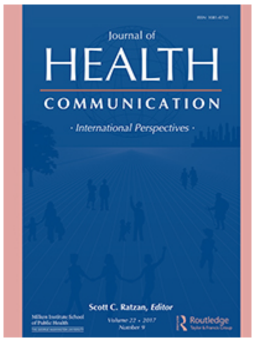

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Do Pattern-Focused Visuals Improve Skin Self-Examination Performance? Explicating the Visual Skill Acquisition Model

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Skin self-examination (SSE) consists of routinely checking the body for atypical moles that might be cancerous. Identifying atypical moles is a visual task; thus, SSE training materials utilize pattern-focused visuals to cultivate this skill. Despite widespread use, researchers have yet to explicate how pattern-focused visuals cultivate visual skill. Using eye tracking to capture the visual scanpaths of a sample of laypersons ($N = 92$), the current study employed a 2 (pattern: ABCDE vs. ugly duckling sign [UDS]) × 2 (presentation: photorealistic images vs. illustrations) factorial design to assess whether and how pattern-focused visuals can increase layperson accuracy in identifying atypical moles. Overall, illustrations resulted in greater sensitivity, while photos resulted in greater specificity. The UDS × photorealistic condition showed greatest specificity. For those in the photo condition with high self-efficacy, UDS increased specificity directly. For those in the photo condition with self-efficacy levels at the mean or lower, there was a conditional indirect effect such that these individuals spent a larger amount of their viewing time observing the atypical moles, and time on target was positively related to specificity. Illustrations provided significant gains in specificity for those with low-to-moderate self-efficacy by increasing total fixation time on the atypical moles. Findings suggest that maximizing visual processing efficiency could enhance existing SSE training techniques.

Melanoma incidence rates continue to rise in the United States (Siegel, Naishadham, & Jemal, 2012). As melanoma risk increases, health communication researchers and practitioners benefit from improving communication to at-risk individuals about prevention and early detection. For melanoma, prevention options include traditional sun safety tips (Chu, Atkinson, Hershfield, & Rosen, 2016), whereas secondary prevention and early detection efforts emphasize teaching individuals to identify atypical moles via skin self-examination (SSE; Goodson & Grossman, 2009). People need proficiency in three behaviors/skills related to SSE to contribute to skin cancer control efforts: (1) completing a *thorough* SSE of their entire body, (2), recognizing and identifying potentially atypical moles while performing SSE, and (3) bringing atypical or suspicious moles to the attention of their primary care provider or dermatologist.

The current study investigates how to enhance people's ability to identify atypical moles.[1] At present, practitioners utilize pattern-focused visual training methods (e.g., ABCDE and ugly duckling sign (UDS)) to teach SSE. Yet, whether and how pattern-focused visuals cultivate skill remains undefined. To address this gap, we explicate the visual skill acquisition model (VSAM), which postulates that eye movements and patterns connect visual messages to visual skills. We then test VSAM via an eye tracking experiment that examines whether pattern-focused visuals enhance mole identification skill.

The Use of Visual Communication in Skin Cancer Control Efforts

Research on skin cancer prevention and detection emphasizes aspects of visual communication more than most other cancer types (see King, 2015; McWhirter & Hoffman-Goetz, 2014). Given increasing incidence rates of melanoma (Rigel, Russak, & Friedman, 2010), improving the design of skin cancer messages offers one outlet to improve early detection. Early detection promotion requires successful communication of SSE behaviors and visual identification skills.

Skin Self-Examination

Visual Pattern (ABCDE vs. UDS)

SSEs ideally lead to clinical examination (see Goodson & Grossman, 2009); though people rarely engage in SSE, and accuracy

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uhcm.

[1]Clinically, *nevus* or *lesion* would be preferred terms. However, *moles* will be used throughout the article.

gains from SSE training are inconsistent (Hamidi, Peng, & Cockburn, 2010). Given these limitations, the U.S. Preventive Services Task Force (2009) labeled SSE a stopgap measure that needs to be improved or replaced. Currently, SSE training materials seek to improve laypeople's ability via what we call *pattern-focused visuals*. Pattern-focused visuals are images that depict characteristic style, model, or form of some object. For SSE, two pattern-focused visual approaches are common: ABCDE and UDS. For the ABCDE technique—where individuals are encouraged to look for (a)symmetry, (b)order irregularity, (c)olors (more than three), (d)iameter greater than 6 mm, and (e)volving features over time—visuals often include an example of each ABCDE feature or form (Robinson & Ortiz, 2009). Alternatively, UDS encourages people to become familiar with their moles and to look for those that seem dissimilar from others (see Grob & Bonerandi, 1998). Studies typically test the ABCDE method (Coups, Manne, Stapleton, Tatum, & Goydos, 2016; McWhirter & Hoffman-Goetz, 2013; Robinson & Turrisi, 2006), while fewer studies test the utility of UDS (King, Carcioppolo, Grossman, John, & Jensen, 2015; Suh & Bolognia, 2009).

Visual Presentation (Photorealistic vs. Illustration)

Pattern-focused visuals consist of two parts: the pattern and the presentation. Concerning the latter, materials promoting SSE often use photographs of atypical moles to provide visual exemplars (see King et al., 2015). An assumption of this approach is that realism is better when it comes to visual training; however, dissenting viewpoints exist as to whether photorealistic images or graphic illustrations are more effective for training (Sung & Mayer, 2012; Thompson, Goldszmidt, Schwartz, & Bashook, 2010).

Research has shown that populations see photographs as more effective for instruction (Hegarty, 2011), despite evidence that illustrations can hold a comprehension advantage (Bol et al., 2015; Hollingsworth, 2016) and provide the capability to visually discriminate between, or entirely remove, extraneous elements (Filippatou & Pumfrey, 1996). For mole identification, photographs have been shown to increase accuracy scores for normal mole classification, while showing no gains for atypical moles (Girardi et al., 2006); suggesting more research is needed to determine whether photorealistic or illustrated training should be more impactful for SSE. Because visuals have the potential to improve health communication outcomes, and often do (see Houts, Doak, Doak, & Loscalzo, 2006), it is important to understand *how* to communicate visual information relevant to improved visual identification. Visual identification skill development requires quality training materials and the belief that one can perform such identification successfully.

Self-efficacy and SSE

Past SSE research has considered the role of self-efficacy in acquiring behavioral and cognitive skills (Robinson, Turrisi, & Stapleton, 2007a). Central to social cognitive theory (see Bandura, 1997), self-efficacy represents an individual's feeling that he or she is capable of performing a particular behavior. Past theorizing suggests that self-efficacy can significantly influence task performance (Bandura, 1997; Glasgow, 2012). Within SSE literature, Robinson and colleagues (2007a, 2007b) found that promoting SSE performance with partners increased self-efficacy and increased future SSE intentions. Lev (1997) also found that higher self-efficacy led to increased participation in cancer screening programs, increased self-care, and greater treatment recommendation adherence. Hay et al. (2006) built on these findings, discovering that self-efficacy mediated for SSE adherence 4 months after an initial dermatologist visit.

Self-efficacy influences SSE performance, but the impact of self-efficacy on accuracy remains unclear. The pattern presented (i.e., ABCDE or UDS) might influence the amount of skill developed by information recipients, and self-efficacy may serve as an intervening variable, as it has correlated positively with cognitive performance in other contexts (see Themanson, Pontifex, Hillman, & McAuley, 2011).

Identifying Visual Patterns Common to Atypical Moles

Laypersons are responsible for 74.7% of initial melanoma identifications (McPherson et al., 2006) and one could assume that training these laypersons would increase diagnosis rates. However, developing skill into expertise takes time (Beam, Conant, & Sickles, 2003; Jaimes et al., 2013), and effective training must overcome several hurdles. First, multiple training techniques exist, focusing on different approaches to mole identification (Grob & Bonerandi, 1998; Rigel, Friedman, Kopf, & Polsky, 2005; Yagerman & Marghoob, 2013). Second, contention exists as to how training messages should be presented to maximize effectiveness—for example, the debate between photorealistic vs. illustrated presentation (Filippatou & Pumfrey, 1996; Hegarty, 2011; Hollingsworth, 2016). Third, even after training, laypersons may only experience moderate gains in accuracy, if any at all (Goodson & Grossman, 2009; Hamidi et al., 2010; King et al., 2015). Each of these issues points to a central problem: Research and practice have not optimized training techniques for laypersons. Enabling laypersons to develop skill in identifying the critical visual indicators of atypical moles offers an innovative solution to this problem.

Eye Tracking and Dermatology

Notwithstanding dermatology's heavy reliance upon visual patterns and cues, literature that applies eye tracking to dermatology is sparse and literature specific to patient-initiated behaviors, such as SSE, is virtually nonexistent. This is surprising given the utility that eye tracking has shown in other visually oriented medical fields, such as radiology (e.g., Cavaro-Ménard, Tanguy, & Le Callet, 2010).

Fixations are one of the most commonly used measures in eye tracking research, defined as points where the subject's eye has stopped long enough to process information (see Goldberg & Kotval, 1999; Jacob & Karn, 2003; Just & Carpenter, 1976). Eye tracking is a natural fit for dermatology, but only two studies have utilized eye tracking to examine visual patterns in mole diagnosis. First, Dreiseitl, Pivec, and Binder (2012) compared people with different diagnostic experience, finding experts arrived at diagnosis 70% quicker than novices. Additionally, both total fixation time and total number of fixations were lower for experts compared to novices.

Second, Krupinski, Chao, Hofmann-Wellenhof, Morrison, and Curiel-Lewandrowski (2014) used eye tracking to measure the success of an online training program comparing two Board-certified dermatologists and two dermatology residents. Results indicated that the dermatologists had more efficient search patterns than their resident counterparts, evidenced by lower numbers of total fixations and shorter total fixation durations (i.e., dwell times). Individuals with greater expertise more consistently make accurate categorizations, relying on fewer fixations and shorter dwell times.

While both these studies reported clear distinctions between higher and lower levels of expertise, neither focused on laypersons—those expected to perform SSE—leaving many questions unanswered. Namely, how do visual patterns used in training influence accuracy outcomes and how can differing presentation styles influence these relationships?

Additional Eye Tracking Metrics Relevant to Skill Acquisition

Fixation-based eye tracking metrics may serve as indicators of differences in processing efficiency achievable through variances in training style. Specifically, research in visual perceptual learning (VPL) and eye tracking indicates that measurable increases in processing efficiency begin to manifest when an individual transitions from novice toward expertise (Ahissar & Hochstein, 2004; Dreiseitl et al., 2012; Fahle, 2005; Krupinski et al., 2014). Eye tracking can capture these shifts in processing efficiency. Using eye tracking to capture processing efficiency elucidates the primary outcome: identifying gains in efficiency separately from gains in skill. For example, a dermatologist in training may begin to identify suspicious moles more quickly, even if his/her diagnostic accuracy has yet to improve. In this case, the increase in processing efficiency likely represents the seeds of skill acquisition, and may be indicative of small shifts on the spectrum toward expertise—shifts that would otherwise go unnoticed when limited to a single skill acquisition outcome. As such, the current study considers the mediating role that processing efficiency may play between training and accuracy, as observable through fixation-based eye tracking metrics.

The inclusion of mediating factors in the forthcoming model serves two overarching purposes: (1) explicating the link between training pattern/presentation and diagnostic accuracy, and (2) verifying the early onset of expert-like visual scanning patterns in trained laypersons (i.e., processing efficiency). We anticipate that skill acquisition (following training) will be discoverable via fixation-based eye tracking metrics.

Explicating a Model of Visual Skill Acquisition for Melanoma Identification

Given the above research reviewed on SSE training methods, visual communication presentation, self-efficacy, and visual pattern identification priorities, we propose and test an initial visual skill acquisition model (VSAM) in the present study (see Figure 1).

VSAM articulates the expected path through which training affects skill. Experts are those who have an established cognitive framework optimized for specific tasks. Fahle (2005) summarized perceptual learning by stating that it "occurs at different processing levels, with different speeds, and is subject to top-down influences" (p. 155). Speed is a key discriminator between experts and novices (Ahissar & Hochstein, 2004). Experts possess well-developed higher level processes, and "are those whose higher level representations have been modified by adding weight to appropriate inputs and pruning uninformative inputs (for the trained task)" (Ahissar & Hochstein, 2004, p. 462).

Because fixation-based eye tracking variables help discriminate between novices and experts, 16 fixation-based eye tracking metrics appear in the VSAM to elucidate training-prompted efficiency gains. Self-efficacy is included in VSAM as a moderator due to its potential to influence participant performance. We define skill acquisition in VSAM as diagnostic accuracy, which consists of calculated scores for participant sensitivity and specificity in identifying atypical moles. *Sensitivity* refers to the calculated ability for an individual to identify an atypical mole correctly as atypical, while *specificity* refers to the calculated ability for an individual to identify a common mole as such.

The intention of VSAM is to lay the groundwork for future inquiry and theory building in the areas of visual communication and training, notably in the context of SSE. As such, the following research questions are proposed and addressed within this study:

Research Question 1: Are features of visual training—such as pattern and presentation—related to changes in processing efficiency?

Research Question 2: Are changes in processing efficiency related to greater sensitivity (RQ2a) or specificity (RQ2b)?

Research Question 3: Does visual pattern—ABCDE vs. UDS—yield significant differences in sensitivity (RQ3a) or specificity (RQ3b)?

Research Question 4: Does visual presentation—illustration vs. photorealistic—yield significant differences in sensitivity (RQ4a) or specificity (RQ4b)?

Research Question 5: Is there a significant interaction between pattern and presentation on sensitivity (RQ5a) or specificity (RQ5b)?

Research Question 6: Does self-efficacy moderate the relationship between pattern/presentation and sensitivity (RQ6a) or specificity (RQ6b)?

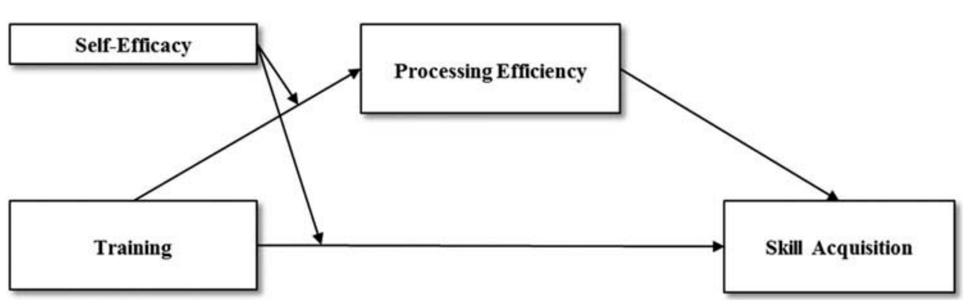

Fig. 1. The visual skill acquisition model (VSAM).

Research Question 7: Does processing efficiency mediate the direct or indirect paths between pattern/presentation, self-efficacy, and sensitivity or specificity?

Method

Design

Ninety-two university students completed the study in exchange for extra credit. Participants were randomized into a between-participants experiment: 2 (visual pattern: ABCDE vs. UDS) × 2 (visual presentation: photo vs. illustration).

Demographic Data

The sample consisted of undergraduate students (91.3%, $n = 84$), recent graduates (4.3%, $n = 4$), and graduate students (4.3%, $n = 4$) from an assortment of communication, psychology, and general education classrooms at a university located in the Western United States. Mean age was 22.3 ($SD = 4.69$), with slightly more females participating (54.3%, $n = 50$). A large proportion of the sample identified as White (87.0%, $n = 80$). The majority of participants reported that their non-sun-exposed skin was "fair" (48.9%, $n = 45$) or "olive" (22.8%, $n = 21$), followed by "very fair" (17.4%, $n = 16$).

Procedure and Experimental Conditions

The first author's institutional review board approved all procedures. Following consent, and prior to entering the lab, we randomly assigned participants to one of four study conditions. Upon entering the lab, participants completed a pretest survey. Following the pretest, participants received visual/written information regarding SSE adapted from King et al. (2015) (see Figure 2). In the *ABCDE illustrated* condition ($n = 22$), participants viewed an information pamphlet that focused on training in the ABCDE pattern featuring illustrated examples. For the *ABCDE photorealistic* condition ($n = 24$), participants viewed the same type of information, but with photorealistic examples. The third condition, called *UDS illustrated* ($n = 23$), trained participants in the UDS pattern using illustrated examples. The final condition, *UDS photorealistic* ($n = 23$), trained participants in the UDS pattern using photorealistic examples. After participants reviewed the information on SSE, the researcher then calibrated them using the eye tracking system (Applied Science Laboratories, 2011; Eyetellect, 2014).

Mole Identification Task

Following training, participants were ready to begin the mole identification task. MoleMap (http://www.molemap.co.nz/) provided the images used in this task, which contained no identifying features beyond moles. During the task, participants viewed a series of images featuring sets of four moles from the same patients and were asked if they believed any of the four moles were atypical. Participants received instructions that moles pictured could be common, or there could be one or multiple atypical moles. The researcher provided no feedback during this process.

Measures

Self-Efficacy

Witte, Cameron, McKeon, and Berkowitz (1996) developed a template for self-efficacy items and we adapted these items for the current study to make them relevant to SSE performance. Five items assessed self-efficacy in the pretest, four from the Witte et al. scale, and one additional item specific to the present study. Examples of the items include "I am able to perform a skin self-exam," "Checking my skin for cancer is easy for me," and the added item "I could tell the difference between skin cancer and other types of ordinary skin growths." Items were anchored with *strongly disagree* (1) and *strongly agree* (5), $M = 2.94$, $SD = .89$, $\alpha = .87$.

Diagnostic Accuracy

Diagnostic accuracy considers four possible participant responses to the mole identification task: *true-positive* (TP)—cases that are atypical, and were deemed so by participants; *false-positive* (FP)—cases that are common, but were deemed atypical; *false-negative* (FN)—cases that are atypical, but were deemed common; and *true-negative* (TN)—cases that are common, and were deemed so. These responses were then aggregated within a 2 × 2 grid, where sensitivity was calculated as a function of TP/(TP+FN), and specificity was calculated as a function of TN/(TN+FP), for each participant. Means and standard deviations for both values were $M = .48$, $SD = .18$ and $M = .79$, $SD = .13$, respectively.

Eye Tracking Measures

Fixation-based metrics have been shown to inversely correlate with visual skill, effectively discriminating between novices and experts (Dreiseitl et al., 2012; Krupinski et al., 2014; Nodine, Mello-Thoms, Kundel, & Weinstein, 2002). As such, a selection of fixation-based metrics were tested in VSAM to track subject skill progression, including number of fixations, average and total fixation duration, fixations within a lookzone (i.e., time spent looking at an atypical mole), and a variety of lookzone-based measures derived from these (listed in Table 1).

Results

We used IBM SPSS 22 for all statistical analyses.[2] The primary objective of the current study was to determine which combination of visual pattern (ABCDE or UDS) and visual presentation (illustration or photorealistic) yielded the greatest gains in subject accuracy when identifying atypical moles, in line with predictions of the proposed VSAM. Eye tracking measures

[2]Statistical power calculations were executed using G*Power 3.1.5 (Faul, Erdfelder, Buchner, & Lang, 2009). The analytical approach utilized two-way ANOVAs and moderated mediation analyses. For ANOVA analyses, effect size standards are small ($f^2 = .10$), medium ($f^2 = .25$), and large ($f^2 = .40$). For the moderated mediation model, effect size standards are small ($f^2 = .02$), medium ($f^2 = .15$), and large ($f^2 = .35$) (Faul et al., 2009; Faul, Erdfelder, Lang, & Buchner, 2007). Achieved power for the two-way ANOVAs was excellent for the detection of large effects (.97), good for the detection of medium effects (.66), and poor for the detection of small effects (.16). Achieved power for the moderated mediation models (with six predictors in the model) was excellent for the detection of large effects (.99), good for the detection of medium effects (.81), and poor for the detection of small effects (.14).

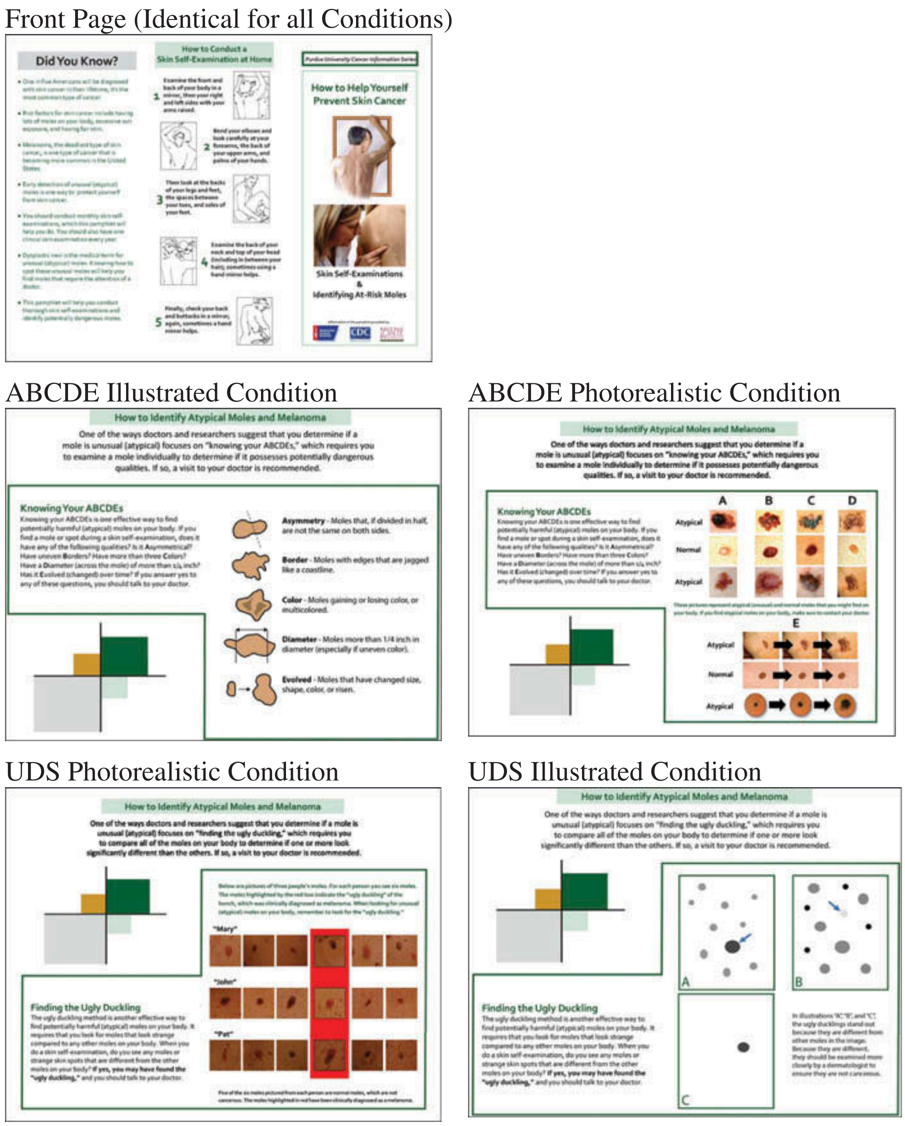

Fig. 2. Training materials participants saw color, not black and white, pamphlets. Readers can request digital copies of the stimuli from the corresponding author.

served as mediators to scrutinize training effectiveness, and, as part of the larger model, we examined self-efficacy as a potential moderating factor.

Bivariate Correlations (RQ1 and RQ2)

We provide the bivariate correlation matrix for relevant study variables in Table 1. Strong correlations were common among the eye tracking variables. This is expected as these variables, in many cases, measure similar things (e.g., total time the image was displayed, and total time fixating on that image) and/or represent combined measures merging one or more instruments (e.g., fixation count/total time in lookzone). The relationships of interest in this matrix were the significant correlations between the eye tracking metrics and the predictors and outcomes.

RQ1 asked whether pattern (coded: UDS = 0, ABCDE = 1) or presentation condition (coded: Illustrated = 1, Photorealistic = 2) were significantly related to changes in visual processing efficiency. Pattern was positively related to total time shown ($r = .27$, $p = .01$), total fixation duration ($r = .29$, $p < .001$), average fixation duration ($r = .44$, $p < .001$), total time in lookzone ($r = .25$, $p = .02$), and total fixation duration in the lookzone ($r = .26$, $p = .01$). These correlations indicate participants trained in the ABCDE method tended to look at the images longer before coming to a decision, spend more time fixating on the images and the atypical moles, and exhibit longer individual fixation times than their peers trained in UDS. Conversely, the measures for overall fixation count/total time shown ($r = -.41$, $p < .001$) and fixation count/total time in the lookzone ($r = -.31$, $p < .001$) were inversely correlated with pattern, indicating that training in UDS resulted in higher values for these measures. Higher values, in this case, means less efficiency; therefore, training in UDS resulted in participants requiring more fixation points than their ABCDE-trained counterparts to come to a decision, in relation to the amount of time they spent scanning. For

Table 1. Bivariate correlation matrix.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
1.	—	–.34*	.07	–.27*	.09	.09	.11	.02	.02	.05	–.07	–.01	.12	–.14	–.18	.08	.15	.14	.12	.01	–.20*
2.			–.15	.20	–.32*	–.31*	–.31*	.14	–.14	–.04	–.20*	–.18	–.11	.05	.04	.49*	–.15	.39*	–.12	–.06	.13
3.				.02	.27*	.29*	.11	–.41*	.44*	–.04	.04	.08	.25*	–.14	–.09	–.06	.10	–.02	.26*	–.31*	–.03
4.					–.07	–.08	–.06	–.05	–.01	.01	.22*	.09	–.08	.18	.20	–.10	–.09	–.16	–.08	–.05	.16
5.						.99*	.89*	–.46*	.43*	.73*	.07	.23*	.91*	–.32*	–.37*	–.25*	.80*	–.16	.90*	–.31*	–.20
6.							.84*	–.50*	.51*	.67*	.07	.17	.91*	–.35*	–.36*	–.22*	.76*	–.15	.91*	–.36*	–.19*
7.								–.09	.04	.84*	.10	.20*	.78*	–.32*	–.41*	–.25*	.88*	–.18	.75*	.02	–.20*
8.									–.92*	–.02	–.03	–.23*	–.44*	.07	.01	.13	–.08	.07	–.47*	.79*	.06
9.										–.07	.05	.09	.43*	–.16	–.02	–.09	.02	–.08	.46*	–.78*	–.06
10.											–.04	.14	.72*	–.36*	–.49*	–.07	.86*	.04	.69*	.06	–.24*
11.												.52*	–.03	.48*	.61*	–.29*	–.03	–.36*	–.03	–.03	–.04
12.													.09	.66*	.44*	–.36*	.10	–.24*	.08	–.11	.01
13.														–.44*	–.45*	.11	.85*	.13	1.0*	–.42*	–.24*
14.															.89*	–.23*	–.43*	–.22*	–.44*	.07	.14
15.																–.14	–.52*	–.24*	–.44*	–.08	.10
16.																	.04	.82*	.12	–.21*	–.09
17.																		.21*	.83*	.03	–.26*
18.																			.14	.02	–.13
19.																				–.45*	–.24*
20.																					.03
21.																					—

Note. Bivariate correlations among variables. $N = 92$.
Variable key:
1. Sensitivity
2. Specificity
3. Pattern condition
4. Presentation condition
5. Total time shown
6. Total fixation duration
7. Number of fixations
8. Fixation count/total time shown
9. Average fixation duration
10. Lookzone: Number of times observed
11. Lookzone: Number of fixations before first arrival
12. Lookzone: Duration before first fixation arrival
13. Lookzone: Total time in zone
14. Lookzone: Percentage of total slide time before first arrival
15. Lookzone: Percentage of total fixations before first arrival
16. Lookzone: Percent of time spent in zone
17. Lookzone: Fixation count
18. Lookzone: Percentage of total fixations
19. Lookzone: Total fixation duration
20. Lookzone: Fixation count/total time in zone
21. Self-efficacy

*$p < .05$.

presentation, a single eye tracking variable correlated positively: Number of fixations before first arrival in the lookzone (r = .22, p = .04). This indicates that participants trained in ABCDE exhibited a greater number of fixations looking at the images before locating the atypical moles, when compared to their counterparts trained in UDS.

RQ2a and RQ2b asked whether changes in processing efficiency relate to sensitivity and specificity. No eye tracking variables showed statistically significant correlations with sensitivity. Several eye tracking variables, however, correlated with specificity. Specifically, the eye tracking variables of total time shown (r = −.32, p < .001), total fixation duration (r = −.31, p < .001), number of fixations (r = −.31, p < .001), and number of fixations before first arrival in the lookzone (r = −.20, p = .03) each inversely correlated with specificity.

Given these findings with regard to specificity, the correlations provide some evidence for a link between processing efficiency and accuracy. Two other eye tracking variables—percent of time spent in the lookzone (r = .49, p < .001) and percent of total fixations in the lookzone (r = .39, p < .001)—correlated positively with specificity. This provides support for the processing efficiency argument, because these variables serve as indicators that a greater portion of viewing time and fixations were spent looking at the atypical moles.

Relationship between Pattern, Presentation, and Accuracy (RQ3–RQ5)

Sensitivity

We conducted a two-way ANOVA with Bonferroni corrections with sensitivity as the outcome and pattern/presentation condition as fixed factors. Results indicated a significant main effect for presentation condition, F(1,88) = 7.10, p = .009, wherein illustrations (M = .52, SD = .20) resulted in greater sensitivity than photos (M = .43, SD = .16, d = .55). The main effect for pattern condition, F (1, 88) = .54, p = .465, and the pattern × presentation condition interaction, F(1,88) = 1.13, p = .29, were not significant (see Table 2).

Specificity

With specificity as the outcome, we again conducted a two-way ANOVA with Bonferroni corrections. The main effect for pattern condition was not significant, F(1, 88) = 2.12, p = .15; however, results indicated a significant main effect for presentation condition, F(1, 88) = 4.08, p = .05, wherein photos (M = .82, SD = .11) resulted in greater specificity than illustrations (M = .77, SD = .14, d = .41). In addition, the interaction for pattern × presentation condition, F(1, 88) = 3.55, p = .06, was significant within a 90% confidence interval, such that those within the UDS/photo condition displayed greater specificity than all other combinations of pattern and presentation condition.

To summarize, for training in both ABCDE and UDS, no significant accuracy advantage manifested for sensitivity or specificity (no to RQ3a and RQ3b). For presentation type and sensitivity, the illustration condition yielded greater accuracy over the photo condition (yes to RQ4a). For specificity, on the other hand, the photo condition exhibited a significant, direct accuracy benefit over the illustration condition (yes to RQ4b). Taken together, results indicate that illustrated visuals enhanced sensitivity, while photorealistic visuals enhanced specificity. Although there was a nonsignificant interaction of pattern/presentation on sensitivity (no to RQ5a), the interaction was significant for specificity (yes to RQ5b).

Moderated Mediation Models (RQ6 and RQ7)

To gain further understanding of the potential mediating role of eye tracking measures in VSAM, and to examine the role of self-efficacy as a potential mediator/moderator, we examined OLS regression models testing mediation/moderation using PROCESS (see Hayes, 2013). Specifically, we used PROCESS Model 10 (moderated mediation) for these analyses, and all indirect effects models used bootstrap analyses with 1,000 bootstrap samples and 95% bias-corrected confidence intervals. We examined moderation analyses using the pick-a-point percentile method, which examines the indirect path at the 10th, 25th, 50th, 75th, and 90th percentiles of the moderator variable (Hayes, 2013). VSAM postulates that 16 eye tracking measures could mediate the relationship between training and skill; however, only 10 of these variables were related to the experimental conditions (pattern, presentation) or the outcomes (sensitivity, specificity) in the bivariate analysis (see Table 1). Correlations between some of the eye tracking variables were very high, because they measure very closely related constructs. Due to these similarities, three variables (9, 16, and 19 in Table 1) were selected that minimized overlap between measures in the moderated mediation models.

First, we ran a model with presentation as the independent variable, self-efficacy, and presentation as moderators, the three eye tracking measures identified above as mediators, and either sensitivity or specificity as the outcomes.

Moderated Mediation and Sensitivity

There was no evidence of mediation, moderation, or moderated mediation, as none of the mediators demonstrated empirical

Table 2. Means and standard deviations by condition (pattern: UDS vs. ABCDE, and presentation: Illustrated vs. Photorealistic) and outcome (sensitivity, specificity).

	Sensitivity			Specificity			
Presentation	UDS	ABCDE	Total	UDS	ABCDE	Total	*N*
Illustrated	.53 (.19)	.52 (.21)	.52 (.20)	.76 (.16)	.78 (.12)	.77 (.14)	45
Photorealistic	.39 (.17)	.46 (.15)	.43 (.16)	.86 (.06)	.78 (.13)	.82 (.11)	47
Total	.46 (.19)	.49 (.18)	.47 (.19)	.81 (.13)	.78 (.12)	.80 (.13)	92
N	46	46	92	46	46	92	

Note. Means and standard deviations (in parentheses) by condition (pattern, presentation) and outcome (sensitivity, specificity), N = 92.

relationships to sensitivity (see Table 3). The pattern × self-efficacy interaction was not significant (p = .38), and none of the moderated mediation pathways were significant.

Moderated Mediation and Specificity

A moderated mediation model was again run using PROCESS, with specificity as the outcome. Self-efficacy was not directly related to specificity (p = .08), nor was the pattern × self-efficacy interaction significant (p = .14; see Table 4). However, there was a significant three-way interaction between pattern, presentation, and self-efficacy (see Table 5). For participants in the photo condition with high self-efficacy (75th percentile or above), UDS increased specificity directly.

Two moderated mediation paths were also significant (see Table 6). First, for those in the photo condition with self-efficacy at the 50th percentile or lower, UDS increased percent of time in lookzone; in other words, these individuals spent a larger amount of their viewing time on target (observing the atypical moles), which is, in turn, positively related to specificity. Second, for those in the illustrated condition with self-efficacy from the 50th to the 25th percentile, UDS increased total fixation duration in the lookzone (observing the atypical moles), which, in turn, was positively related to specificity.

Thus, self-efficacy does not appear to moderate the relationship between pattern and sensitivity (no to RQ6a) but was a significant moderator for specificity (yes to RQ6b). Finally, processing efficiency does indeed appear to be a factor, given the significant moderated mediation models for specificity (yes to RQ7).

Discussion

The present study examined visual skill acquisition in the context of SSE, which is an important strategy for cancer prevention and early detection. Two different stories manifested when comparing the impact of training type on sensitivity (correctly identifying an atypical mole) and specificity (correctly identifying a common mole), the primary accuracy outcomes of this study. For sensitivity, we found a main effect supporting illustrated information presentation, such that those who received instruction with illustrations manifested significantly higher sensitivity scores, regardless of whether their training was in the ABCDE or UDS method. These findings are consistent with earlier research on illustrations versus photos in training materials, which showed a knowledge acquisition advantage for illustrations, counter to general preferences for realistic visuals (Bol et al., 2015; Hollingsworth, 2016).

Table 3. Regression model for sensitivity.

	R	R^2	MSE	*F*	*df*1	*df*2	*p*
Model summary	.3331	.1110	.0332	1.2950	8.0000	83.0000	.2575
Model		Coeff.	*SE*	*t*	*p*	LLCI	ULCI
Constant		.7700	.1815	4.2430	.0001	.4090	1.1309
Average fixation duration		−.1130	.2866	−.3942	.6945	−.6830	.4571
LZ: Percent of time spent in zone		.0007	.0038	.1773	.8597	−.0069	.0082
LZ: Total fixation duration		.0079	.0234	.3373	.7367	−.0386	.0543
Pattern condition		−.2006	.1692	−1.1859	.2391	−.5371	.1359
Presentation condition		−.1302	.0548	−2.3759	.0198	−.2393	−.0212
Pattern × presentation condition		.0751	.0795	.9444	.3477	−.0830	.2232
Self-efficacy		−.0379	.0321	−1.1826	.2403	−.1017	.0259
Pattern × self-efficacy		.0406	.0456	.8898	.3762	−.0502	.1314

Note. *N* = 92. LLCI = lower level confidence interval; ULCI = upper level confidence interval.

Table 4. Regression model for specificity.

	R	R^2	*MSE*	*F*	*df1*	*df2*	*p*
Model summary	.5754	.3311	.0115	5.1355	8.0000	83.0000	.0000
Model		Coeff	*SE*	*t*	*p*	LLCI	ULCI
Constant		.2994	.1068	2.8027	.0063	.0869	.5118
Average fixation duration		.0287	.1687	.1703	.8652	−.3068	.3643
LZ: Percent of time spent in zone		.0114	.0022	5.1069	.0000	.0069	.0158
LZ: Total fixation duration		−.0244	.0137	−1.7742	.0797	−.0517	.0030
Pattern condition		.1775	.0996	1.7825	.0783	−.0206	.3755
Presentation condition		.0806	.0323	2.4987	.0144	.0164	.1448
Pattern × presentation condition		−.0523	.0468	−1.1180	.2668	−.1454	.0408
Self-efficacy		.0334	.0189	1.7715	.0801	−.0041	.0710
Pattern × self-efficacy		−.0402	.0269	−1.4965	.1383	−.0937	.0132

Note. *N* = 92. LLCI = lower level confidence interval; ULCI = upper level confidence interval.

Table 5. Conditional direct effects of pattern on specificity at values of the moderator.

Moderator: Presentation	Self-efficacy	Effect	*SE*	*t*	*p*	LLCI	ULCI
Illustrated	1.600	.0608	.0476	1.2772	.2051	–.0339	.1556
Illustrated	2.400	.0287	.0361	.7928	.4301	–.0432	.1006
Illustrated	3.000	.0045	.0345	.1313	.8959	–.0641	.0732
Illustrated	3.600	–.0196	.0400	–.4902	.6253	–.0991	.0599
Illustrated	3.800	–.0276	.0430	–.6429	.5221	–.1131	.0579
Photorealistic	1.600	.0085	.0540	.1573	.8754	–.0990	.1160
Photorealistic	2.400	–.0237	.0396	–.5972	.5520	–.1025	.0552
Photorealistic	3.000	–.0478	.0341	–1.4005	.1651	–.1157	.0201
Photorealistic	3.600	–.0719*	.0358	–2.0115	.0475	–.1430	–.0008
Photorealistic	3.800	–.0800*	.0378	–2.1132	.0376	–.1552	–.0047

Note. $N = 92$. LLCI = lower level confidence interval; ULCI = upper level confidence interval. Negative coefficients indicate an advantage for UDS, while positive coefficients indicate a preference toward ABCDE.
*$p < .05$.

Table 6. Conditional direct effects of pattern on specificity at values of the moderator.

Moderator: Presentation	Self-efficacy	Effect	Boot *SE*	Boot LLCI	Boot ULCI
Mediator: LZ: Percent of time in zone					
Illustrated	1.600	–.0136	.0246	–.0645	.0327
Illustrated	2.400	.0058	.0202	–.0298	.0534
Illustrated	3.000	.0204	.0211	–.0146	.0739
Illustrated	3.600	.0349	.0253	–.0074	.0954
Illustrated	3.800	.0398	.0272	–.0063	.1049
Photorealistic	1.600	–.0645*	.0291	–.1421	–.0188
Photorealistic	2.400	–.0451*	.0212	–.0986	–.0122
Photorealistic	3.000	–.0305*	.0183	–.0785	–.0030
Photorealistic	3.600	–.0160	.0195	–.0684	.0145
Photorealistic	3.800	–.0111	.0208	–.0622	.0240
Mediator: LZ: Total fixation duration					
Illustrated	1.600	–.0236	.0174	–.0739	.0003
Illustrated	2.400	–.0202*	.0143	–.0590	–.0002
Illustrated	3.000	–.0176*	.0127	–.0521	–.0004
Illustrated	3.600	–.0150	.0120	–.0491	.0005
Illustrated	3.800	–.0142	.0120	–.0498	.0010
Photorealistic	1.600	–.0122	.0123	–.0535	.0021
Photorealistic	2.400	–.0088	.0085	–.0347	.0013
Photorealistic	3.000	–.0063	.0067	–.0278	.0013
Photorealistic	3.600	–.0037	.0067	–.0225	.0054
Photorealistic	3.800	–.0028	.0071	–.0218	.0075

Note. $N = 92$. LLCI = lower level confidence interval; ULCI = upper level confidence interval. Negative coefficients indicate an advantage for UDS, while positive coefficients indicate a preference toward ABCDE.
*$p < .05$.

For specificity, the story is more complicated. In contrast to the sensitivity findings, photorealistic visuals provided a main effect, such that individuals trained with photorealistic materials achieved significantly higher specificity scores than their illustration-trained peers, regardless of ABCDE or UDS training.

Specificity refers to the capability to tell that a common mole is common, and photographs may be better suited to showing an individual the look of a common mole, while illustrations are better suited to showing the key attributes of atypical moles. This finding counters the conclusion of some research that suggests “a quick look at a few photographs is sufficient to improve the ability of [laypersons] to recognize a melanoma just by optimizing their spontaneous image recognition capacities” (Girardi et al., 2006, p. 2276). If photorealistic training improved laypersons’ abilities to identify atypical moles, then a significant path between photo training and sensitivity should have manifested, but it did not. Instead, illustrated training enhanced sensitivity. The results, considering past research, suggest that specific imagery might optimize recognition differently depending on myriad factors still to be identified by researchers.

The specificity finding becomes even more compelling when examining the interaction within the present study’s moderated mediation model. For individuals with higher levels of self-efficacy, training in the UDS/photo condition resulted in significant, direct gains for specificity. For individuals with lower levels of self-efficacy, training in the UDS/photo condition caused them to spend a greater percent of their time focused on the atypical moles before arriving at a decision. Therefore, it is possible that increased time on target is what gave the UDS/photo condition an advantage in accuracy over all other conditions, because increased time on target begets increased visual data to inform the decision.

Similarly, a second significant mediation path manifested for the illustrated condition through total fixation duration within the lookzone, such that those within the low-to-moderate self-efficacy range fixated longer on the atypical moles. In turn, increased lookzone fixation time was associated with higher specificity scores. Previous research found illustrations to be effective for emphasizing essential features and delineating inessential features in training applications (Bol et al., 2015; Hollingsworth, 2016), and it is possible that, for these low-to-moderate self-efficacy individuals, illustrations were the best format to effectively convey the essential criteria for ABCDE and UDS application. In this case, the increased fixation time on the atypical moles could be evidence of applying those principles to their decisions, which yielded better results in the form of higher specificity scores. That certainly seemed to be the case in the current study, though further research is necessary to see how these findings manifest in other applications.

The presence of two significant moderated mediation paths from training to specificity provides early support for VSAM as a viable model of visual skill acquisition. In application to SSE, VSAM presented an opportunity to explore both the visual and psychological mechanisms that mediate and moderate the direct relationship between training and skill. Fixation-based eye tracking measures provide a promising avenue for quantifying gains in subject visual processing efficiency, and VSAM provides a platform for further exploration of their utility.

Limitations and Future Research Directions

The current study complements extant SSE research by using eye tracking to quantify visual processing of atypical moles. However, it is not without limitations. First, the sample size, while larger than what is presently available in the literature, was only large enough to detect medium- to large-sized effects consistently. Second, the sample favored White, college-aged individuals, which is not representative of the general SSE-performing population. Therefore, the current design is acceptable for identifying mechanisms, but inadequate for generalization. Third, the current study only used one type of mole search task. Research has shown that search accuracy can be impacted by presentation style (e.g., larger photos beget greater accuracy; Robinson & Turrisi, 2006). Therefore, varying mole size in a subsequent study could yield differing results. Finally, other advances in perceptual expertise training suggest that conducting multiple training sessions over time could yield great benefits for laypersons (see Xu, Rourke, Robinson, & Tanaka, 2016).

Conclusion

Drawing upon a variety of training methodologies, researchers have shown that SSE fails to provide a consistent accuracy benefit for laypersons. The current study sought to scrutinize SSE training, using eye tracking to search for evidence of processing efficiency gains that should naturally follow the development of proficiency in a visual search task such as SSE. Preliminary evidence suggests that illustrated training visuals enhance SSE sensitivity (correctly identifying an atypical mole), while photorealistic training visuals offer similar enhancement for SSE specificity (correctly identifying a common mole). At the practical level, these findings suggest that training materials aiming to increase layperson SSE accuracy should include a combination of illustrated and photorealistic visuals, to support respective gains in sensitivity and specificity. Furthermore, practitioners should consider using a combination of illustrated and photorealistic visuals, to support respective gains in sensitivity and specificity, and pairing photorealistic examples with UDS to maximize gains in specificity. Overall, these findings lend support to VSAM as a model that can begin to explicate the process of visual skill acquisition in SSE.

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References

Ahissar, M., & Hochstein, S. (2004). The reverse hierarchy theory of visual perceptual learning. *Trends in Cognitive Sciences*, *8*(10), 457–464. doi:10.1016/j.tics.2004.08.011

Applied Science Laboratories. (2011). *Eye tracker systems manual ASL eye-trac 6 D6 desk mounted optics v3.04*. Bedford, MA: Applied Science Laboratories.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: W. H. Freeman and Company.

Beam, C. A., Conant, E. F., & Sickles, E. A. (2003). Association of volume and volume-independent factors with accuracy in screening mammogram interpretation. *Journal of the National Cancer Institute*, *95*(4), 282–290. doi:10.1093/jnci/95.4.282

Bol, N., Smets, E. M. A., Eddes, E. H., De Haes, J. C. J. M., Loos, E. F., & Van Weert, J. C. M. (2015). Illustrations enhance older colorectal cancer patients' website satisfaction and recall of online cancer information. *European Journal of Cancer Care*, *24*(2), 213–223. doi:10.1111/ecc.12283

Cavaro-Ménard, C., Tanguy, J. Y., & Le Callet, P. (2010, March). Eye-position recording during brain MRI examination to identify and characterize steps of glioma diagnosis. In *SPIE Medical Imaging* (pp. 76270E–76270E). Bellingham, WA: International Society for Optics and Photonics.

Chu, M. B., Atkinson, J., Hershfield, L., & Rosen, C. F. (2016). An update to the recommended core content for sun safety messages for public education in Canada: A consensus report. *Canadian Journal of Public Health*, *107*(4/5), E473. doi:10.17269/cjph.107.5556

Coups, E. J., Manne, S. L., Stapleton, J. L., Tatum, K. L., & Goydos, J. S. (2016). Skin self-examination behaviors among individuals diagnosed with melanoma. *Melanoma Research*, *26*(1), 71–76. doi:10.1097/CMR.0000000000000204

Dreiseitl, S., Pivec, M., & Binder, M. (2012). Differences in examination characteristics of pigmented skin lesions: Results of an eye tracking study. *Artificial Intelligence in Medicine*, *54*(3), 201–205. doi:10.1016/j.artmed.2011.11.004

Eyetellect. (2014). *Gaze tracker 10 reference manual*. Charlottesville, VA: Eyetellect.

Fahle, M. (2005). Perceptual learning: Specificity versus generalization. *Current Opinion in Neurobiology*, *15*(2), 154–160. doi:10.1016/j.conb.2005.03.010

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149–1160. doi:10.3758/BRM.41.4.1149

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. doi:10.3758/BF03193146

Filippatou, D., & Pumfrey, P. D. (1996). Pictures, titles, reading accuracy and reading comprehension: A research review (1973–95). *Educational Research*, *38*(3), 259–291. doi:10.1080/0013188960380302

Girardi, S., Gaudy, C., Gouvernet, J., Teston, J., Richard, M. A., & Grob, J. J. (2006). Superiority of a cognitive education with photographs over ABCD criteria in the education of the general population to the early detection of melanoma: A randomized study. *International Journal of Cancer*, *118*(9), 2276–2280. doi:10.1002/ijc.21351

Glasgow, R. E. (2012). Perceived barriers to self-management and preventive behaviors. *Health behavior constructs: Theory, measurement & research*. Retrieved June 6, 2017, from https://cancercontrol.cancer.gov/brp/research/constructs/barriers.html

Goldberg, J. H., & Kotval, X. P. (1999). Computer interface evaluation using eye movements: Methods and constructs. *International Journal of Industrial Ergonomics*, *24*, 631–645. doi:10.1016/S0169-8141(98)00068-7

Goodson, A. G., & Grossman, D. (2009). Strategies for early melanoma detection: Approaches to the patient with nevi. *Journal of the American Academy of Dermatology*, *60*, 719–735. doi:10.1016/j.jaad.2008.10.065

Grob, J. J., & Bonerandi, J. J. (1998). The 'ugly duckling' sign: Identification of the common characteristics of nevi in an individual as a basis for melanoma screening. *Archives of Dermatology*, *134*, 103–104. doi:10.1001/archderm.134.1.103-a

Hamidi, R., Peng, D., & Cockburn, M. (2010). Efficacy of skin self-examination for the early detection of melanoma. *International Journal of Dermatology*, *49*(2), 126–134. doi:10.1111/ijd.2010.49.issue-2

Hay, J. L., Oliveria, S. A., Dusza, S. W., Phelan, D. L., Ostroff, J. S., & Halpern, A. C. (2006). Psychosocial mediators of a nurse intervention to increase skin self-examination in patients at high risk for melanoma. *Cancer Epidemiology Biomarkers & Prevention*, *15*(6), 1212–1216. doi:10.1158/1055-9965.EPI-04-0822

Hayes, A. F. (2013). *Model templates for PROCESS for SPSS and SAS*. Retrieved from http://www.afhayes.com/public/templates.pdf

Hegarty, M. (2011). The cognitive science of visual-spatial displays: Implications for design. *Topics in Cognitive Science*, *3*(3), 446–474. doi:10.1111/tops.2011.3.issue-3

Hollingsworth, J. C. (2016). *Differences in participant recall and preference based on patient medication information* (Unpublished doctoral dissertation). Auburn University, Auburn, AL.

Houts, P. S., Doak, C. C., Doak, L. G., & Loscalzo, M. J. (2006). The role of pictures in improving health communication: A review of research on attention, comprehension, recall, and adherence. *Patient Education and Counseling*, *61*(2), 173–190. doi:10.1016/j.pec.2005.05.004

Jacob, R. J. K., & Karn, K. S. (2003). Eye tracking in Human-Computer Interaction and usability research: Ready to deliver the promises. In J. Hyönä, R. Radach, & H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research* (pp. 573–605). Radarweg, Amsterdam: Elsevier.

Jaimes, N., Dusza, S. W., Quigley, E. A., Braun, R. P., Puig, S., Malvehy, J., . . . Marghoob, A. A. (2013). Influence of time on dermoscopic diagnosis and management. *Australasian Journal of Dermatology*, *54*(2), 96–104. doi:10.1111/ajd.12001

Just, M. A., & Carpenter, P. A. (1976). Eye fixations and cognitive processes. *Cognitive Psychology*, *8*, 441–480. doi:10.1016/0010-0285(76)90015-3

King, A. J. (2015). A content analysis of visual cancer information: Prevalence and use of photographs and illustrations in printed health materials. *Health Communication*, *30*, 722–731. doi:10.1080/10410236.2013.878778

King, A. J., Carcioppolo, N., Grossman, D., John, K. K., & Jensen, J. D. (2015). A randomised test of printed educational materials about melanoma detection: Varying skin self-examination technique and visual image dose. *Health Education Journal*, *74*, 732–742. doi:10.1177/0017896914558645

Krupinski, E. A., Chao, J., Hofmann-Wellenhof, R., Morrison, L., & Curiel-Lewandrowski, C. (2014). Understanding visual search patterns of dermatologists assessing pigmented skin lesions before and after online training. *Journal of Digital Imaging*, *27*(6), 779–785. doi:10.1007/s10278-014-9712-1

Lev, E. L. (1997). Bandura's theory of self-efficacy: Applications to oncology. *Research and Theory for Nursing Practice*, *11*(1), 21–37.

McPherson, M., Elwood, M., English, D. R., Baade, P. D., Youl, P. H., & Aitken, J. F. (2006). Presentation and detection of invasive melanoma in a high-risk population. *Journal of the American Academy of Dermatology*, *54*(5), 783–792. doi:10.1016/j.jaad.2005.08.065

McWhirter, J. E., & Hoffman-Goetz, L. (2013). Visual images for patient skin self-examination and melanoma detection: A systematic review of published studies. *Journal of the American Academy of Dermatology*, *69*(1), 47–55. doi:10.1016/j.jaad.2013.01.031

McWhirter, J. E., & Hoffman-Goetz, L. (2014). A systematic review of visual image theory, assessment, and use in skin cancer and tanning research. *Journal of Health Communication*, *19*, 738–757. doi:10.1080/10810730.2013.837562

Nodine, C. F., Mello-Thoms, C., Kundel, H. L., & Weinstein, S. P. (2002). Time course of perception and decision making during mammographic interpretation. *American Journal of Roentgenology*, *179*(4), 917–923. doi:10.2214/ajr.179.4.1790917

Rigel, D. S., Friedman, R. J., Kopf, A. W., & Polsky, D. (2005). ABCDE: An evolving concept in the early detection of melanoma. *Archives of Dermatology*, *141*(8), 1032–1034. doi:10.1001/archderm.141.8.1032

Rigel, D. S., Russak, J., & Friedman, R. (2010). The evolution of melanoma diagnosis: 25 years beyond the ABCDs. *CA: A Cancer Journal for Clinicians*, *60*(5), 301–316.

Robinson, J. K., & Ortiz, S. (2009). Use of photographs illustrating ABCDE criteria in skin self-examination. *Archives of Dermatology*, *145*(3), 332–333. doi:10.1001/archdermatol.2008.604

Robinson, J. K., & Turrisi, R. (2006). Skills training to learn discrimination of ABCDE criteria by those at risk of developing melanoma. *Archives of Dermatology*, *142*, 447–452. doi:10.1001/archderm.142.4.447

Robinson, J. K., Turrisi, R., & Stapleton, J. (2007a). Efficacy of a partner assistance intervention designed to increase skin self-examination performance. *Archives of Dermatology*, *143*(1), 37–41. doi:10.1001/archderm.143.1.37

Robinson, J. K., Turrisi, R., & Stapleton, J. (2007b). Examination of mediating variables in a partner assistance intervention designed to increase performance of skin self-examination. *Journal of the American Academy of Dermatology*, *56*(3), 391–397. doi:10.1016/j.jaad.2006.10.028

Siegel, R., Naishadham, D., & Jemal, A. (2012). Cancer statistics, 2012. *CA: A Cancer Journal for Clinicians*, *62*(1), 10–29.

Suh, K. Y., & Bolognia, J. L. (2009). Signature nevi. *Journal of the American Academy of Dermatology*, *60*(3), 508–514. doi:10.1016/j.jaad.2008.10.056

Sung, E., & Mayer, R. E. (2012). When graphics improve liking but not learning from online lessons. *Computers in Human Behavior*, *28*(5), 1618–1625. doi:10.1016/j.chb.2012.03.026

Themanson, J. R., Pontifex, M. B., Hillman, C. H., & McAuley, E. (2011). The relation of self-efficacy and error-related self-regulation. *International Journal of Psychophysiology*, *80*(1), 1–10. doi:10.1016/j.ijpsycho.2011.01.005

Thompson, A. E., Goldszmidt, M. A., Schwartz, A. J., & Bashook, P. G. (2010). A randomized trial of pictorial versus prose-based medication information pamphlets. *Patient Education and Counseling*, *78*(3), 389–393. doi:10.1016/j.pec.2010.01.010

U. S. Preventive Services Task Force. (2009). Screening for skin cancer: U. S. preventive services task force recommendation statement. *Annals of Internal Medicine*, *150*, 188–193. doi:10.7326/0003-4819-150-3-200902030-00008

Witte, K., Cameron, K. A., McKeon, J. K., & Berkowitz, J. M. (1996). Predicting risk behaviors: Development and validation of a diagnostic scale. *Journal of Health Communication*, *1*(4), 317–342. doi:10.1080/108107396127988

Xu, B., Rourke, L., Robinson, J. K., & Tanaka, J. W. (2016). Training melanoma detection in photographs using the perceptual expertise training approach. *Applied Cognitive Psychology*, *30*, 750–756. doi:10.1002/acp.3250

Yagerman, S., & Marghoob, A. (2013). Melanoma patient self-detection: A review of efficacy of the skin self-examination and patient-directed educational efforts. *Expert Review of Anticancer Therapy*, *13*(12), 1423–1431. doi:10.1586/14737140.2013.856272