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Commentary on Stoffer and Umiltà: Focus-Related or Fovea-Related Spatial Codings?

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The contribution of Thomas Stoffer and Carlo Umiltà bundles together numerous recent findings that have gathered evidence for an attention-shifting account of S-R compatibility and the Simon effect. Their basic assumption is that whenever an attention shift is about to be executed, a relative spatial code originates from the direction of the shift. The spatial coding responsible for S-R compatibility or for the Simon effect is therefore a *focus-related* coding[1] that could converge or conflict with a to-be-generated response. Thus, the relevant spatial coding results from the momentarily focused position (spatial frame of reference) and a new attentional shift that is directed, for example, toward a laterally presented imperative stimulus. As the authors demonstrate this offers a powerful explanation for several related findings. Starting with four questions, the following will address more speculative implications, problems, and possible extensions of this account.

1 Does Attention Operate on Spatial Maps with Pregiven Spatial Knowledge or Does it Add New Spatial Information and a New Map?

The authors' reference to Logan (1995) and to Stoffer (1991) seems to indicate their preference for two kinds of spatial representations: one that defines an object's *absolute* location and one that defines its *relative* location. Attentional shifts seem to operate on maps with pregiven (absolute) locations, whereas shifts themselves provide the system with relative spatial codes (i.e., focus-related

[1] The generation of a focus-related code does not necessarily require the execution of an attentional shift. It would suffice to postulate that a spatial code is formed with respect to the just focused position (cf., Nicoletti & Umiltà, 1989). However, in Stoffer and Umiltà's target, the generation of a relative spatial code is coupled with the execution of an attentional shift (see Section 3.2).

codes). Therefore, the focus of attention does establish a new frame of reference, but this frame seems to basically recruit given spatial information; it originates from a simple transformation of the absolute locations (Stoffer & Yakin, 1994). In this sense, an attentional shift provides the system with "transformed" spatial information only, it does not add substantial new information.

Operating on a map with given (absolute) locations solves the problem that shifting attention to an object requires at least some knowledge of the objects' location before the shift is executed. Note, however, that this knowledge need not be perfect; coarse knowledge about the position may suffice. More precise information could be added during the shift or, possibly, "zeroing in" at the target is accomplished by corrective shifts similar to corrective saccades (cf. Adam et al., 1995). In this view, shifting attention can contribute to adding new spatial information and to building up a new spatial map—at least a spatial map that contains the reportable spatial relations after the shift has been carried out. Together with the well-known finding that directing attention needs processing time, this can extend the present account and open it up for a broader class of phenomena. Assume, for example, that a stimulus triggers an attentional shift, but the stimulus' shape or location is somehow modified when the shift is executed. What is perceived is not the state of the stimulus when it elicits the attention shift, but its state when the shift of attention reaches it. Such an account can, for example, be applied successfully to metacontrast masking (Bachmann, 1994; Neumann, 1987) or to movement-induced mislocations (Müsseler & Neumann, 1992).

Still, even if attentional shifts contribute to generating a spatial map, this does not necessarily imply the simultaneous generation of focus-related codes. The assumption of these codes seems to originate from the old spotlight metaphor, which assumes that visual attention acts like a spotlight on a stage. It moves or jumps from object to object, from position to position within the visual field; and as the last focused position is always the starting point of a new attentional shift, relative spatial coding with respect to the last focused position is near at hand. However, this is not necessarily true: Up to the present, findings in the context of visual attention have indicated merely that directing attention leads to an enhanced and prioritized processing at some position. Given a spatial map, directing attention could simply mean that a certain location is "switched on"; it is purely enhanced and prioritized. That does not imply that this "switching on" starts from the previously focused position (Müsseler, 1994), and, therefore, relative spatial codes have to be generated. This problem of the functionality of relative codes will be continued in the following questions.

2 What Happens if Focus-Related Codings Diverge from Fovea-Related Codings?

This question relates the attention-shifting account of spatial compatibility to the "premotor hypothesis of attention". In the present context, the authors introduced this premotor hypothesis to point to the close functional relationship between attentional shifts (incl. their relative spatial codings) and the spatial parameters needed for programming a saccade. This hypothesis states that attention is directed after the specific oculomotor program has been prepared—in other words, when the parameters for direction and amplitude of saccades have been specified (Rizzolatti et al., 1987, p. 39). The saccade itself need not be carried out, because peripheral inhibition mechanisms can prevent it. That is, directing attention is independent of whether attention orients overtly or covertly.

A close link between attention shifts and eye movements is also postulated elsewhere (e.g., Posner & Cohen, 1984; Van der Heijden, 1992, Chap. 4.8; Wolff, 1987). But, in these conceptions, the function of attention shifts is often to determine the target position of the subsequent saccade. There, an attention shift *precedes* each goal-directed saccade *and* their programming, whereas the premotor hypothesis suggests an insoluble temporal coupling of both programming the eye-movement parameters and directing the attentional focus. However, in the present context, the problem is that programming a saccade seems to require fovea-related and not focus-related codings; after all, it is the fovea that has to be shifted to the new location.

In the original Simon paradigm, fovea-related codings match with focus-related codings. But let us imagine the following dual-task experiment: The subjects' main task is to maintain fixation while verbalizing a stream of digits that appear one after the other, say, to the left of fixation. The aim of this task is to keep attention at the stream of digits. The secondary task is to press a left or a right key, respectively, whenever a red or a green circle shows up, and to move the eyes to that stimulus. The critical question would be what happens with respect to compatibility if the circle appears just in between the fixation point and the digits, that is, when the focus of attention has to be shifted to the right, while a saccade still has to be programmed to the left. In this case, focus-related and fovea-related codes diverge—and predictions that can be derived from the attention-shifting account and the premotor hypothesis as well. Several similar experiments reported by the authors indicate that the outcome of this kind of experiment may be in favor of the focus-related account, hence of the attention-shifting model: The right code is activated due to the direction of the attention shift and, consequently, a right keypress is faster than a left keypress. On the other hand, a saccade could normally be initiated before (about 250 ms after the stimulus onset), and this needs the activation of the left code. Thus, a single coherent solution of this problem in terms of the attention-shifting account *and* the premotor hypothesis is not in sight. This would require at least a further specification of the underlying (temporal) assumptions.

3 What is a Focus-Related Code (or a Relative Spatial Code) Needed for?

Surely not to produce spatial compatibility effects. As the authors indicate, such a question would be even more difficult to answer within the referential-coding account (Hommel, 1993). There, the generation of relative codes is simply stated without any further embedding. Within the attention-shifting account, relative coding is a by-product of an (obviously existing) cognitive process, that is, the attentional selection process. But what is the function of focus-related coding outside our laboratories?

An answer within the present framework stresses the relation to eye movements. Under everyday conditions, foveation and attentional focusing normally coincide, that is, attention is directed to the foveated region, then shifted to a peripheral region, and is finally retracted to the fovea (after saccade execution). According to this, there is a continuous interplay between foveation and attention. In this context Deubel, Irwin, and Schneider (1995) report a related observation: Their subjects frequently claimed that they moved their eyes to the location before their eyes actually moved. In other words, immediately before executing a saccade, they reported that their actual frame of reference was already at the to-be-fixated position—a finding that fits into the present attentional account for spatial compatibility. In a laboratory, the normal cycle of foveation and attention is frequently violated, that is, a left shift of attention is not necessarily accompanied by a subsequent left eye movement. Nevertheless, the left code could be—as usual—activated with the shift, thus producing a focus-related code quasi automatically.[2]

An answer outside the present framework could stress the human being's mental ability to change his or her perspective. Obviously, we can judge spatial positions from another, only mentally occupied perspective (e.g., "the object to your left!"), we can mentally rotate objects, or—while reading—we can build up a spatial representation of a chamber we have never seen (Shepard, 1994). Such changes of own perspective require at least two different spatial representations or two spatial frames of reference: one perspective that corresponds to the actual visual world we live and act in, and a second perspective that corresponds to another (intentionally) chosen point of view. So, clearly, the relative spatial locations of these two frames of reference—and thus their spatial codes—can

[2] Note that this is in line with the premotor hypothesis under everyday conditions. The main difference is that the premotor hypothesis and its programming of the eye-movement parameters must always assume fovea-related codings; this producing the above-mentioned problems.

differ from each other. One problem is, however, that the present attentional account is assumed to generate the focus-related codings quasi-automatically, whereas changes in personal perspective are normally viewed as an intentionally induced process. But can an impact of possible intentional processes really be excluded? And what is the difference between automatic and intentional processes?

4 Can Spatial Compatibility Effects be Induced with Symbolic Stimuli?

Consider the following simple experiment: Subjects maintain fixation while left- and right-pointing arrows are presented at fixation. In one block of trials, the subject's task is to press corresponding left or right keys, whereas in another block, the key instruction is reversed. I actually do not know whether such an experiment has been run yet, but I should be surprised if its outcome were to differ basically from that of a normal spatial compatibility experiment (with laterally presented stimuli). However, the attentional account would have problems with this outcome. Because, on the one hand, all information is presented at the fixation point and therefore no attention shifts are indicated, whereas, on the other hand, the generation of relative spatial codes is assumed to be linked to the attentional shifts, a compatibility effect cannot be explained so far. Either it is assumed that such symbolically induced compatibility effects have nothing to do with the reported spatial compatibility effects, which is not a very likely conclusion, or the present account has to be extended.

The same is true when considering the spatial Stroop effect (for an overview, see Lu & Proctor, 1995): Either it is assumed that the spatial Stroop effect is only a variant of the Simon effect, thus ignoring its symbolic features and fitting with the present attentional account, or it is assumed that the spatial Stroop effect has much in common with the color-word Stroop interference. In that case, a purely attentional account is not sufficient to explain the empirical findings.

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