Can a Checklist Reduce SOS Errors in Chest Radiography?[1]

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Rationale and Objectives. A previous study demonstrated unexpected protection from satisfaction of search (SOS) effects when observers verbalized the focus of their attention during visual search and interpretation of chest radiographs. We suggested that protection from SOS might have occurred if each observer developed an informal checklist to help generate the verbal descriptions. The objective of this study is to determine whether a formal checklist reduces SOS effects in chest radiology.

Materials and Methods. Fifty-seven chest radiographs, half of which demonstrated diverse, native abnormalities were read twice by 20 observers, once with and once without the addition of a simulated pulmonary nodule. Area under the receiver operating characteristic (ROC) curve for detecting the native abnormalities was estimated for each observer in each treatment condition using the contaminated binormal ROC model. Radiologists in the current experiment used a checklist during the interpretation, rather than describing their visual search. Results were compared with those of the verbalization study, which used the same set of radiographs.

Results. Although no SOS effect was found when the checklist was used, ROC performance was, on average, much poorer with the checklist than when ongoing search was reported verbally (0.68 versus 0.75, $F(1,37) = 17.26$, $P < .001$).

Conclusions. Our results indicate that the recommendation to use a self-prompting checklist to counteract SOS is not warranted. The relative superiority of verbalizing search over using an imposed checklist may be based on the consistency of each of these interventions with the observer's internal strategy for searching radiographs.

Key Words. Diagnostic radiology; observer performance; images; interpretation; quality assurance.

Satisfaction of search (SOS) occurs when a lesion is "missed" after detecting another lesion in the same image. Scientific study of SOS has been crucial to finding its causes. Laboratory studies use an operational definition of SOS not found in accounts of clinical errors. According to this operational definition, *the lesion that is missed because of SOS is shown to be detected in the absence of other lesions*. To accomplish this, a known abnormality is defined as the *test* abnormality because detection of that abnormality is measured. The test abnormalities are always presented twice to observers: once alone and once with another abnormality presented within that same examination. SOS occurs when the test abnormality is missed in the presence of the added abnormality, but not in its absence. Although detection of any abnormality may affect detection of any other abnormality, SOS can only be measured rigorously on the test abnormality because it is the only abnormality that is presented by itself as a critical control condition.

An SOS effect in chest radiology, defined operationally as a reduced accuracy in detecting native abnormalities on chest radiographs in the presence of simulated pulmonary

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nodules, has been demonstrated (1–3). Another study demonstrated an SOS effect defined as reduced accuracy in detecting simulated pulmonary nodules on chest radiographs in the presence of native abnormalities (4). The authors of that study recommended "some heuristic method of self-prompting, such as an automatic checklist" to counteract SOS.

In a previous study requiring observers to provide verbal descriptions of their search during the interpretation of cases, unexpected protection from SOS effects was found (5). Most observers' verbal reports demonstrated a deliberate, personally unique pattern of search, often over many examinations. We thought that observers might have generated an individual checklist to allow more systematic verbalizations.

In the current study, we tested whether an actual externally imposed checklist could eliminate SOS effects of added nodules on detection of native abnormalities in chest radiography.

MATERIALS AND METHODS

Experimental Conditions

To test whether a checklist could alter the satisfaction of search effect, we used the same two conditions that were used in previous SOS demonstrations: presentation of each chest radiograph with and without a simulated pulmonary nodule. The detection accuracy for native, subtle lesions was compared with that for those same lesions when a simulated pulmonary nodule was added photographically to the radiograph. Thus the background anatomy and actual lesions were perfectly matched for the two conditions. Simulated and native lesions were not spatially superimposed, and the native abnormalities were physically identical with and without the nodules.

In this experiment, observers were asked to search and report abnormalities according to a checklist in both of these conditions.

Case Sample

This experiment was performed using 57 radiographic examinations of the chest that had been used in earlier SOS studies (1,3,5). Thirty cases had diverse, subtle, and clinically important native abnormalities; 27 had no native abnormalities. The examinations were presented in two conditions: once with and once without the simulated pulmonary nodule. As in other SOS experiments, the detection accuracy for native abnormalities was compared with that for those same abnormalities when a simulated pulmonary nodule was introduced.

The Checklist

Figure 1 shows the checklist used. The response form for each case differed only in the patient information provided. The checklist begins with "global Gestalt." Many who have theorized about visual search suggest that there is an initial phase of inspection in which the observer orients to the general nature of the image (6). Notice that the second item on the checklist is "lungs." Previous SOS experiments in chest radiology (2,7) suggest that, in the absence of clinical history, pulmonary nodules are found before nonpulmonary abnormalities. In addition, we did not want to preclude an SOS effect by directing search to the native abnormalities before the added nodules. There would seem to be little possibility of a second abnormality affecting detection on another abnormality that had already been found. Although many nodules seem to be found during global Gestalt anyway, a checklist order that places lungs after other regions would not give interpretable SOS results.

Most of the rest of the checklist categories and order was based on the most common patterns of search found in the verbalization experiment (5). Individual verbalizations about search seemed to demonstrate more consistent intrapersonal patterns than we might have expected from the literature. Although each observer had a unique order of search, most described a single detailed search pattern over and over across many examinations. This finding was consistent with those of others who have considered checklists. Gale and Worthington (8) reviewed radiologic textbooks for recommendations on how to search chest radiographs. All texts suggested that a search should consist of a series of independent searches of separate anatomic regions. Although the texts did not agree on a particular order to examine regions, they did seem to include the same regions. Their conclusion, that the particular order of search is less important than sticking to one fixed order, was confirmed in the results of a survey of viewing techniques conducted by Carmody et al (9). Because it is known that radiologists distribute their attention based on the probability distribution of abnormalities (10), some details of our checklist order reflect consideration of disease prevalence.

The native abnormalities of our sample included six abnormalities of the lungs, four abnormalities of the heart or great vessels; four abnormalities of the mediastinum or trachea; three abnormalities of the chest wall, ribs, or