the two-factor theory, prediction-error theorists minimize or disavow this distinction:

> The boundaries between perception and belief at the physiological level are not so distinct. An important principle that has emerged is that both perception of the world and learning about the world (and therefore beliefs) are dependent on predictions and the extent to which they are fulfilled. This suggests that a single deficit could explain abnormal perceptions and beliefs. (Fletcher & Frith 2009, p. 51)

> Within this framework there is no qualitative distinction between perception and belief, because both involve making inferences about the state of the world on the basis of evidence. (Frith & Friston 2013, p. 5)

Furthermore, according to prediction-error theorists delusions provide examples of cognition penetrating perception: There exist "interactions between perception and belief-based expectation" (Corlett et al. 2010, p. 357), and "delusional beliefs can alter percepts such that they conform to the delusion" (Corlett et al. 2010, p. 353). This position seems to be in tension with the hypothesis F&S present. Consequently, we suggest it would be useful for F&S to expand the scope of their review by critically examining whether there is empirical evidence from research on delusions that cognition penetrates perception. If empirical evidence is compelling, then there exists a counterexample to F&S's hypothesis.

In this commentary, we have shown that the relationship between cognition and perception is a major point of interest in contemporary research on delusions. This suggests that evidence from cognitive neuropsychology and cognitive neuropsychiatry may play an important role in testing the hypothesis F&S present.

Attention and memory-driven effects in action studies

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Abstract: We provide empirical examples to conceptually clarify some items on Firestone & Scholl's (F&S's) checklist, and to explain perceptual effects from an attentional and memory perspective. We also note that action and embodied cognition studies seem to be most susceptible to misattributing attentional and memory effects as perceptual, and identify four characteristics unique to action studies and possibly responsible for misattributions.

Firestone & Scholl (F&S) make a strong case against the effect of top-down beliefs on perception. The argument for the cognitive impenetrability and modular nature of (visual) perception is reminiscent of the historic debate between Fodor and Turvey (Fodor & Pylyshyn 1981; Turvey et al. 1981), especially when most of the top-down modulation literature can find its roots in Gibson's (1966; 1979) ecological psychology. However, several aspects make F&S's article theoretically unique and important: (1) taking a logical approach such as with the El Greco fallacy, (2) speaking to a wider range of researchers beyond the action or embodied cognition literature, and (3) perhaps most important, providing a checklist of criteria for future studies against the six pitfalls they have cogently identified.

One common pitfall among studies that mistake top-down effects in judgment for perceptual effect is the use of subjective report in measuring percepts (e.g., light and darkness, reachability, distance). Not only is subjective report highly susceptible to task demand (e.g., Durgin et al. 2011a), but also it is problematic because it provides no additional information that would enable researchers to trace the source of the top-down effect. Accordingly, in order to dissociate perception and judgment, it is advisable to use performance-based measures that supply additional information (e.g., spatial, temporal), thereby making it possible to infer the stage of processing over which top-down cognition exerts its influence. One of our previous studies (Tseng & Bridgeman 2011) demonstrates this point: To test whether hands near a visual stimulus would *enhance* processing of the stimulus (as opposed to hands far; see Tseng et al. 2012 for a review), participants performed a forced-choice visual memory change detection task that provides accuracy and reaction time data, as opposed to subjective report. The rationale was that if hand proximity could really change the way visual stimuli are processed in a positive way, then hand proximity would predict enhanced visual processing, which would lead to better change detection performance. This would effectively rule out the judgment component; the participants cannot fake better performance.

Here it is important to clarify F&S's conceptual distinction between "perception and judgment": The two are not mutually exclusive, nor do they exhaust all alternatives (e.g., attention). Therefore, even if the judgment factor is accounted for by performance-based measures, such a result would not necessarily guarantee an effect in perception, especially because the effects on attention – which can modulate perception – can often disguise themselves as effects on perception (F&S's "periphery effect of attention"). To revisit the example above, although it is tempting to conclude that perception was directly modulated by hand proximity, it is equally plausible that the effect stemmed from biased attention near the hands. Indeed, analyzing participants' hit rates region by region on the screen showed a shift of correct responses toward the right-hand side, suggesting that the effect was mediated by biased spatial attention, not visual perception. This conclusion not only reemphasizes the importance of having a performance-based measure that can be analyzed differently to provide additional information, but also it is consistent with Pitfall 5, "peripheral attentional effects" (sect. 4.5), on F&S's checklist. The same rationale is also true for Pitfall 6, "memory and recognition" (sect. 4.6), and we attacked this problem by turning a potential artifact into an independent variable. Throwing a marble into a hole makes the thrower judge the hole as bigger following success than failure, but only if the hole is obscured after throwing. If the hole remains visible, the effect disappears (Blaesi & Bridgeman 2015; Cooper et al. 2012). The logic of this experiment is analogous to many efforts to demonstrate effects of action on perception, and it shows those results to affect memory, not perception. Modifying memory on the basis of experience is useful; modifying perception is not. Taken together, we recommend that future studies should consider Pitfalls 2, 5, and 6 together by controlling for judgment and memory effects and then moving on to tease apart the effects in perception versus attention.

Lastly, it is intriguing to us that a majority of the studies reporting top-down effects on perception are related to action (e.g., affordance, reachability). Might action studies be more susceptible to misattributing attentional or memory effects to perception? We speculate four possible reasons unique to the action literature for why this may be the case:

1. Universality: Due to motor action's depth in evolutionary time, action's effects on perception or attention are likely very widespread. This differs from the way in which ruminating about things, such as a sordid past, would make the room seem

darker (e.g., Banerjee et al. 2012; Meier et al. 2007). Because ruminations about the past involve parts of the cognitive economy that are evolutionarily recent, and because darkness metaphors of this type depend largely upon cultural interpretations that might be unique to humans, effects on perception are not as likely as actions and affordances.

2. Implicitness: Unlike certain, consciously accessible, top-down beliefs, information regarding action possibilities, or affordances, is often implicit properties that subjects may not be consciously aware of. Thus, the implicit nature of affordance information is assumed to be processed below consciousness threshold, and likely at the perceptual stage.

3. Well-established neurophysiology: The neuronal mechanisms for processing affordance or other action-relevant information (e.g., space, distance, graspability) have been well investigated in monkeys (e.g., Graziano & Botvinick 2002). Visual–tactile neurons in premotor and parietal cortices move their receptive fields with the hands instead of eyes, and they respond to objects that are within reach, even when "reachable" means "reachable with a tool."

4. Perception–action loop: The idea of perception–action coupling has been important in ecological psychology, and still is today in the embodied cognition literature. We suspect an overly literal interpretation of the idea can sometimes mislead researchers to mistake attentional effects as perceptual.

In summary, the effect of action on perception or attention is clearly quite different from other types of top-down beliefs. Although it is unfortunate that most action studies have mistaken attentional effects as perceptual, one can at least see why these studies may be more vulnerable to an inclination towards perceptual interpretations. Therefore, we recommend researchers in the field of perception and action and embodied cognition to especially consider F&S's arguments in the context of action when making conclusions.

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Perception, as you make it

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Abstract: The main question that Firestone & Scholl (F&S) pose is whether "what and how we see is functionally independent from what and how we think, know, desire, act, and so forth" (sect. 2, para. 1). We synthesize a collection of concerns from an interdisciplinary set of coauthors regarding F&S's assumptions and appeals to intuition, resulting in their treatment of visual perception as context-free.

No perceptual task takes place in a contextual vacuum. How do we know that an effect is one of perception *qua* perception that does not involve other cognitive contributions? Experimental instructions alone involve various cognitive factors that guide task performance (Roepstorff & Frith 2004). Even a request to detect simple stimulus features requires participants to understand the instructions (*language, memory*), keep track of them (*working memory*), become sensitive to them (*attention*), and pick up the necessary information to become appropriately sensitive (*perception*). These processes work in a dynamic parallelism that is required when one participates in any experiment. Any experiment with enough cognitive content to test top-down effects would seem to invoke all of these processes. From this task-level vantage point, the precise role of visual perception under strict *modular* assumptions seems, to us, difficult to intuit. We are, presumably, seeking theories that can also account for complex natural perceptual acts. Perception must somehow participate with cognition to help guide action in a labile world. Perception operating entirely independently, without any task-based constraints, flirts with hallucination. Additional theoretical and empirical matters elucidate even more difficulties with their thesis.

First, like Firestone & Scholl (F&S), Fodor (1983) famously used visual illusions to argue for the modularity of perceptual input systems. Cognition itself, Fodor suggested, was likely too complex to be modular. Ironically, F&S have turned Fodor's thesis on its head; they argue that perceptual input systems may interact as much as they like without violating modularity. But there are some counterexamples. In Jastrow's (1899) and Hill's (1915) ambiguous figures, one sees either a duck or rabbit on the one hand, and either a young woman or old woman on the other. Yet, you can cognitively control which of these you see. Admittedly, cognition cannot "penetrate" our perception to turn straight lines into curved ones in any arbitrary stimulus; and clearly we cannot see a young woman in Jastrow's duck-rabbit figure. Nonetheless, cognition can change our interpretation of either figure.

Perhaps more compelling are auditory demonstrations of certain impoverished speech signals called sine-wave speech (e.g., Darwin 1997; Remez et al. 2001). Most of these stimuli sound like strangely squeaking wheels until one is told that they are speech. But sometimes the listener must be told what the utterances are. Then, quite spectacularly, the phenomenology is one of listening to a particular utterance of speech. Unlike visual figures such as those from Jastrow and Hill, this is not a bistable phenomenon; once a person hears a sine wave signal as speech, he or she cannot fully go back and hear these signals as mere squeaks. Is this not top-down?

Such phenomena – the bistability of certain visual figures and the asymmetric stability of these speechlike sounds, among many others – are not the results of confirmatory research. They are indeed the "amazing demonstrations" that F&S cry out for.

Second, visual neuroscience shows numerous examples of feedback projections to visual cortex, and feedback influences on visual neural processing that F&S ignore. The primary visual cortex (V1) receives descending projections from a wide range of cortical areas. Although the strongest feedback signals come from