Fostering Perceptual Skills in Medical Diagnosis

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Abstract. This paper presents a novel instructional approach for conveying perceptual aspects of clinical knowledge (perceptual skills) in diagnosing medical images. Although, the importance of perceptual skills for diagnosis from medical images has been shown in many expertise difference studies, medical education has hardly focused on conveying those skills, yet. We propose an approach based on theories for conveying cognitive skills: cognitive modeling and (cognitive) process-oriented worked examples. In both cases, an expert model externalizes her/his cognitive processes by verbalizations. We argue that diagnosing based on medical images is not only a cognitive, but also a perceptual task. Consequently, the expert model should additionally externalize her/his perceptual processes as eye movements (eye movement modeling examples). This approach is supported by a study in the example of medical diagnosis based on patient video cases.

Keywords: example-based learning; worked examples; cognitive modeling; medical education; eye tracking.

Theoretical Background

With progressing technical development visually complex and dynamic displays are increasingly in use for medical diagnosis. The task to diagnose based on medical images can be seen as a visually complex, knowledge-rich, and perceptual task. In particular, since research could show expertise differences on a perceptual level (e.g., Kundel, Nodine, Krupinski, & Mello-Thoms, 2008). Not only diagnosing based on artificial medical images, but also in real-life situations is difficult from a perceptual perspective. This includes so called patient videos cases, where patients are taped on video while displaying behavior that is suspected to be diseased. Medical students show severe difficulties when diagnosing based on those videos, in particular on a perceptual level (Balslev et al., in prep.).

To convey diagnostic skills medical education focused in its beginnings on the role of biomedical knowledge (i.e., knowledge of scientific facts: e.g., Feltovich & Barrows, 1984). Current research found that for stating correct diagnoses besides biomedical also clinical knowledge (actual experience with patients) is crucial (e.g., Boshuizen & Schmidt, 1992). One important aspect of clinical knowledge that medical education has hardly focused on, yet, are perceptual skills, like detecting and interpreting relevant features for diagnosis (e.g., Manning, Gale, & Krupinski, 2005). Diagnosis of diseases that manifest in occasionally occurring behavioral patterns, like seizures, is very difficult on a perceptual level: It is crucial to recognize the important features relevant for the diagnosis, which, however, might be short-term, subtle, time-sensitive, and not salient compared to other features. Thus, this paper aims at presenting an instructional approach to foster perceptual skills in medical diagnosis.

Conveying Perceptual Skills by Eye Movement Modeling Examples

Knowledge of experts is often directly or indirectly used to convey skills (Feldon, 2005). Two prominent methods for early skill acquisition are modeling (Bandura, 1977) and worked examples (Sweller, Van Merriënboer, & Paas, 1998). In learning from modeling a person learns by observing a model performing a task. For cognitive tasks, where not the action but not observable cognitive processes of the model are crucial, the model externalizes her/his processes by verbalization (cognitive modeling: Collins, Brown, & Newman, 1989). In learning from worked examples a person studies a written worked-out solution procedure of a problem. For cognitive tasks it is beneficial to present additionally an expert's verbal explanations why those steps were chosen (process-oriented worked examples: Van Gog, Paas, & Van Merriënboer, 2008). Some cognitive tasks, however, require the

inspection of visualizations. Those tasks are called perceptual tasks (Manning et al., 2005). For perceptual tasks, it may be concluded that the expert model should also externalize her/his perceptual processes. The best evidence of perceptual processes are eye movements. Thus, we propose eye movement modeling examples (EMME) as instructional approach. EMME are composed of the problem (i.e., the to-be-inspected visualization), the externalizations of cognitive (i.e., verbal explanations) and perceptual processes (i.e., eye movements) of the expert model.

The question is how to present eye movements to learners. Eye movements can be presented either by displaying them as additional information or by manipulating existing information. Presenting eye movements as additional information has shown to decrease learning (Van Gog, Jarodzka, Scheiter, Gerjets, & Paas, 2009). It is unclear, however, whether this display did guide the attention of the learners or rather disturbed it. Presenting eye movements as a manipulation of existing information, i.e., by blurring non-attended areas, has shown to guide attention (Barth, Dorr, Böhme, Gegenfurtner, & Martinetz, 2006). It is unclear, however, whether this might also influence learning. In a prior study on instructional design we showed that in a locomotion classification task perceptual skills could be conveyed by means of EMME (Jarodzka, Van Gog, Dorr, Scheiter, & Gerjets, in prep.). In particular, both display types have shown to guide the learners' attention. While manipulating existing information fostered learning to detect the relevant areas, displaying additional information fostered learning to interpret those areas. In general, EMME seems to foster perceptual skills. How to present the perceptual processes of the expert model, however, remains unsolved. Since, patient video cases are similar to locomotion videos on a surface level (realistic, dynamic scenes) and both require similar perceptual skills (detecting relevant areas and interpreting them) it is very likely that the EMME approach is useful for medical education in this area.

Empirical Verification of the EMME Approach

The here presented study applied EMME to medical education in the example of pediatric neurology (epileptic seizures). In that, the crucial perceptual skills are to visually detect the relevant features of the infant patient from other random behavior and to interpret it correctly based on patient video cases (PVC). We recorded a didactically behaving expert pediatrician's eye movements and verbal explanations while he was diagnosing two patients taped on video.

Method

60 medical students saw either PVCs with verbal explanations only (control condition), PVCs with verbal explanations and an additional display of the expert's eye movements as a circle (circle condition), or PVCs with verbal explanations and additionally areas the expert did not attend to blurred (spotlight condition). While studying those PVCs students' eye movements were recorded. Next, students watched three novel PVCs without EMME while their eye movements were recorded. After each case they had to interpret the behavior of the patient based on a multiple-choice questionnaire.

Results

Results show that the spotlight display guides the attention of the medical students during example study significantly stronger compared to the other two conditions ($F(2,59)=3.60$, $p=.03$). Moreover, when studying the novel patient videos cases, medical students of the spotlight condition looked longer on areas relevant for diagnosis ($F(2,59)=3.64$, $p=0.3$) and they interpreted those areas more correctly ($F(2,59)=7.41$, $p<.01$) compared to the other two condition.

Discussion

These findings show that guiding students' attention during studying modeling examples based on an expert's attention allocation may foster learning of perceptual aspects of clinical knowledge in the example of patient video cases of epileptic seizures if implemented in a spotlight manner. These results show the need to take perceptual skills into account, when considering education of medical diagnosis based on medical images. Moreover, the EMME approach seems to be a reasonable way to address this need. The question is, whether it may also be used for other medical images. So far, we have only considered dynamic, realistic scenes (i.e., videos). However, there is a large body of novel medical images that are very likely to present medical students with problems in terms of perceptual skills. Those medical images are often artificial animations or a combination of static pictures. Further research should investigate, which features of medical images are problematic for students on a perceptual level and whether EMME might foster the necessary perceptual skills.

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