square, filled, etc.) and that this list is tagged in some way to indicate their collocation on the same object. If imagined and real features are encoded, stored, or represented in the same way, then at recall they may be confused, resulting in illusory conjunctions between percepts and images.

The argument of a common symbolic vocabulary is less convincing when one considers other tasks, particularly lower-level tasks such as acuity or target detection. There are several findings with visual imagery that do not mirror those with physically presented stimuli. For example, in a signal-detection paradigm based on Segal and Fusella (1970), participants presented with an acuity target (vertical line offsets, Fig. 1B) in a region where they imagined four vertical lines showed strong interference (a loss of 0.8 d′ units). Similar interference was found when imagining four horizontal lines (Craver-Lemley & Reeves 1987, Fig. 1C). However, with physically presented lines, only the vertically oriented lines interfered with acuity. Again, Craver-Lemley and Reeves found that imagined lines interfered with the target at spatial extents in which physical lines have no effect, and that imagined lines still interfered for up to five seconds after the subjects stopped imagining them, unlike real lines which only interfere (as masks) for one or two tenths of a second after presentation. A lack of correspondence between physical and imagined stimuli was discovered under conditions of induced-depth as well. Imagining four vertical lines or a solid bar in front of a line target in an induced depth display (Fig. 1D) interfered with acuity but imagining the four lines or a solid bar behind the target location did not (Fig. 1E, Craver-Lemley et al. 1997). In contrast, physically presented bars interfered with acuity regardless of whether they were located in front of or behind the target. And finally, imagining a solid bar interfered with target detection (an asterisk) only when the target overlapped the image location (Craver-Lemley & Arterberry 2001). In this case, the target and the image had no features in common except spatial location.

We explained many of these results by postulating that the visual system suppresses competing (local) visual input from the visual field in order to facilitate entertaining a visual (mental) image. But why might imagery and perception compete? We do not know, but an interesting suggestion is from Sartre (1948), who, having elegantly dismantled various picture-in-the-head views, concluded, "The image and the perception, far from being two elementary psychical factors of similar quality which simply enter into different combinations, represent the two main irreducible attitudes of consciousness. It follows that they exclude each other" (p. 153). Whether or not this is so, the properties of the interference effect have fairly clear implications for the spatial nature of visual imagery. We note here that Segal and Fusella (1970) also demonstrated that complex auditory images (e.g., of bells) interfered with auditory detection (of tones), but no one has followed this up with simpler images. Our notion that perceptual systems suppress inputs in order to make room for images (or Sartre's notion of exclusion) implies that auditory imagery is similar to visual in this respect. Thus, images of pure notes should interfere chiefly with neighboring frequencies, should do so over a broader spectrum than real-tone maskers, and perhaps should interfere for a longer period of time.

Thus, we have several examples where we do not find complete concordance of effects with real and imagined stimuli; a visual image does not always mimic the effects of physical stimuli. The difference in interference effects between imagined and real stimuli described in the above examples cannot be accounted for by attentional factors, as shown by dual-task attentional manipulations (see Craver-Lemley & Reeves 1992). Nor can they be explained easily by tacit knowledge. Many of the interference effects are contrary to expectations based on experiences with real stimuli (e.g., as mentioned, real horizontal lines do not interfere with Vernier acuity; if subjects knew this to be the case, then imagined horizontal lines should not interfere with Vernier acuity either, but they do). Finally, we are sure that expectations are irrelevant. Craver-Lemley and Reeves (1992) told half the participants in one experiment that imagined vertical lines would facilitate performance, and half that the image would impair it. The participants all believed the cover story and all showed *interference* despite their different expectations.

Pylyshyn states, "It may be that visual percepts and visual images interact because both consist of symbolic representations that use some of the same proprietary spatial or modality-specific vocabulary" (sect. 6.2). We accept that symbol interference may happen at a higher level of representation responsible for image-stimulus illusory conjunctions, but we think the application of "symbolic representations" to spatial and temporal contiguity in the interference effect is stretching matters. Surely the spatial properties of interference point to a pictorial component of visual mental imagery.

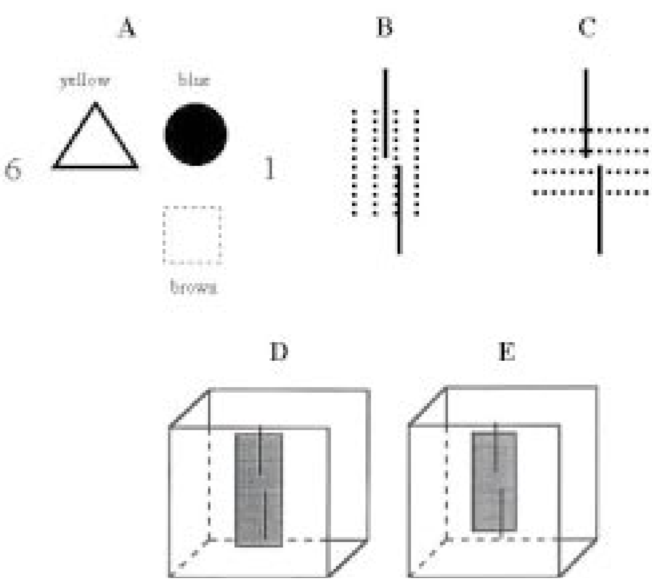

Figure 1 (Arterberry et al.). *A.* Stimulus used to study illusory conjunctions between physical and imagined geometric figures. The hashed lines represent the item the participant imagined. *B.* Vernier acuity target and a four-vertical-line image. *C.* Vernier acuity target and a four-horizontal-line image. In *D* and *E* the bar image was positioned either in front of (*D*) or behind (*E*) the acuity target in an induced-depth display.

Can we change our vantage point to explore imaginal neglect?

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Abstract: Right brain-damaged patients with unilateral neglect, who ignore left-sided visual events, may also omit left-sided details when describing known places from memory. Modulating the orienting of visual attention may ameliorate imaginal neglect. A first step toward explaining these phenomena might be to postulate that space-related imagery is a cognitive activity involving attentional and intentional aspects.

Patients with lesions in the posterior part of the right hemisphere may ignore events on their left side, a condition known as unilateral neglect. Neglect patients are often completely unaware of their disorder (they are said to be "anosognosic"), and extremely unwilling to acknowledge it. A large amount of neuropsychological evidence (reviewed in Bartolomeo & Chokron 2002) suggests that left-sided stimuli fail to exert their normal attraction on neglect patients' attention. Thus, a basic mechanism of left neglect could be a deficit of exogenous, or stimulus-related, orienting of attention toward left-sided targets. In partial disagreement with this interpretation, it has been shown that neglect can occur not only in vision, but also in the absence of any physical object in the patient's visual field. For example, when asked to imagine and describe from memory familiar surroundings from a determined vantage point, neglect patients can omit left-sided details, only to later describe these same details when invited to assume the opposite point of view (Bisiach et al. 1981; Bisiach & Luzzatti 1978). In these studies, imaginal neglect co-occurred with visual neglect. This association has often been interpreted as supporting pictorial models of visual mental imagery (Bisiach & Berti 1990; Kosslyn 1994). Neglect patients would avoid mentioning left-sided imagined details because they would lack the left half of a (spatially organized) mental representation (Bisiach & Luzzatti 1978). It would indeed be difficult to contend that neglect patients have a (however tacit) knowledge of their visual exploratory bias, and would consequently reproduce in imaginal tasks a neglect behavior of which they are, as a rule, completely unaware (Bisiach & Berti 1990). It is, of course, also hard to see how a propositional code compatible with Pylyshyn's "null hypothesis" could have such spatial or directional properties to account for imaginal neglect.

On the other hand, the accumulation of neuropsychological evidence of multiple dissociations between imagery and perceptual abilities in brain-damaged patients (recently reviewed in Bartolomeo 2002), has proved devastating for models of mental imagery based on a functional and anatomical equivalence between these abilities, like Kosslyn's pictorial model. Some of these dissociations are not only functional, but seem to have also an anatomical basis. While occipital damage can determine perceptual deficits, it seems neither necessary, nor sufficient to produce imagery deficits. On the other hand, rather extensive damage of the left temporal lobe seems necessary in order to produce visual imagery deficits for object shape or color (Bartolomeo 2002), as well as for orthographic material (Bartolomeo et al. 2002). Although dissociations have been described between visual and imaginal neglect (see Bartolomeo & Chokron 2001 for a recent review), no such anatomical segregation apparently emerged. Apart from occasional case descriptions of imaginal neglect after right frontal (Guariglia et al. 1993) or thalamic damage (Ortigue et al. 2001), most cases of imaginal neglect result from lesions in the right temporal-parietal cortex, which is the same anatomical correlate of visual neglect (Vallar 1993).

To explore the relationships between visual and imaginal neglect, we assessed them in 30 right- and 30 left-brain-damaged patients, and found imaginal neglect only in right-brain-damaged patients (Bartolomeo et al. 1994). Imaginal neglect always co-occurred with visual neglect,[1] and scores measuring the lateral bias in the two types of tasks positively correlated, thus suggesting that the two disorders share some common underlying mechanism. Additional evidence confirming a relationship between visual and imaginal neglect comes from the outcome of maneuvers known to modulate visual neglect. When a patient had his eyes and head physically turned toward the left side, his descriptions from memory included more left-sided details (Meador et al. 1987). Similar results were obtained by irrigating patient's left ear with cold water (Rode & Perenin 1994), a vestibular stimulation likely to induce a leftward orienting of attention (Gainotti 1993). Imaginal neglect was also reduced by introducing a short adaptation period to a prismatic rightward shift of the visual field to the right (Rode et al. 2001), another maneuver known to ameliorate visual neglect (Rossetti et al. 1998). Thus, sensory-motor procedures can influence imaginal neglect.[2] It has been proposed that at least some of these procedures act by facilitating leftward orienting of attention (Chokron & Bartolomeo 1999; Gainotti 1993).

If so, one could surmise that neglect patients' visual attention can be laterally biased during place description, thus producing signs of imaginal neglect. In section 5.4 of his target article, Pylyshyn suggests that visuo-motor effects on imagery might depend on orienting one's gaze or attention on *real,* as opposed to imagined, locations. This interesting possibility, which would be coherent with what we know about the neglect patients' tendency to be attracted by right, non-neglected, visual targets (Gainotti et al. 1991), could perhaps help explain imaginal neglect. During place description, patients' attention could be attracted by right-sided visual details, and this could in some way influence their performance in imaginal tasks. However, this account does not hold, at least for the studies of the Lyon group, in which patients kept their eyes closed during the imaginal tasks (Gilles Rode, personal communication). If there is an asymmetry of attentional shifts in imaginal neglect, then, it would be rather akin to analogous biases that neglect patients show in situations where no external stimulus is present, as, for example, in the disappearance of leftward REMs during sleep (Doricchi et al. 1993). An implication of this possibility, and one which is relevant to the "imagery debate," is that orienting of attention can influence space-related imagery. Although visual images are certainly not "seen" by the visual system, the phenomenon of imaginal neglect is consistent with the possibility that visual imagery involves some of the attentional-exploratory mechanisms that are employed in visual behavior (Thomas 1999). According to a recent proposal (O'Regan & Noë 2001), these motor processes are actually responsible for the "visual" character of visual experience. The "perceptual" aspects of visual mental images might thus result not from the construction of putative "quasi-perceptual" representations, but from the engagement of attentional and intentional aspects of perception in imaginal activity.

ACKNOWLEDGMENT

We thank Nigel Thomas for very helpful discussion on visual mental imagery.

NOTES

1. In fact, about two thirds of left neglect patients showed definite signs of neglect only in visual tasks, and not in imaginal tasks, probably because right-sided visual details exerted a powerful attraction on patients' attention (see Gainotti et al. 1991). However, when imaginal neglect was present, it was always associated with visual neglect.

2. Conversely, a purely imaginal training can ameliorate visual neglect (Smania et al. 1997).

Spatial models of imagery for remembered scenes are more likely to advance (neuro)science than symbolic ones

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Abstract: Hemispatial neglect in imagery implies a spatially organised representation. Reaction times in memory for arrays of locations from shifted viewpoints indicate processes analogous to actual bodily movement through space. Behavioral data indicate a privileged role for this process in memory. A proposed spatial mechanism makes contact with direct recordings of the representations of location and orientation in the mammalian brain.

Pylyshyn's target article omits some of the evidence for the spatial organisation of visual imagery to be found in studies of memory for spatial scenes or arrays of objects. While not conclusive, this evidence may be instructive in escaping some of the logical caveats raised by Pylyshyn, and extending the discussion of the functional space in which retrieval products from memory are processed. Although other caveats will be found regarding these data, interpreting them in terms of their mapping onto space and our phys-