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Learning to See Like an Expert: On Professional Vision and Visual Practices

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Abstract

Goodwin's notion of professional vision suggests that learning to see in professionally relevant ways includes appropriating the visual practices within a domain. This observational study aimed to analyze how experts communicate these visual practices to novices to help them make meaning of domain-specific representations. Informed by a sociocultural perspective and founded on conversation analysis and ethnomethodology, video-recorded discourse and interaction between one expert in radiology and four laypeople were analyzed. The findings indicate three visual practices the medical expert uses to teach the novices how to see: highlighting, rotating, and zooming. The qualitative analyses suggest that learning to see professionally can be described as the mastering of expert practices in a focal domain. Implications for visual expertise research are discussed.

Keywords: professional vision; expertise; learning; radiology; ethnomethodology.

Learning to See Like an Expert: On Professional Vision and Visual Practices

1. Introduction

Many professions interpret images as part of their daily work. For example, radiologists interpret X-ray scans of the human body and communicate findings to the ordering physician as a resource for diagnosis (Patel, Kaufman, & Kannampallil, in press). Meteorologists interpret satellite images to observe, monitor, and predict weather activity and features of the earth's atmosphere (Hoffman, LaDue, Mogil, Roebber, & Trafton, 2017). And air traffic controllers monitor radar scans of airspace to organize the safe flow of air traffic (Durso, Dattel, & Pop, 2018). All these domains rely on visual material as inputs to decision-making and control of activities. To become proficient in such a domain requires learning how to work with the domain's visual material. The present study analyzes this learning process in the domain of radiology.

1.1. Professional Vision

Analysis of how an understanding of visual material develops is contingent on the epistemological perspective researchers use in their conceptualization of vision (Gegenfurtner & Van Merriënboer, 2017). What does it mean to see? Visual perception can be understood as neural activation in the visual cortex caused by external stimuli; as focusing of the eye's cornea and lens; as signals in the optic nerves; as the formation of mental models in working memory, et cetera. Such physiological accounts of seeing conceptualize vision in terms of an individual activity that is accomplished through the processing of sensory input inside the mind (Brunyé, Drew, Weaver, & Elmore, 2019; Gegenfurtner, Kok, Van Geel, De Bruin, & Sorger, 2017; Seidel & Stürmer, 2014). An alternative account considers seeing as a social activity that is accomplished through the

deployment of discursive practices inside a community of professionals. Understanding seeing as a situated and contested set of practices is associated with the work of Charles Goodwin (1994), who coined the term "professional vision" to afford analyses of how seeing is interpersonally, materially, and epistemically mediated by tools, people, and discourse in socially organized visual practices that are lodged within particular (professional) communities (Goodwin, 2017).

Over the years, professional vision has been studied in a range of settings, including archeological field excavations (Goodwin, 1994, 2000), oceanographic research vessels (Goodwin, 2017), geochemical laboratories (Goodwin, 1997), courts of law (Goodwin, 1994, 2000), optics labs in schools (Lindwall & Lymer, 2008), neuroscience laboratories (Alac, 2008), forensic laboratories (Mustonen & Hakkarainen, 2015), ship simulators (Hontvedt, 2015), classrooms (Seidel & Stürmer, 2014; Stürmer , Seidel, & Holzberger, 2016), sports arenas (Gegenfurtner & Szulewski, 2016), as well as critique sessions in architecture (Ivarsson, 2010; Lymer, 2009). Moreover, professional vision has been studied in different medical disciplines, including dentistry (Hindmarsh, Reynolds, & Dunne, 2011), emergency medicine (Szulewski, Braund, Egan, Gegenfurtner, Hall, Howes, Dagnone, & Van Merriënboer, in press; White, Braund, Howes, Egan, Gegenfurtner, Van Merriënboer, & Szulewski, 2018), endodontics (Lindwall & Lymer, 2014), gynecology (Nishizaka, 2013), laparoscopic surgery (Bezemer, Murtagh, & Cope, 2019; Koschmann, LeBaron, Goodwin, & Feltovich, 2011; Zemel & Koschmann, 2014), neurology (Styhre, 2010), pathology (Nivala, Rystedt, Säljö, Kronqvist, & Lehtinen, 2012), primary care (Stivers & Heritage, 2001), and radiology (Lymer, Ivarsson, Rystedt, Johnson, Asplund, & Båth, 2014; Rystedt, Ivarsson, Asplund, Johnsson, & Båth, 2011). If we limit our research agenda to study how seeing is socially organized and accomplished through discourse, then

our units of analysis are the visual practices used and lived within a particular domain under scrutiny (Goodwin, 2017; Lehtinen, 2012; Säljö, 2019).

1.2. Visual Practices

We define visual practices as acts of meaning making that are considered relevant for the discourse in a particular community of professionals. Visual practices are thus constitutive for the practical work of a domain. Newcomers, novices, laypeople, apprentices, or students, who wish to gain understanding of the domain's work, must learn and appropriate these practices (Koschmann & Zemel, 2011) to understand the mediated activities that are "central to the social and cognitive organization of a profession" (Goodwin, 1994, p. 626). For example, in the work of archeologists, Goodwin (1994) identified that the visual practices of coding, highlighting, and producing material representations were central to the activity of analyzing post molds. More specifically, an expert archeologist and her student interacted in learning how to use a coding scheme to classify the color of soil (the coding practice); how to make a post mold perceptually salient against an amorphous background (the highlighting practice); and how to make a profile map of the site they excavate (the practice of producing material representations). This set of visual practices is not universal, but context-bound; different visual practices are produced, used, and actualized in different activities of a focal domain. From this perspective, visual practices are embedded in discourse in which meaning making (Ivarsson, 2017; Mäkitalo & Säljö, 2001; Mondada, 2016) unfolds in sequences (Schegloff, 2007) of coordinated talk-in-interaction (Säljö, 1997; Mercer, 1995), gestures (Koschmann, LeBaron, Goodwin, Zemel, & Dunnington, 2007; McNeal, Levy, & Duncan, 2015), and spatial arrangements of bodies (Keating, 2015) and material artifacts (Goodwin, 2010; Säljö, 2019). Such a sociocultural analysis of the mind, unlike the previously described analyses relying on physiological

data (Gegenfurtner & Van Merriënboer, 2017), affords an examination of learning, seeing, and expertise as mediated social action (Ivarsson & Säljö, 2005). Because visual practices are lodged endogenously within particular communities of practice, members of these communities face "the task of building new members who can be trusted to see, understand and act upon the world in relevant ways" (Goodwin, 2013, p. 9) through modeled tool use (Goodwin, 2010) and contingent scaffolding (Van de Pol & Elbers, 2013).

The present study was concerned with analyzing the process of conveying the visual practices of chest X-ray diagnosis as they unfolded in sequences of talk-in-interaction, gestures, and spatial arrangements of bodies and material artifacts between an expert radiologist and a small group of laypeople. Laypeople are defined as people without specialized or professional knowledge in a domain (Bromme & Jucks, 2018). While research on professional vision typically analyzes the discourse of an expert interacting with apprentices or students, the present study focuses on laypeople to illuminate the discursive practices in expert-laypeople communication in the context of diagnosing radiographs. A particular focus was on how the expert communicated the visual practices of radiology to help and scaffold the laypeople to make meaning of the pictorial X-ray representations of the human anatomy (Bromme & Jucks, 2018). An implicit assumption was that appropriating the visual practices modeled by the expert radiologist would be mediated by discourse and, ultimately, shape the novices' understandings of the visual data that are constitutive to the diagnostic work in radiology.

2. Materials and Methods

2.1. Setting and Participants

The study was situated in the radiology department of a large university hospital in Finland. Participants in this study were team members of an international, interdisciplinary

research project. The project focused on learning and medical imaging and included researchers from the faculties of education and medicine. Because the educational researchers were newcomers to the domain of medicine, a meeting was organized in which a medical expert introduced the domain or, more precisely, how to produce diagnoses with chest x-ray pictures. The material analyzed in this study was collected in that meeting. The expert (Oliver) was one of the directors of the radiology department. He teaches undergraduate and graduate students on a regular basis. The laypeople were four educational researchers, one female (Alma) and three male (Ben, Carl, Dan), all novice and inexperienced in medical diagnosis and untrained in the language and practices of diagnostic radiology.

2.2. Data Collection

The meeting was videotaped. In the meeting, the medical expert took the role of a teacher and gave a lecture to demonstrate to the laypeople what kind of visual practices he typically uses for diagnosing if chest x-ray pictures of the lungs show pathologically normal lungs (a healthy patient) or if the patient suffers from pneumothorax. A pneumothorax is a potential medical emergency wherein air or gas is present in the pleural cavity; this can result in collapsed lungs, which can cause death of the patient. One indication of pneumothorax visible on x-rays is an extremely thin white line, called the pleural line. A second indication of pneumothorax is that rib spaces are collapsed. The visual practices the expert used in the lecture aimed to scaffold the newcomers into "seeing" the pleural line and the collapsed rib spaces on the chest x-rays to decide if pneumothorax was present or not.

The videotaped material captured a total of 1:02:28 hr of discourse between the expert, the novices, and their mutual interactions with the chest x-ray pictures. Figure 1

shows the time sequence of the lecture. The expert started with an introduction in which he explained relevant aspects of human anatomy, terminology, and the etiology of pneumothorax (until minute 07:44). He then continued with a number of x-ray films that he had selected a priori for the meeting and pinned on a lightbox; a lightbox is a plane panel mounted on the wall that has a translucent surface illuminated from behind to show x-ray films with high contrast. The x-ray films used in the lecture were from different patients. The expert used these pictures as example cases and training cases (minutes 07:44 to 45:33). There were a total of five example cases and five training cases, as shown in Figure 1. In the example cases, the expert modeled and verbally explained the diagnosis of a patient. In the training cases, the novices were asked to make a diagnosis of a new patient themselves, guided and supported by the expert. The lecture ended with a summary, discussion, and reflection of the meeting (minutes 45:33 to 1:02:28). During the lecture, all participants used English as a second language; the participants' native languages were Finnish, German, and Swedish. Because all participants knew each other from previous project meetings, the dialogue during the lecture could be described as familiar and informal. Participants consented to the recording and its anonymized analysis for research purposes.

(Add Figure 1 here)

2.3. Data Analysis

Taking an analytical stance inspired by a sociocultural perspective and founded on conversation analysis and ethnomethodology, the video recordings were examined to identify episodes in which visual practices were used. The selection of episodes was guided by an interest in making visible how the expert and the laypeople interacted with

each other and with the chest x-rays in order to learn “to see what there was to see”. Of course, an hour of videotaped instruction includes a rich variety of episodes that can be analyzed under a rich variety of theoretical umbrellas. For example, the videotaping includes situations that can be readily analyzed as instances of example-based learning, cognitive apprenticeship, conceptual change, classroom management, transfer of learning, peer collaboration, clinical reasoning, and the list continues. The rationale that guided the selecting of episodes in the present study was strongly driven by our interest in Goodwin’s (1994) notion of professional vision. The analysis aimed to reconstruct what kind of visual practices the expert uses, how the expert interacts with the laypeople, how the expert interacts with the imaging material, how the laypeople interact with the material, how the communication and interaction sequentially unfolds, and, ultimately, how the chest x-ray films mediate the unfolding communication and interaction. With this analytic attention, the research team identified three episodes for deeper analysis because they showed key instances of professional vision in radiology and how the novices (aimed to) appropriate these expert visual practices. Talk was transcribed verbatim. Table 1 presents the notation system used for transcription (Schegloff, 2007).

(Add Table 1 here)

3. Results

3.1. Zooming and Highlighting

The analyses start with an excerpt taken from the first training case. Up to that point, Oliver, the expert, has already introduced what pneumothorax is and how it represents itself on X-ray films. Moreover, Oliver has already introduced and modeled three visual practices he typically uses when producing diagnoses from X-ray films. Standing next to

and in front of the lightbox, he modeled these practices for the laypeople who sat in chairs arranged in a semi-circle in front of the lightbox, facing Oliver. For the first training case, Oliver pins a new patient case on the lightbox and asks Alma, Ben, Carl, and Dan to rise from their seats. The novices face their training case, but hesitate and stand a few meters away from the lightbox.

Excerpt 1:1

01	Oliver	so (.) do you find the white line? (0.6) or not. (1.4) you have to go closer.
02	Ben	*((approaches the lightbox))*
03	Oliver	you have to enla:rge [the image [(0.3) you have to focus right. now. (.)
04	Dan	[*((approaches the lightbox))*
05	Alma, Carl	[*((approach the lightbox))*
06	Oliver	otherwise you cannot¿ see the belt

Oliver invites the novices to approach the lightbox and to overcome the empty space created between the chairs and the lightbox on the wall, which represents an attempt to dissolve the particular coordinates of bodies and chairs that are constitutive of a typical sociocultural organization of teacher-student situations in schools (Keating, 2015). Oliver frames this invitation to move from the periphery to the center as a first visual practice: zooming. It is timely to consider here that a pneumothorax can be diagnosed when an extremely thin white line, the pleural line, is found and detected on the X-ray picture. Naturally, X-ray pictures display a variety of white, grey, and black lines as graphical representations of anatomical features, so it is a complex visual problem to distinguish a single thin white line among the plurality of other, distracting structures visible on the image. As a first step, therefore, Oliver invites the novices to "enla:rge the image" as a means to improve the likelihood that the pleural line is identified. He asks Alma, Ben, Carl, and Dan to zoom in. Zooming gestures are frequently used nowadays with digital

devices, such as smartphones or tablets, to magnify what is hard to see on the display. The material affordance here is that of a non-digital photography that cannot be zoomed or clicked to magnify image portions: it remains fixed. Therefore, the newcomers use their bodies to zoom in. Ben is the first one to follow Oliver's request that they "have to go closer" to the lightbox. Dan approaches the image at Oliver's second request, then Carl and Alma follow. At the end of this sequence, they all stand in front of the X-ray, gazing on the structures at a distance of approximately 30 cm. No one but Oliver has yet spoken in this first training case.

Excerpt 1:2

01	Oliver	so (.) do you find the white line? (0.6) or not. (1.4) you have to go closer.
02	Ben	*((approaches the lightbox))*
03	Oliver	you have to enla:rge [the image [(0.3) you have to focus right. now. (.)
04	Dan	[*((approaches the lightbox))*
05	Carl, Alma	[*((approach the lightbox))*
06	Oliver	otherwise you cannot¿ see the belt
07		(11.2)
08	Oliver	°it's not ea:sy. (3.2) [this time.° (1.2) it's (.) o:ne example (.) is
09	Ben	[°m::°
10	Oliver	*((points with a stick on the image))*
11		you cannot see it from here¿ (1.3)
12		*((highlights the pleural line on the image))*
13		but the pleural line is clea::rly clea::rly °se[en.°

A relatively long pause of 11.2 seconds follows as the laypeople gaze at the X-ray picture. Oliver shifts his gaze between the laypeople and the lightbox. He ends the silence, guessing that what is obvious for him is difficult to see for Alma, Ben, Carl, and Dan. He confirms empathically in a silent voice that "°it's not ea:sy. this time.°" Ben is the first to

produce an utterance, a silent but confirming "°m::°", indicating the difficulty of discriminating the pleural line among the plethora of visible structures in white, grey, and black. As a contingent reaction, Oliver increases the level of scaffolding (Van de Pol & Elbers, 2013) and uses a second visual practice: highlighting. Taking a wooden stick, he points at the picture and traces it along the pleural line. With this highlighting gesture, mediated by the wooden stick, he does what Goodwin (1994, p. 610) describes as a method "used to divide a domain of scrutiny into a figure and a ground, so that events relevant to the activity of the moment stand out" in a dense perceptual field "(…) so that those parts of it which contain information relevant to their own work are made salient." Indeed, salient but redundant features of the image are deemphasized, even though they may stand out because of sheer size or brightness (line 11: "you cannot see it from here¿)", while portions of the X-ray that are diagnostically interesting but smaller and of lesser contrast are highlighted through a simple gesture that helps structure the visual field into what is relevant and what can be perceptually ignored (line 13: "but the pleural line is clea::rly clea::rly °seen.°"). By highlighting a visually salient but redundant line and immediately following the harder-to-see pleural line in its vicinity, Oliver creates a "field of meaningful opposition" (McNeil et al., 2015). The highlighting gesture here is an integral component of Oliver's speech: it carries discourse information and points to clinical content on the picture.

Excerpt 1:3

12	Oliver	*((highlights the pleural line on the image))*
13		but the pleural line is clea::rly clea::rly °se[en.°
14	Alma	[a:::h. (.) a:h.
15	Ben	[*((points with the little =*
16		*= finger of the right hand along the pleural line))*

17		[here is here [it's there it is.
18	Carl	[m¿ (.) okay (1.3)
19	Oliver	it's a big on[e.
20	Ben	[°yes° (.) h?
21	Alma	[yeah. [jap.
22	Dan	[°m::° h

What results from the practices of zooming and highlighting is, eventually, the seeing of the pleural line. Although the pleural line was of course see-able from the outset of this training case, it became an object of scrutiny that stood out once it was highlighted as a figure against a diagnostically irrelevant background noise. Alma and Ben are the first to utter their understanding with an elongated "a::::h. (.) a:h." and a "here is here it's there it is." As shown in Figure 2, Ben mirrors Oliver's highlighting gesture and follows the pleural line with the little finger of his right hand. Through their highlighting, Oliver and Ben discursively shape from the anatomical information provided by the X-ray film the phenomenal object that is the concern of the radiologic profession when diagnosing pneumothorax patients. And what was first invisible is now "a big one." that strongly gained in visibility.

(Add Figure 2 here)

Excerpt 1:4

23	Oliver	now you can (1.1) see it easily (.) when you go back¿ (0.4) you can =
24		= see it very ve:ry easily.
25	Ben	*((goes back))*
26		ya h¿ (0.6) yes (.) it's a very[=
27		[*((shakes his right hand))*

28		= it's a clear shift once you see it. °and°
29	Oliver	*((highlights a different structure with the stick))*
30		it's not¿ visible the::[re¿ (0.9)
31	Alma	[ya:h (.) °ya (.)[ya°
32	Oliver	[*((highlights the pleural line))*
33		[but it's very easily seen. it comes =
34		= a longlong [way. (1.2)
35	Ben	[*((approaches the lightbox))*
36	Alma	yes? (.)[it's a long°long line°
37	Ben	[*((points with finger along the pleural line))*

In spotting and tracing the pleural line with eyes and fingers, the visual practices helped make the pleural line prominent and discernible among all other represented structures (line 28: "it's a clear shift once you see it."). This former thin white line became a pleural line, a phenomenal object that stayed visible even after Oliver invited the laypeople to "zoom out" again (lines 23-24: "when you go back¿ you can see it very ve:ry easily."). For Alma, Ben, Carl, and Dan, the X-ray structures and also the space in front of the lightbox became a socially organized perceptual framework; they gained access to the epistemic categories (Mäkitalo & Säljö, 2001) and resources shared within the community of radiologists. Oliver has focused and directed the newcomers' attention. He structured the visual field into the diagnostically relevant, but formerly invisible pleural line (line 36: "it's a long°long line°") and an amorphous background containing irrelevant diagnostic information. This structuring was accomplished through coordinated talk, gesturing, and bodily movements.

3.2. Rotating

In the second training case, Oliver starts the episode with another visual practice to convey professional vision: rotating. By turning the X-ray film upside down, the image structures lose their anatomical references because we are not accustomed to see lungs or a rib cage in an inverted position. This spatial reconfiguration achieved through flipping and rotating the image may help reduce the X-ray film to its basic features of white, grey, and black structures. The position of the laypeople in the room has slightly changed between the first and second training case: Alma stands very close to the lightbox, Oliver is next to the lightbox, and Ben, Carl, and Dan observe the scene from a little distance, waiting for the next patient case.

Excerpt 2:1

38	Oliver	this is ca:rl's¿ patient. (1.5) sick¿ or not¿ (3.6)
39	Carl	*((approaches the image))*
40	Oliver	you can turn¿ the image upside do[wn.
41	Ben	[°m:: this [is°
42		[*((approaches the image, reaches =*
43		*= his right arm out toward the image))*
44	Alma	[m yeah let's turn¿ it =
45		= upside down.
46	Oliver	*((rotates the x-ray film on the lightbox by 180 degrees))* (3.1)

Oliver explicitly invites Carl to diagnose the patient and almost excludes Alma, Ben, and Dan from participation when he says "this is ca:rl's¿ patient.". In the first training case, both Carl and Dan had not been as vividly engaged in the diagnostic process as Ben and Alma. Inviting Carl now to give the first diagnostic hint can be seen as an attempt of activating one of the formerly passive novices. As a response, and 5.7 seconds after Oliver's invitation, Carl approaches the image and positions himself on the right side next

to Alma, facing the X-ray picture pinned on the lightbox. Instead of waiting for Carl's diagnosis, Oliver offers help in the form of a visual practice (line 40: "you can turn¿ the image upside down."), which is welcomed by Alma (lines 44 and 45: "m yeah let's turn¿ it upside down.") and finally executed by Oliver. In teaching situations, in which Oliver finds himself at the moment, drawing out from students the information teachers seek is often described as a "cued elicitation" (Mercer, 1995). In this case, Oliver's cued elicitation includes a first verbal hint (line 38: "sick¿ or not¿") and, after a short break in which Oliver does not wait for Carl's answer, a second verbal proposal to turn the image upside down, which, in this case, offers strong visual clues for enlarged rib spaces. Before this sequence, Ben approaches the image in an attempt to highlight what he seems to have seen (line 41: "°m:: this is°"), but Alma and Carl, who stand almost shoulder on shoulder in front of the image, block his way to the light box. Ben reaches out his right arm between Alma and Carl to get access to the picture, but withdraws the arm as Oliver starts to rotate the X-ray film.

Excerpt 2:2

46	Oliver	*((rotates the x-ray film on the lightbox by 180 degrees))* (3.1)
47	Dan	[*((approaches the image))*
48	Oliver	[so::: (0.3) the::re i:s a (.) pneumo(.)thorax [(.) h present on the =
49	Dan	[*((goes back again))*
50	Oliver	= right side? (0.4)
51		*((highlights the pleural line, then rotates the image back into its =*
52		*= original position))*
53		a::nd (.) is that a pencil or not.
54		(7.9)
55		°high [pressure low pressure.° [(3.8)
56	Dan	[*((approaches the image))*

57	Oliver	[*((goes away from the image))*

At the beginning of the second training case, Ben, Carl, and Dan stood at a distance from the lightbox. Carl and Ben have already approached the X-ray film and after Oliver rotates the image, also Dan comes closer with his gaze toward the picture. Oliver then produces the right diagnosis ("so::: the::re i:s a pneumothorax h present on the right side?"), highlights the pleural line with his finger as a visual proof for the diagnosis, and then rotates the picture back into its original position. He refers to the pleural line as a "pencil" (line 53). In the first training case, he labeled the pleural line as "the white line" (line 01) and "the belt" (line 06). Oliver articulates the correct medical term "pleural line" (e.g., on line 13), but more often than not he uses vernacular terms or quite simply refers to the pleural line as "it". Symptomatic for the choice of words is a perceived asymmetry of clinical knowledge between the expert and the laypeople. The X-ray film here intersects between different epistemic resources and participation frameworks: while its cultural embeddedness is typically associated with the institutional spheres of radiology, the X-ray films now transfuse and traverse the boundaries of radiology labs and are presented to members of another expert culture who do not share the same language repertoires for producing meaning from the image.

Excerpt 2:3

58	Oliver	you kno:w¿ all the too:ls¿ (0.7)
59	Dan	i would say low (2.8)
60	Oliver	ya:. [h °low.°
61	Carl	[yes (0.4)
62	Oliver	°definitely° (0.6)
63		*((approaches the image, moves his index finger along the rip spaces))*
64		rip spaces are collapsed (2.5) the mediastinum is not so easy to see: =

65		= he:re¿ (.) but [this °volume is definitely low° (0.3)
66		[*((moves his right palm clockwise across the image))*
67	Ben	°ya:h° (.)
68	Oliver	and if you [go lo:nger [and lo::nger[(1.1) away¿ (0.9)
69		[*((goes away from the image))*
70	Ben, Dan	[*((go away from the image))*
71	Carl	[*((goes away from the image))*
72	Oliver	the better we will see that °the rip spaces are collapsed.°

After a long pause of 7.9 seconds and repeated attempts of cued elicitation (Mercer, 1995), Dan produces the right diagnosis on line 59 ("i would say low"), which is confirmed both by Oliver (lines 60 and 62: "ya:. h °low. definitely°" and line 65: "this °volume is definitely low°") and by Carl (line 61: "yes"). This loudly spoken "yes" is the only utterance of Carl in what was declared by Oliver at the outset of the second training case to be "Carl's patient" (line 38). Oliver then highlights the collapsed rib spaces with his index finger (line 63) and models again the zooming practice. The zooming-out movement—going farther and farther away from the wall— is initiated by Oliver, picked up first by Ben and Dan, and then copied by Carl. Alma continues standing in front of the lightbox, gazing at the X-ray picture. Figure 3 shows the talk and movement in space.

(Add Figure 3 here)

Throughout the second training case, much bodily movement can be observed. While in the beginning Ben, Carl, and Dan stand in the background, they approach the lightbox in different intervals and zoom-in. Dan is the first to zoom-out again (line 49), but soon after he re-approaches the image from a different angle (line 56). Then Oliver goes away from the image (line 57), returns (line 63), and distances himself again from the

lightbox (line 69). This final zooming-out movement initiates parallel trajectories from all male newcomers (lines 70 and 71). Alma is a stable fix point, anchoring in front of the lightbox and fixating the X-ray film. These movements are locally and socially organized in what Goodwin referred to as a "hybrid space" and "embodied framework of mutual orientation" (2010): the participants move seamlessly between other actors and the material objects on the lightbox to spatially zoom in and out of particular regions of the image. The spatial orientation and bodily reconfiguration here contribute to an embodied interpretation (Steier et al., 2015) and to the social order and arrangement of events that are constitutive of professional vision in this case.

3.3. Negotiating Color Categories

In the fourth training case, Oliver pins another X-ray patient case on the lightbox and then retreats, stands about 1.5m on the right side of the lightbox, and gazes at both the picture and the novices. Alma and Ben stand in front of the lightbox, with their gazes directed at the X-ray film. Carl stands about 1m behind Ben's right shoulder, fixating on the picture. Dan stands about 2m behind Alma and Ben and looks from between them on the new X-ray film.

Excerpt 3

73	Oliver	pneu¿mothorax or not?
74		(9.4)
75	Carl	*((approaches the image and highlights the pleural line with his left =*
76		*= index finger))*
77		m: (.) about he:[re?
78	Ben	[°ya (.) yah° (4.0)
79		[*((parallels Carl's movement with his right little finger))*
80	Alma	so¿ maybe on (0.7) ei:[ther si:[de¿ (1.2) the [white.

81		[*((moves her right index finger over the image))*
82	Oliver	[*((approaches the image))*
83		[no::¿ (1.2)
84	Carl	[°m: (.) m°
85	Oliver	no. (.) [can you see it <u>the</u>re? (0.4) what carl¿ pointed out¿ (0.3)
86		[*((highlights the pleural line))*
87	Alma	*((moves her index finger over the image))*
88	Oliver	black lines are <u>not</u>¿ accepted <u>white</u>¿ lines are accepted. (0.4)
89		*((highlights the pleural line))*
90		<u>tha:</u>t's¿ (.) whi:te¿
91	Ben	°mh yeah and that is black° (0.2)
92		*((highlights a structure next to the pleural line with his index finger))*
93	Oliver	<u>black</u>. (.) ya [°ya° (.)
94	Carl	[m (.) m
95	Alma	[*((highlights with a pen in her right hand the same structure as Ben))*
96		[that's? <u>black</u>¿
97	Ben	yes it's a °black [li:ne°.
98		[*((highlights the structure again))*
99	Alma	[and that has to be <u>whi[te (0.6)</u>
100	Oliver	[yes.
101	Alma	[*((highlights the pleural line with a pen in her right hand))*
102		[°and° the <u>white</u> is over he:re. (0.3)
103	Oliver	°ya:h [ya° (.)
104	Ben	[it's very clear

Oliver starts the sequence with the question "<u>pneu</u>¿mothorax or not?" (line 73). Carl approaches the picture, zooms in, and then highlights the pleural line with his left index finger ("m: (.) about <u>he</u>:<u>re</u>?"). Ben, gazing on the picture, confirms Carl's detection and uses the same highlighting practice to trace the pleural line ("°ya yah°"). The practice of

highlighting here serves a dual function: first, it is used to test a hypothesis in a questioning utterance and, second, it is used to re-test and co-confirm what has been detected. Seeing is thus practically negotiated. In the remainder of this excerpt, negotiating activities continue with a specific focusing on color. X-ray films of a human chest abound with lines colored in different tones of white, grey, and black, representing lung tissue, muscle, or bone structures. Initial confusion about the meaning of different lines is thus unsurprising. Oliver corrects an attempt by Alma when he highlights the pleural line and refers to its white color (lines 85-90: "can you see it there? what carl¿ pointed out¿ black lines are not¿ accepted white¿ lines are accepted. tha:t's¿ whi:te¿"). The aim of Oliver's contingent support (Van de Pol & Elbers, 2013) is to indexically align the color category of white to the anatomical category of pleural line. Constituting a field of meaningful opposition (McNeil et al., 2015), Ben then immediately highlights a black line (line 91: "°mh yeah and that is black°"). Seeing black is confirmed by Ben (line 93: black. ya °ya°) and Carl (line 94: "m m"). Learning to distinguish what counts as black and what as white on the X-ray picture is finalized in Alma's utterances (lines 96-102: "that's? black¿" (…) "and that has to be white" (…) "°and° the white is over he:re."), indicating the social negotiation of black and white as co-constructed color categories. In his analysis of how the color "jet black" was established in the work of chemists, Goodwin (1997) notes that the "analysis of situated activity systems provides one way of investigating how cognitive phenomena, such as color categories, are constituted through the social deployment of a collection of diverse practices lodged within the lifeworld of a relevant community of practice" (p. 117). Säljö (2009) offers another example how color codes are categorized and made significant in human practices when he vividly remembers "the first time I learned the distinction between white and off-white. This distinction emerged for me as a living category when I went in to a shop to buy a sweater as a present. While pointing to a sweater and calling it

white, the shop assistant indirectly, and quite politely, corrected me by saying that this was the color of current fashion, which was off-white" (p. 205). The point here is that color categories are not universal and context-free; rather, they are artfully accomplished through the coordinated use of a set of systematic visual practices (Goodwin, 1997; Goodwin, 2017). In Säljö's words: "seeing is informed by a highly specialized knowledge system, and to see in this manner, one has to learn what there is to see" (Säljö, 2009, p. 205). The lived nature of colors is evidenced in the analyzed sequence when Alma, Ben, and Oliver negotiate, mediated through the repeated highlighting of lines on the X-ray film, what is radiologically seen as white and black.

4. Discussion

Goodwin's (1994) notion of professional vision suggests that seeing in a particular domain can be understood as being accountable to a set of specific professional practices that are developed, cultivated, and lived within the community of this domain. Learning to see thus includes learning these visual practices (Goodwin, 2017; Koschmann et al., 2011). Taking an analytical stance inspired by a sociocultural perspective and founded on conversation analysis and ethnomethodology, the present study explored the learning of visual practices in the domain of radiology. In analyses of the moment-by-moment unfolding of discourse around chest X-ray films, the study indicates how an expert communicates to a group of laypeople the way radiologists accomplish parts of their diagnostic work (Bromme & Jucks, 2018). Three practices emerged from the analyses: highlighting, zooming, and rotating. First, highlighting the pleural line on the X-ray film helped distinguish diagnostically relevant information from visually more salient, but diagnostically redundant structures. Second, zooming-in and zooming-out helped change the diagnostic perspective and shaped the social arrangement of the diagnostic space. Third, rotating the

X-ray picture afforded an atypical frame for inspecting human anatomy, which supported the identification of collapsed rib spaces as indicator for pneumothorax. The artful deployment of this set of visual practices, and their gradual appropriation by all newcomers, constituted the "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (Goodwin, 1994, p. 606), in this case: radiologists detecting symptoms of pneumothorax. It is possible, however, that results may have differed if the radiologist was teaching a group of novice medical students as opposed to laypeople used in the present study. This possibility can be explored in future research. Still, as Oliver stated in the beginning of the meeting, he typically uses these three visual practices when producing diagnoses from X-ray films.

The identification and re-making of these visual practices, together with their mediation through talk-in-interaction (Mercer, 1995), gestures (McNeil et al., 2015), and spatial arrangements of body (Steier et al., 2015) and artifacts (Goodwin, 2010), afforded an examination of learning, seeing, and expertise as mediated social action (Ivarsson, 2017). Analyzing the sequential unfolding of how the discursive work practices were appropriated in the present sample contributes to the growing body of research that delineates practice-based theorizing of learning (Nivala et al., 2012; Rystedt et al., 2011), instruction (Lindwall & Lymer, 2014; Zemel & Koschmann, 2014), and work (Damşa, Froehlich, & Gegenfurtner, 2017; Nishizaka, 2013; Alac, 2008) in medical disciplines and beyond. These empirical analyses of professional vision form a sociocultural alternative to studies that adopt a cognitive or physiologic stance on visual perception and expertise (Bertram, Helle, Kaakinen, & Svedström, 2013; Boshuizen & Van de Wiel, 2014; Brunyé et al., 2019; Gegenfurtner, Lehtinen, Jarodzka, & Säljö, 2017; Gruber & Harteis, 2018; Kok, De Bruin, Van Geel, Gegenfurtner, Heyligers, & Sorger, 2018; Seidel & Stürmer, 2014; Stürmer et al., 2016) in that they emphasize the socially mediated nature of seeing

and visual expertise. Interestingly, it seems as if the sociocultural analyses associated with the highlighting practice corresponded with the cognitive finding related to Haider and Frensch's (1996) information-reduction hypothesis: experts perceptually ignore task-irrelevant information and focus on task-relevant information (e.g., Gegenfurtner et al., 2017; Szulewski, Egan, Gegenfurtner, Howes, Dashi, McGraw, Hall, Dagnone, & Van Merriënboer, 2019), which can be modeled to novices and laypeople by highlighting what is diagnostically relevant and where diagnostically salient information is located amidst visually salient structures in medical visualizations.

The study has some limitations that should be noted. A first limitation relates to the data source. The case study was conducted in one particular context (a research team meeting in one particular university hospital). The results may not generalize to other university hospitals or to teaching contexts such as teaching undergraduate medical students. A second limitation concerns the sampling. Participants were laypeople inexperienced in radiologic diagnoses; this group of novices might have affected how the expert communicated and modeled visual practices, which could have been different or more elaborate had Oliver interacted with medical students who share clinical or biomedical knowledge. Finally, a third limitation relates to the analysis. Professional vision was studied here with close reference to Goodwin's (1994, 1997) original approach—using qualitatively oriented, socioculturally informed, and ethnomethodologically founded analyses. Still, the notion of professional vision has since progressed and a number of alternative, positivist, and cognitively oriented analyses of professional vision emerged—including eye tracking, brain imaging, and quantifications of verbal data (Gegenfurtner et al., 2017; Kok et al., 2018; Stürmer et al., 2016; Szulewski et al., 2019). Future research may wish to use mobile eye tracking, for example, to uncover if the pleural line—once zoomed on and highlighted—was indeed fixated.

Implications of the study for educational practice are associated with the visual practices modeled by the expert radiologist. These practices can be used in medical education to train students and help them develop the skills needed to diagnose radiographic representations of the human body. Another implication for educational practice relates to the technological aspect of X-ray films. As Nivala et al. (2012, p. 516) note: "Medical images are not neutral or perfectly accurate representations of biomedical phenomena. How these imperfections are communicated to the students may play a substantive role in how students learn to understand and interpret medical images." In medical education, students will need to understand how X-ray films are produced, what they depict, how they can be manipulated, and which kinds of visually salient but diagnostically irrelevant information X-ray films can contain. Finally, a third implication for educational practice relates to contingent scaffolding (Van de Pol et al., 2013). Visual practices can be repeated or decreased based on the development of novice (laypeople or student) understanding. This adaptation is reflected in how Oliver sometimes combined and repeated visual practices and how he sometimes used a single practice once. Modeling the visual practices of zooming, rotating, and highlighting can thus be considered as contingent scaffolds that seem useful to include when teaching and learning to see like an expert.

Professional vision is intrinsically bound to the kind of visual data produced in a domain. In medical disciplines, these visual data are indexically aligned to the technological tools by means of which they are produced, which render visible anatomical structures and functions through, for example, laparoscopic cameras (Koschmann et al., 2007), positron emission tomography (Gegenfurtner et al., 2017), ultrasound (Nishizaka, 2013), microscopes (Helle, Nivala, Kronqvist, Gegenfurtner, Björk, & Säljö, 2011), functional magnetic resonance images (Styhre, 2010), videos (Szulewski, Braund, Egan,

Hall, Dagnone, Gegenfurtner, & Van Merriënboer, 2018), or live broadcasts (Lindwall & Lymer, 2014). It is an interesting question to pursue how the visual practices in a domain change when the visual data and their underlying representational technologies change. Many technology-intensive professions face material changes (Gegenfurtner, Nivala, Lehtinen, & Säljö, 2009; Helle & Säljö, 2012; Lehtinen, Hakkarainen, & Palonen, 2014; Patel et al., in press), and medicine is no exception. More specifically, medical professionals are challenged to adapt their expert practices from radiography to tomosynthesis (Lymer et al., 2014; Rystedt et al., 2011), from traditional to virtual microscopes (Helle et al., 2011; Nivala et al., 2012), or from singular to fusion images (Gegenfurtner et al., 2017). It seems likely that in the coming years medicine and other professions will experience many more alterations of their established technological repertoires (Gegenfurtner et al., 2009; Helle & Säljö, 2012; Lehtinen et al., 2014; Säljö, 2019). Future ethnomethodologically inspired work can thus aim at adopting a comparative perspective in examining how visual practices unfold and prove effective in dynamically changing work settings. Such work may also help us understand the nature of scaffolding needed to appropriate expertise as experienced members of the community articulate what they consider relevant and irrelevant in rich, but for novices highly ambiguous, visual resources.

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Highlights

- This qualitative, observational video study analyzed professional vision
- A radiology expert modeled and explained visual practices to four laypeople
- The visual practices the expert used were *highlighting*, *rotating*, and *zooming*
- Analyses were founded on conversation analysis and ethnomethodology
- The findings contribute to practice-based theorizing on visual expertise

Figure Captions

Figure 1. Time sequence of the lecture.

Figure 2. Highlighting as a visual practice.

Figure 3. Zooming as a visual practice.

Table 1

Notation system used for transcription

Notation	Meaning
word	Underlined words or syllables are spoken with special emphasis.
°	Utterances enclosed by degree signs (°) indicate noticeably quieter sound.
:	Colons (:) mark prolongation of the sound preceding them, as in a:::h, with more colons indicating more extended sounds.
h	The letter h marks audible aspiration.
(1.2)	Numbers in single parentheses note the length of pauses in tenths of seconds, for example (1.2).
(.)	A period in single brackets (.) marks audible but not readily measurable micropauses—pauses of less than 0.1 seconds.
[	Left square brackets ([) on two successive lines indicate overlapping talk or action by different people; horizontal alignment in the second line marks the onset of the overlap.
=	An equal sign (=) at the end of a line as well as at the start of the next line indicates a single continuous utterance or action without pause from the same person.
.	A period (.) indicates a falling intonation contour, not the end of a sentence.
?	A question mark (?) indicates a rising contour, not necessarily a question.

¿	An inverted question mark (¿) indicates a rising intonation weaker than a question mark.
((action))	Double parentheses include descriptions of extralinguistic action, as in *((highlights the pleural line))*, with italicized letters to better contrast talk from action in the transcripts.
New line	A new line marks a new turn or action.