach. The second step involves translating that model to a population of interest, and using the model to explain the underlying bases of the disorder or other deviation from the normal baseline—and this would be a crucial step in eventually developing effective treatments. This population could suffer from some type of clinically dysfunctional behavior, such as the four psychiatric groups described in Part 4 of Volume 2 of the *Handbook*. It could be an adolescent or older adult population, as described in a handful of chapters scattered across sections of the *Handbook*. Or—as was not covered in the *Handbook*, but might be in the future—it could be a vulnerable group for whom training in a specific type of cognitive, affective, or social skill would improve the quality of life.

The possibilities abound—and it would behoove researchers in cognitive neuroscience to capitalize on as many of them as possible. Not just for the pragmatic reason that they may be more likely to be funded but, more importantly, for the principled reason that *it matters*. It matters that we understand real-world, consequential behavior. Yes, we need to start by studying the ability to learn a list of words in the lab, and we need to understand the brain systems responsible for such relatively simple tasks. But then we need to move toward understanding, for example, how these brain systems do or do not function normally in a child growing up in an impoverished household compared with a child afforded every advantage (Noble et al., 2007).

(p. 604) Happily, there is evidence that federal funding agencies are beginning to understand the importance of this two-step, foundational-to-translational research sequence. In 2011, the National Institute of Mental Health (NIMH) announced the Research Domain Criteria (RDoC) framework as part of NIMH’s Strategic Plan to “Develop, for research purposes, new ways of classifying mental disorders based upon dimensions of observable behavior and neurobiological functioning" (http://www.nimh.nih.gov/about/strategic-planning-reports/index.shtml). In essence, the RDoC's framework aims to replace the traditional symptom-based means of describing abnormal behavior (and that characterizes traditional psychiatric diagnosis) with a means of describing the full range of normal to abnormal behavior in terms of fundamental underlying processes. The idea is that, over time, researchers will seek to target and understand the nature of these processes, the ways in which they can go awry, and the behavioral variability to which they can give rise—as opposed to targeting traditionally defined clinical groups. For example, a researcher could target processes for generating positive or negative affect, or their control, or the ways in which interactions between affect and control processes break down to produce anhedonia or a preponderance of negative affect—as opposed to focusing on a discretely defined disorder such as major depression (e.g, Pizzagalli et al., 2009).

The two-step approach allows initial research to focus on understanding core processes—considered in the context of different levels of analysis—but with an eye toward then understanding how variability in these processes gives rise to the full range of normal to abnormal behavior. Elucidating the fundamental nature of these cognitive and emotional processes, and their relation to the behavioral/experiential level above and to the neural level below, is the fundamental goal of cognitive neuroscience.

Concluding Comment

How do we measure the success of a field? By the number of important findings and insights? By the number of scientists and practitioners working within it?

If we take that late 1970s taxicab ride, when the term *cognitive neuroscience* was first used as the inception point for the field, then by any and all of these metrics, cognitive neuroscience has been enormously successful. Compared with physics, chemistry, medicine, and biology, however—or even compared with psychology and neuroscience—cognitive neuroscience is just beginning to hit its stride. This is to be expected, given that it has existed only for a very short period of time. Indeed, the day for cognitive neuroscience is still young.

This is good news. Even though cognitive neuroscience is entering its mid-30s, compared with these other broad disciplines that were established hundreds of years ago, this isn't even middle age. The hope, then, is that the field can continue to blossom and grow from its adolescence to full maturity—and make good on the promising returns it has produced so far.

References

Barch, D. M., Braver, T. S., Carter, C. S., Poldrack, R. A., & Robbins, T. W. (2009). CNTRICS Final task selection: Executive control. *Schizophrenia Bulletin*, *35*, 115–135.

Barch, D. M., Mitropoulou, V., Harvey, P. D., New, A. S., Silverman, J. M., & Siever, L. J. (2004). Context-processing deficits in schizotypal personality disorder. *Journal of Abnormal Psychology*, *113*, 556–568.

Bickart, K. C., Wright, C. I., Dautoff, R. J., Dickerson, B. C., & Barrett, L. F. (2011). Amygdala volume and social network size in humans. *Nature Neuroscience*, 14, 163–164.

Cacioppo, J. T. (1994). Social neuroscience: Autonomic, neuroendocrine, and immune responses to stress. *Psychophysiology*, *31*, 113–128.

Cacioppo, J. T. (2002). Social neuroscience: Understanding the pieces fosters understanding the whole and vice versa. *American Psychologist*, *57*, 819–381.

Cacioppo, J. T., & Berntson, G. G. (2004) (Eds.). *Social neuroscience: Key readings* (Vol. 14). New York: Ohio State University Psychology Press.

Carter, C. S., Barch, D. M., Gur, R., Pinkham, A., & Ochsner, K. (2009). CNTRICS Final task selection: Social cognitive and affective neuroscience-based measures. *Schizophrenia Bulletin*, *35*, 153–162.

Casey, B. J., Jones, R. M., Levita, L., Libby, V., Pattwell, S. S., et al. (2010). The storm and stress of adolescence: Insights from human imaging and mouse genetics. *Developmental Psychobiology*, *52*, 225–235.

Charles, S. T., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review Psychology*, *61*, 383–409.

Chiao, J. Y. (2009). Cultural neuroscience: a once and future discipline. *Progress in Brain Research*, *178*, 287–304.

Chiao, J. Y. (2010). Neural basis of social status hierarchy across species. *Current Opinion in Neurobiology*, *20*, 803–809.

Eisenberger, N. I., & Cole, S. W. (2012). Social neuroscience and health: neurophysiological mechanisms linking social ties with physical health. *Nature Neuroscience*, *15*, 669–674.

Johnstone, T., van Reekum, C. M., Urry, H. L., Kalin, N. H., & Davidson, R. J. (2007). Failure to regulate: counterproductive recruitment of top-down prefrontal-subcortical circuitry in major depression. *The Journal of Neuroscience: the Official Journal of the Society for Neuroscience*, *27*, 8877–8884.

Kober, H., Mende-Siedlecki, P., Kross, E. F., Weber, J., Mischel, W., et al. (2010). Prefrontal-striatal pathway underlies cognitive regulation of craving. *Proceedings of the National Academy of Sciences of the United States of America*, *107*, 14811–14816.

Mather, M. (2012). The emotion paradox in the aging brain. *Annals of the New York Academy of Sciences*, *1251*, 33–49.

(p. 605) Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information* (397pp). San Francisco: W.H. Freeman.

Muscatell, K. A., & Eisenberger, N. I. (2012). A social neuroscience perspective on stress and health. *Social and Personality Psychology Compass*, *6*, 890–904.

Muscatell, K. A., Morelli, S. A., Falk, E. B., Way, B. M., Pfeifer, J. H., et al. 2012. Social status modulates neural activity in the mentalizing network. *NeuroImage*, *60*, 1771–7.

Neisser, U. (1967). *Cognitive Psychology* (Vol. 16). New York: Appleton-Century-Crofts.

Noble, K. G., McCandliss, B. D., & Farah, M. J. (2007). Socioeconomic gradients predict individual differences in neurocognitive abilities. *Developmental Science*, *10*, 464–480.

Ochsner, K. (2007). Social cognitive neuroscience: Historical development, core principles, and future promise. In A. Kruglanksi & E. T. Higgins (Eds.), *Social Psychology: A Handbook of Basic Principles* (pp. 39–66). New York: Guilford Press.

Ochsner, K. N. (2008). The social-emotional processing stream: Five core constructs and their translational potential for schizophrenia and beyond. *Biological Psychiatry*, *64*, 48–61.

Ochsner, K. N., & Barrett, L. F. (2001). A multiprocess perspective on the neuroscience of emotion. In T. J. Mayne & G. A. Bonanno (Eds.), *Emotions: Current Issues and Future Directions* (pp. 38–81). New York: Guilford Press.

Ochsner, K. N., & Gross, J. J. (2004). Thinking makes it so: A social cognitive neuroscience approach to emotion regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of Self-regulation: Research, Theory, and Applications* (pp. 229–255). New York: Guilford Press.

Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. *American Psychologist*, *56*, 717–734.

Panksepp, J. (1991). Affective neuroscience: A conceptual framework for the neurobiological study of emotions. *International Review of Studies on Emotion*, *1*, 59–99.

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. New York: Oxford University Press.

Paxton, J. L., Barch, D. M., Racine, C. A., & Braver, T. S. (2008). Cognitive control, goal maintenance, and prefrontal function in healthy aging. *Cerebral Cortex*, *18*, 1010–1028.

Pizzagalli, D. A., Holmes, A. J., Dillon, D. G., Goetz, E. L., Birk, J. L., Bogdan, R., et al. (2009). Reduced caudate and nucleus accumbens response to rewards in unmedicated individuals with major depressive disorder. *Am J Psychiatry*, *166* (6), 702–710.

Schacter, D. L., & Tulving, E. (1994). *Memory Systems 1994* (Vol. 8). Cambridge, MA: MIT Press.

Todorov, A. B., Fiske, S. T., & Prentice, D. A. (2011). *Social neuroscience: Toward Understanding the Underpinnings of the Social Mind* (Vol. 8). New York: Oxford University Press.

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