Précis of "Cognition does not affect perception"

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How does the mind work? Though this is the central question posed by cognitive science, one of the deepest insights of the last half-century is that it has no single answer: There is no *one way* the mind works, because the mind is not one thing. Instead, the mind has *parts*, and the different parts of the mind operate in different ways: Seeing a color works differently than planning a vacation, which works differently than understanding a sentence, moving a limb, remembering a fact, or feeling an emotion. In characterizing and individuating these 'parts', there may be no more foundational distinction between types of mental processes than the distinction between perception and cognition — what we *see* vs. what we *think, want, say,* or *do*. How do seeing and thinking interact? And how do they fail to interact?

In contrast to the traditional "modular" understanding of perception, according to which visual processing is encapsulated from higher-level cognition, a tidal wave of recent research spanning two decades and hundreds of papers has alleged that desires, emotions, intentions, linguistic representations, and other higher-level states reach down into visual processing and literally change what we see. As a result, there is a growing consensus that such effects are ubiquitous, and that the distinction between seeing and thinking may itself be unsustainable.

My dissertation argues otherwise: There are no such top-down effects of cognition on perception, or "cognitive penetrability". **Chapter 1** reviews over two decades of recent literature on this topic and identifies a small number of empirically anchored 'pitfalls' that recast all such evidence, in each case showing how alleged top-down effects on perception not only *can be* explained by alternative factors, but actually *are* explained by such factors. These pitfalls are anchored by empirical "case studies", which I report in **Chapters 2, 3 and 4** to develop new and generalizable tools and strategies for separating perception from cognition. Many of these strategies have already been incorporated into other researchers' work on such questions, and so **Chapter 5** considers this project in its broader context, exploring responses for and against the work from earlier chapters.

This work combines approaches from vision science, cognitive psychology, philosophy, and psycholinguistics to explore a diverse range of topics and phenomena, including how visual perception relates to morality, conceptual knowledge, emotion, action, and even racial classification — phenomena that have been of tremendous interest not only throughout psychology, but also in neighboring disciplines such as philosophy of mind (Macpherson 2012; Siegel 2012), neuroscience (Bannert & Bartels 2013; Landau et al. 2010), psychiatry (Bubl et al. 2010), and even aesthetics (Nanay 2014; Stokes 2014). It would be enormously exciting to discover that perception changes how it operates in direct response to goings-on elsewhere in the mind. My hope is thus to advance future work on this foundational question, by identifying and exploring the key empirical challenges.

Chapter 1. Cognition does not affect perception

(Published as Firestone & Scholl, 2016a, *Behavioral & Brain Sciences*)

The distinction between perception and cognition is woven deeply into our field: It structures introductory courses and textbooks, differentiates scholarly journals, and organizes academic departments. It is also a distinction respected by common sense: Anyone can appreciate the difference between, on one hand, *seeing* a red apple and, on the other hand, *thinking about*, *remembering*, or *desiring* a red apple. Indeed, we can even feel this distinction in a single moment, when perception and cognition conflict — as in most visual illusions, which often involve *seeing* the world in a way we *know* it not to be (Fig. 1.1).

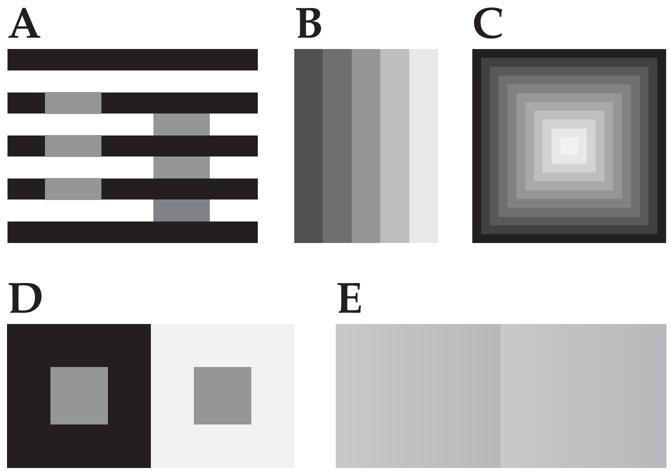

Figure 1.1. Lightness illusions that we can experience directly (Adelson 2000). (A) The two gray rectangles have equal luminances, but the left one looks lighter. (B) The rectangles are uniformly gray, but they appear to lighten and darken along their edges. (C) Uniformly colored squares of increasing luminance produce an illusory light "X" shape at their corners. (D) The two central squares have the same luminance, but the left looks lighter. (E) The two rectangles are identical gradients, but the right looks lighter. Here and elsewhere, we see the world one way, but believe it to be another way.

The top-down challenge

Despite the explanatory and intuitive power of the distinction between seeing and thinking, a vocal chorus has vigorously challenged the extent of this division, seeking to blur the lines between perception and cognition (for recent reviews, see Balcetis 2016; Collins & Olson 2014; Dunning & Balcetis 2013; Goldstone et al. 2015; Lupyan 2012, 2015; Proffitt & Linkenauger 2013; Stefanucci et al. 2011; Vetter & Newen 2014). On this increasingly popular view, what we see is routinely “penetrated” by a vast array of higher-level cognitive states: For example, it has been reported that desiring an object makes it look closer (Balcetis & Dunning 2010), reflecting on unethical actions makes the world look darker (Banerjee et al. 2012), wearing a heavy backpack makes hills look steeper (Bhalla & Proffitt 1999), morally relevant words are easier to see (Gantman & Van Bavel 2014), and racial categorization alters the perceived lightness of faces (Levin & Banaji 2006). Recently, this literature has grown to include hundreds of distinct top-down effects, reported in over 175 papers since 1995 (for a comprehensive list, see http://perception.yale.edu/TopDownPapers), many of which are illustrated in Figure 1.2.

Such reports go far beyond more pedestrian senses of “top-down”, such as shifting one’s gaze/attention or being influenced by the surrounding context (as in the lightness illusions in Figure 1.1). Instead, these effects purportedly reflect “direct” influences of higher-level cognition on perception, in ways explicitly intended to *revolutionize* our understanding of how perception works (cf. Fodor, 1983; Pylyshyn, 1999). Indeed, the volume and nature of such effects has led several authors to declare this revolution complete, asserting that it is a “generally accepted concept that people tend to see what they want to see” (Radel & Clement-Guillotin 2012, p.233), that “the postulation of the existence of visual processes being functionally encapsulated…cannot be justified anymore” (Vetter & Newen 2014, p.73), and even that “[a]ll this makes the lines between perception and cognition fuzzy, perhaps even vanishing” (Clark 2013, p.190).

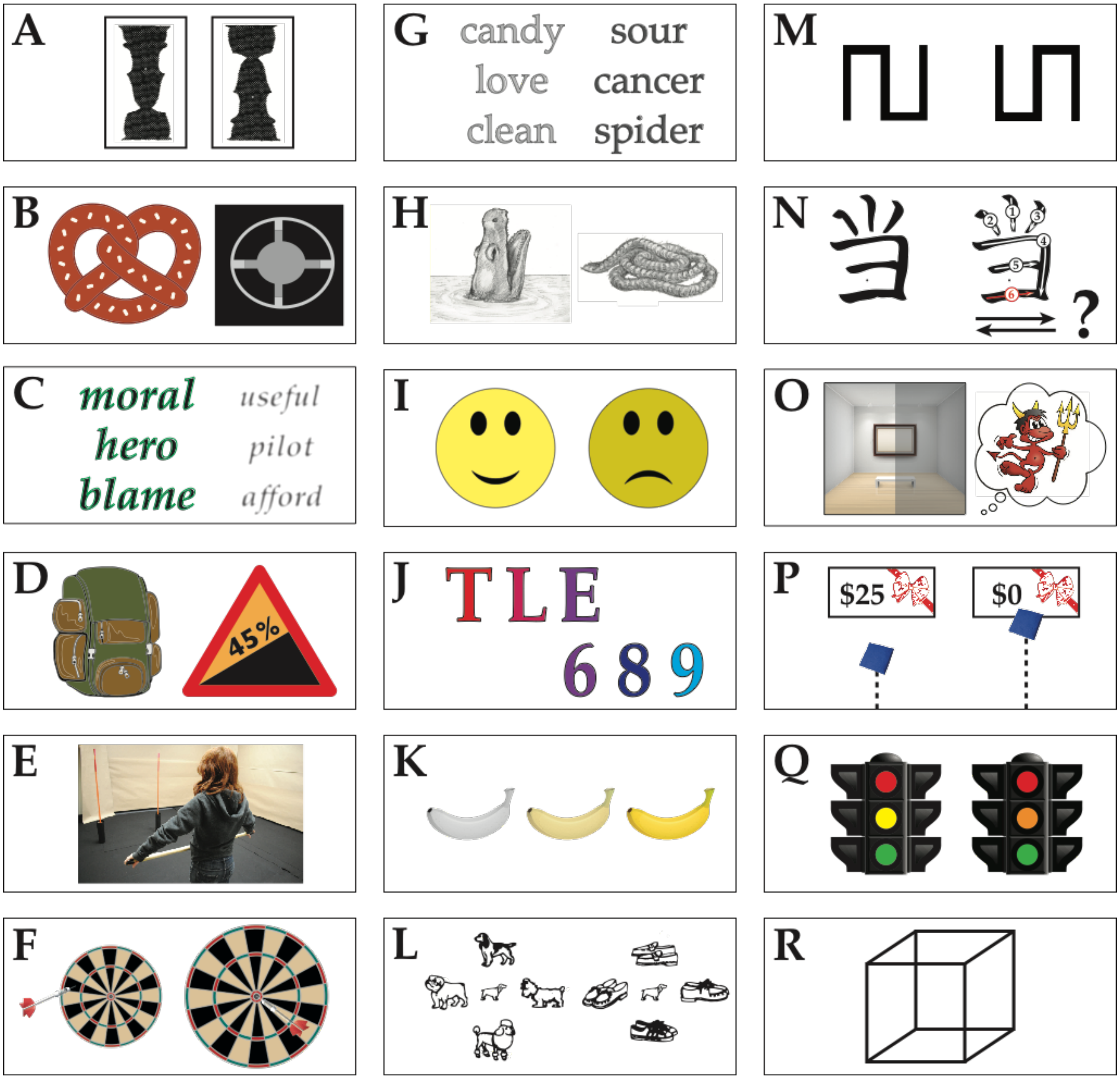

Figure 1.2. Illustrations of various possible top-down effects on perception. (A) Figure-ground assignment is biased toward familiar shapes, such as a woman's profile (Peterson & Gibson 1993). (B) Being thirsty (after eating salty pretzels) makes ambiguous surfaces look transparent (Changizi & Hall 2001). (C) Morally relevant words are easier to see (Gantman & Van Bavel 2014). (D) Wearing a heavy backpack makes hills look steeper (Bhalla & Proffitt 1999). (E) Holding a wide pole makes apertures look narrower (Stefanucci & Geuss 2009). (F) Accurate throwing biases subsequent estimates of target-size (Canal-Bruland et al. 2010; Wesp et al. 2004). (G) Positive words appear lighter (Meier et al. 2007). (H) Scary music makes ambiguous images assume their scarier interpretation (Prinz & Seidel 2012). (I) Smiling faces look brighter (Song et al. 2012). (J) Learning color-letter associations biases color perception (e.g., 'E' will look redder and '6' will look bluer; Goldstone 1995). (K) A grayscale banana appears yellow (Hansen et al. 2006). (L) Conceptual similarity enhances size-contrast (Coren & Enns 1993). (M) Labeling shapes as "2" and "5" enhances visual search (Lupyan & Spivey 2008). (N) Calligraphic knowledge affects the direction of apparent apparent motion (Tse & Cavanagh 2000). (O) Unethical thoughts make the world look darker (Banerjee et al. 2012). (P) Desired objects are seen as closer, as measured by beanbag throws (Balcetis & Dunning 2010). (Q) The middle traffic light is called gelb (yellow) in German and oranje (orange) in Dutch, which influences its perceived color (Mitterer et al. 2009). (R) You may be able to intentionally decide which interpretation of a Necker cube to see (cf. Long & Toppino 2004).

The six "pitfalls" of top-down effects on perception

Against this wealth of evidence and its associated consensus, I argue that there is no evidence for such top-down effects of cognition on visual perception, in every sense these claims intend. With hundreds of reported effects, this is, admittedly, an ambitious claim. My approach is thus to explicitly identify the "pitfalls" that account for reported top-down penetration of visual perception without licensing such conclusions, motivating a positive proposal of how seeing relates to thinking and pointing to concrete avenues for confirming or refuting this conception of mental organization. These pitfalls are few in number (rather than a laundry list), empirically anchored (not merely 'theoretical' objections), general in scope (each applying to dozens of reported top-down effects), and theoretically rich (raising foundational questions about how the mind is organized). They are:

1. **An overly confirmatory research strategy**: Seeking only 'positive' evidence, rather than 'negative' evidence
2. **Perception vs. judgment**: Failing to separate what we *see* from what we *judge based on what we see*
3. **Demand and response bias**: Allowing subjects to discern a study's purpose and modify their responses accordingly
4. **Low-level differences (and amazing demonstrations!)**: An absence of subjectively appreciable top-down "demonstrations"
5. **Peripheral attentional effects**: Effects driven by where we choose to look or attend
6. **Memory and recognition**: Effects that reflect how we recall information, rather than how we see the world

Some of these pitfalls (especially #2 and #5) are primarily founded on the work of other researchers, and so I do not discuss those at length in this précis (though Chapter 1 itself discusses all of them in detail). Instead, I focus below on the pitfalls that are anchored in my own empirical work, each with a dissertation chapter devoted to it. In each case, I present the empirical work supporting these pitfalls, and I also demonstrate their wide applicability to other effects. Collectively, my dissertation argues that these six factors capture *every single* alleged top-down effect of cognition on perception ever reported in the literature, and that all future work must consider them in order to make compelling claims about the nature of seeing and thinking.

Chapter 2. An overly confirmatory research strategy

(Published as *Firestone & Scholl, 2014, Psychological Science*)

How do we support experimental hypotheses? Crudely speaking, there are two kinds of ways: You should observe effects when your theory calls for them, and you should *not* observe effects when your theory demands their absence. The vast majority of reported top-down effects involve only the first sort of test: A hypothesis is proffered that some higher-level state affects perception, and then such an effect is observed. Though the popularity of such "confirmatory predictions" is unsurprising, this approach essentially misses out on half the possible decisive evidence. This chapter introduces a new research strategy that takes advantage of this second class of evidence, inspired by an infamous art-historical reasoning error: The "El Greco fallacy".

The El Greco fallacy in perception research

Why did El Greco paint oddly elongated figures (Fig. 2.1)? To explain these distortions, it was once supposed that El Greco suffered from uncommonly severe astigmatism that effectively "stretched" his perceived environment, such that El Greco was simply painting what he saw. Though perhaps intuitively plausible, this theory is conceptually confused: If El Greco truly experienced a stretched-out world, then he would also have experienced a stretched-out *canvas*, canceling out the supposed real-world distortions. The elongations in his paintings, then, could not reflect literal perceptual distortions (Firestone 2013).

Figure 2.1. Canonical examples of the elongated figures painted by Spanish Renaissance artist El Greco. Clockwise from left: Saint John the Baptist; The Repentant Magdalen; Portrait of a Man.

I exploited the El Greco fallacy to show that multiple alleged top-down effects *cannot* genuinely be effects on perception. Consider the report that thinking unethical thoughts makes the world look darker (Banerjee et al. 2012; Fig. 1.2O). The original study used a numerical scale: After reflecting on ethical or unethical actions, subjects picked a number on the scale to rate the brightness of the room they were in. I replicated this effect with one small change: Instead of a numerical scale, subjects rated the room's brightness using actual grayscale patches, and picked the patch that best matched the room's brightness. If unethical thoughts really make the world look darker, then the patches of the scale should look darker too, and the effects should cancel out. However, the follow-up study *succeeded*: subjects picked darker patches after reflecting on unethical actions. This effect, then — like El Greco's distortions — must not reflect the way the world actually looked to subjects!

Other susceptible studies, and a lesson for future research

This is not an isolated investigation of a single top-down effect: The El Greco fallacy is a *general* strategy that can be applied to nearly any result in perception research. To demonstrate this, I also used it to explore a very different alleged top-down effect. Holding a wide rod across one's body (Fig. 2.2A) reportedly makes apertures look narrower (since they become harder to pass through), as measured by having subjects instruct an experimenter to adjust a measuring tape to visually match the aperture's width (Fig 2.2B; Stefanucci & Geuss 2009). I replicated this result, but instead of adjusting a measuring tape, the experimenter adjusted two poles that themselves formed a potentially passable aperture (Fig. 2.2C). If holding a rod really does perceptually compress apertures, then this variant should "fail", since subjects should see *both* apertures as narrower. But the experiment did not "fail": Subjects again reported narrower apertures even when responding *using an aperture*. Therefore, this effect cannot reflect a true perceptual distortion — not because the effect fails to occur, but rather because it occurs *even when it shouldn't*.

(This last example also supported Pitfall #3: Demand and Response Bias. In a separate experiment, I showed that these subjects may have answered that the aperture was narrower simply because they discerned the experiment's purpose — which, after all, involved a salient manipulation [a mysteriously unexplained rod] and a single question [how wide an aperture appeared]. When I gave subjects a false "cover story" to explain the rod's purpose — involving the need to keep their balance, like a tightrope walker — the effect on aperture-width judgments disappeared!)

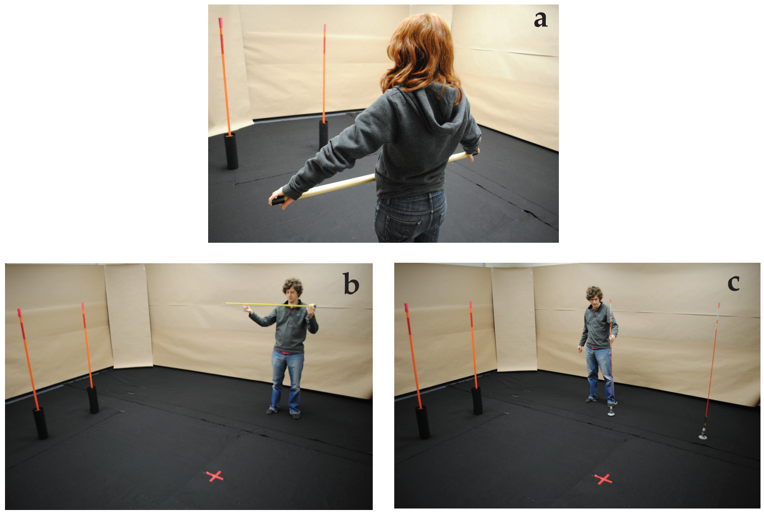

Figure 2.2. Photos of materials and procedures used in Experiments 1 through 3 of Chapter 2.

Still other effects may have committed the El Greco fallacy by *mistake*. Consider the report that after repeatedly viewing red-and-violet letters and blue-and-violet numbers, subjects judged token violet letters as redder and token violet numbers as bluer (Goldstone 1995; Fig. 1.2J). This effect was measured by having subjects adjust the hue of a stimulus to visually match the symbol being judged. However, the adjusted stimulus was a *copy of that symbol*! For example, after viewing a red "T," a reddish-violet "L," and a violet "E," subjects judged the E to be redder — as measured by adjusting the hue of a *second* E. This commits the El Greco fallacy: if Es really look redder after seeing other red letters, then both the to-be-matched E *and* the adjustable E should have looked redder, canceling out their effects. That such an effect nevertheless occurred suggests it cannot be perceptual.

To best determine how and whether cognition influences perception, future studies should employ both confirmatory and disconfirmatory research strategies; to do otherwise is to ignore half the relevant evidence!

Chapter 3. Low-level differences (and amazing demonstrations!)

(Published as *Firestone & Scholl, 2015a, Psychonomic Bulletin & Review*)

A privilege of studying the human visual system is that the phenomena one becomes interested in can often be studied not only through laboratory experiments, but also through "demonstrations" allowing such phenomena to be *experienced* directly (as in Figure 1.1). Can we experience top-down effects for ourselves? An awkward fact about these claims is that nearly all such examples are not subjectively noticeable: If you place a $1 bill beside a $100 bill, the latter does not appear *noticeably* closer; if you stand before a hill and don a heavy backpack, the hill does not look *noticeably* steeper; if you think now of past transgressions, the room does not seem *noticeably* dimmer. Though such demos are not *required* for some effect to be perceptual, 'demos' provide especially compelling evidence, and effectively silence other methodological worries.

A singular exception

One especially compelling and currently influential top-down effect on perception is a report that Black (i.e., African-American) faces look darker than White (i.e., Caucasian) faces, even when matched for mean luminance (Levin & Banaji 2006; Figure 3.1A). This finding is widely regarded as one of the strongest counterexamples to modularity (Collins & Olson 2014; Macpherson 2012; Vetter & Newen 2014) — no doubt because, in addition to the careful experiments reported in the paper, the difference in lightness is subjectively apparent: The Black face just *looks* darker.

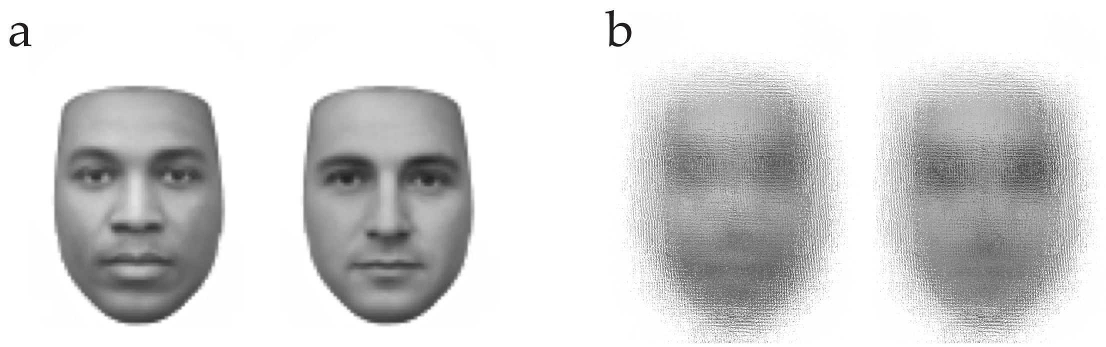

Figure 3.1. (A) Face stimuli (matched in mean luminance) from Experiment 1 of Levin and Banaji (2006). (B) Blurred versions of the same stimuli, which preserved the match in mean luminance but obscured the race information.

But is this a *top-down* effect on perception? Though the faces were matched for mean luminance, many lightness cues go beyond mean luminance; after all, countless lightness illusions involve two regions of equal luminance that nevertheless appear lighter or darker (Fig. 1.1). And indeed, a close examination of the faces in Figure 3.1A suggests that the Black face seems to be under illumination, whereas the White face doesn't look particularly illuminated or shiny — a difference long known to influence perceived lightness (Adelson 2000; Gilchrist & Jacobsen 1984). And the Black face has darker cheeks, whereas the White face has darker eyes. Could such low-level differences — rather than race per se — explain this effect?

To test this, I blurred the face stimuli to eliminate racial categorization while preserving many low-level image differences (including matched mean luminance and contrast; Figure 3.1B). After blurring, the vast majority of observers asserted that the two faces had the same race. However, considering only those observers who stubbornly detected no difference in race, the blurry image derived from the Black face was judged to be darker than the blurry image derived from the White face! Thus, this effect may not reflect race at all — since low-level image properties are apparently sufficient to obtain a difference in perceived lightness. Stepping back, this undermines the strongest piece of subjectively appreciable evidence for top-down effects of cognition on perception.

Other susceptible studies, and a lesson for future research

This example joins other effects that initially seemed to reflect high-level factors but actually reflected lower-level visual differences. For example, conceptual knowledge had been reported to facilitate 'pre-attentive' visual search, with more efficient search for animals among artifacts, and vice versa (Levin et al. 2001). This appeared to be a high-level effect on a low-level process; however, closer investigation by the same researchers revealed systematic low-level differences in the stimuli — wherein the animals (e.g., snakes, fish) had more curvature than the artifacts (e.g., chairs, briefcases) — which sufficiently explained the search benefits.

Such low-level confounds face *any* top-down effect that varies stimuli across conditions — for example, studying how fear affects distance perception by placing subjects high on a precarious balcony (Stefanucci & Proffitt 2009) or using different objects (e.g., live tarantulas vs. plush toys; Harber et al. 2011). Future studies that do this must also either preserve the high-level factor while eliminating the low-level factor (and still observe the effect), or preserve the low-level factor while eliminating the high-level factor (and fail to observe the effect).

Chapter 4. Perception vs. memory

(Published as *Firestone & Scholl, 2015b, Cognition*)

Top-down effects on perception are meant to reflect what we *see*, but many such studies instead report effects on how we *recognize* various stimuli. For example, assigning linguistic labels to simple shapes improves reaction time in visual search and other recognition tasks (Lupyan & Spivey 2008; Fig. 1.1M), and briefly-flashed morally relevant words are easier to identify than morally irrelevant words (the "moral pop-out effect"; Fig. 1.1C; Gantman & Van Bavel 2014). Such reports invoke the revolutionary language of cognitive penetrability, claiming effects on "basic awareness" or "early" vision. However, by its nature, recognition necessarily involves not only visual processing per se, but also memory: To recognize something, the mind must determine whether a stimulus matches some stored representation in memory. Thus, any top-down improvement in visual recognition could reflect a "front-end" effect on visual processing itself, or instead a "back-end" effect on memory access (in which case the effect may not have the same revolutionary consequences).

Consider again "moral pop-out", wherein morally relevant words were easier to see than morally irrelevant words, supposedly because morality is "privileged" in the mind (Gantman & Van Bavel 2014). Subjects were shown briefly (40–60ms) presented words and nonwords one-at-a-time, and decided whether each stimulus was a word or nonword (Fig. 4.1A). Some words were morally relevant (e.g., "illegal"), and some were morally irrelevant (e.g., "limited"); subjects more accurately identified morally relevant words than morally irrelevant words. However, by virtue of being related to morality, the morally relevant words were also related to *each other* (also including "law," "justice," "crime," "convict," "guilty," and "jail"), whereas the non-moral words were unrelated (including "rule," "exchange," "steel," "confuse," "tired," and "house"). For this reason, it's possible that the moral words simply *primed* each other and were easier to recognize for that reason (rather than anything special about morality). Crucially, such semantic priming would not be a top-down effect on *perception*: After all, when "doctor" is easier to recognize when preceded by "nurse" than by "butter" (Meyer & Schvaneveldt 1971), it's not because of some boost to visual processing itself, but rather because the relevant memory representations become temporarily easier to retrieve (due to spreading activation in memory) when evaluating whether a visual stimulus is familiar (Collins & Loftus 1975). Similarly, words like "illegal" may have primed related words like "justice" (whereas words like "limited" would not have primed unrelated words like "exchange").

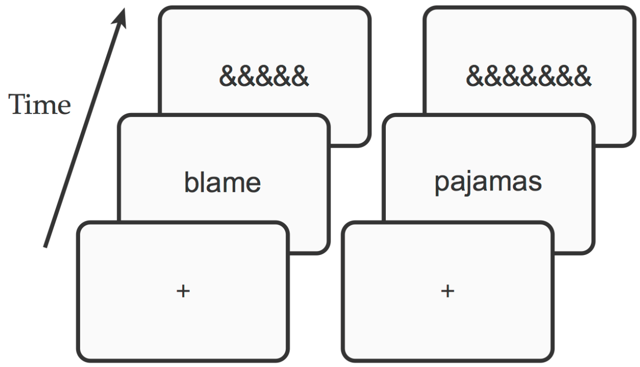

Figure 4.1. Schematic design for detecting "enhanced visual awareness" of various word categories. After fixation, a word or nonword appeared for 50ms and then was masked by ampersands for 200ms.

If this alternative account is correct, then *any* category whatsoever should show a similar "pop-out effect" — including completely arbitrary categories without any privileged status in the mind. To test this possibility, I replicated "moral pop-out", but instead of using moral words (e.g., "hero," "virtue"), I used words related to *clothing* (e.g., "robe," "slippers"). The effect replicated even with this trivial, arbitrary category: Fashion-related words were more accurately identified than non-fashion-related words. (A second experiment replicated the phenomenon again, with transportation-related words like "car" and "passenger.") These results suggest that relatedness is the key factor in such effects, and thus that memory, not perception, improves detection of moral words.

Other susceptible studies, and a lesson for future research

Here too, the implications of this case study extend to many other effects. For example, hungry subjects more accurately identified briefly presented food-related words relative to satiated subjects (Radel & Clement-Guillotin 2012), which was interpreted as an effect on "early visual perception". But consider the perception vs. memory distinction: If hungry subjects were simply *thinking about food* more than nonhungry subjects were, then it is no surprise that they better recognized words related to what they were thinking about, having activated the relevant representations in memory even before a stimulus was presented.

Since visual recognition involves both perception and memory as essential but separable parts, it is incumbent on reports of top-down effects on recognition to separate them, in part because effects on "back-end" memory have no implications for the nature of perception. (If they did, then the discovery of semantic priming would have conclusively demonstrated the cognitive penetrability of perception back in the 1970s, rendering the recent bloom of such studies unnecessary!)

Chapter 5. Where do we stand?

When combined with the other pitfalls explored in my dissertation, I contend that the above work recasts an entire literature comprising hundreds of empirical papers and theoretical reviews. However, the ultimate goal is not to *defend* that contention, but instead to develop tools and criteria to allow the field to finally decide the answers to these questions — whatever those answers turn out to be. How has the field responded?

Happily, the "El Greco fallacy" (Chapter 2) has caught on as a strategy for separating perception from cognition (e.g., Cole et al., 2016; Kirsch et al., 2016; Martin et al., 2016). One recent and elegant application investigated claims that hypnosis slows the perception of time, such that when asked to report when two minutes have elapsed, hypnotized subjects wait four (Naish, 2001). Martin et al. (2016) exploited the El Greco fallacy by asking subjects to report which of *two* durations was longer, with one or both durations experienced under hypnosis. Hypnosis affected estimation of the first duration even when the second duration was also experienced under hypnosis, ruling out a perceptual interpretation of this effect (since then *both* durations should have been hypnotically altered). This is precisely the sort of outcome I intend: to develop a general tool that is useful whenever the distinction between perception and judgment is critical.

The work on race-based lightness distortions (Chapter 3) motivated an entirely new set of studies from an author of the original paper (Baker & Levin, 2016), who now showed that ~75% of subjects can correctly identify the blurry faces' races when forced to choose between "African-American" and "Caucasian" (rather than our "same/different" judgment). Apparently, then, "participants could detect the race of the blurred faces" (Baker & Levin, 2016, p.501), which Baker and Levin used to question (what they thought was) the assumption that blurring eliminated *all* the race information in the face images. However, Chapter 3's argument was only that the lightness distortion remains even in those subjects who *don't* categorize the faces based on race — however many such subjects there may be. And so it simply doesn't matter if many subjects can correctly guess the races when forced — as long as those who *don't* still exhibit an effect, which remains consistent with Baker and Levin's results.

These are just two of several other published replies to the specific work discussed here (see also Gantman & Van Bavel, 2016, on "moral popout"). In other cases, entire research programs have considered their studies in light of the "six-pitfall framework"; for example, Witt (2017) examines the entire "action-specific literature" and concludes that it survives each pitfall on the checklist. See Firestone and Scholl (2016b) to see why I disagree!

In conclusion

The challenge of understanding the natural world is to capture generalizations about it — to "carve nature at its joints." Is there a 'joint' in the mind between seeing and thinking? I have suggested that vision is not simply *another kind of cognition*, but rather is a truly distinct, encapsulated process in the mind. But ultimately my perspective is empirically based, and so open to refutation. Time (and new, careful experiments that are sensitive to the 'pitfalls' presented above) will tell if the thesis survives!

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