Does Hearing About Cancer Influence Stimulus Control? An Exploratory Study of Verbal Modulation of Stimulus Generalization

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Published online: 2 May 2016

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Abstract Participants first became familiar with an image showing moderate symptoms of the skin cancer melanoma. In a generalization test, they indicated whether images showing more and less pronounced symptoms were “like the original.” Some groups (cancer context) were told that the images depicted melanoma and that the disease is deadly unless detected early. Control groups were not told what the images depicted. For control groups, generalization gradients were fairly typical of what is normally reported in the generalization literature, but for cancer context groups, gradients were shifted such that highly symptomatic moles were identified as “like the original” more than normal and subtly symptomatic ones were endorsed less than normal. These results may have implications for melanoma education efforts and, more generally, illustrate the possible importance of studying interactions between verbal behavior and primary stimulus control.

Keywords Stimulus generalization · Cancer · Melanoma · Verbal modulation

Cutaneous melanoma (referred here as melanoma) is a skin cancer that is readily treatable if detected early, but often deadly if allowed to progress (Geller, Swetter, Oliveria, Dusza, & Halpern, 2011; Kasparian, McLoone, & Meiser, 2009). It is most often detected through visual inspection of the skin, a process that, unfortunately, usually is unreliable when performed by persons other than dermatologists (e.g., U.S.

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Preventive Services Task Force, 2009). Among the goals of melanoma-focused public health efforts, therefore, has been to improve the ability of patients to discriminate skin symptoms that may indicate the development of cancer.

In traditional melanoma education, persons at risk for developing melanoma are told about the visually apparent symptoms that indicate a lesion that may be cancerous (see Friedman, Rigel, & Kopf, 1985; McWhirter & Hoffman-Goetz, 2013), often in conjunction with example images of lesions exhibiting clear melanoma symptoms. They are then told to watch for subtle skin changes that could indicate the early development of melanoma. One goal of our own research has been to understand how features of traditional patient-education interventions affect the relevant stimulus control.

Casual observation suggests that traditional interventions typically coningle two factors that, in the language of behavior analysis, may be described as follows. First, there is an attempt to establish stimulus control by features of cancerous skin lesions (moles) over responses such as “I’m sick and need medical attention.” This effort involves displaying images of obviously cancerous lesions (see Fig. 1). In this regard, patient education loosely parallels the structure of discrimination training, although it involves limited exemplars and often does not include examples of non-cancerous lesions. At the time of this writing, we examined ten public service web sites that provided downloadable melanoma educational materials or single-page descriptions of melanoma symptoms; the mean number of example images was about 2, with a range of 0 (text descriptions only) to 5, and only half included images of asymptomatic lesions. Our previous research has modeled the effects of this “discrimination training” by assessing gradients of generalization around the example stimuli. As the medical literature would suggest, we have found that this procedure does not reliably induce detection of subtle melanoma symptoms (Dalianis, Critchfield, Howard, Jordan, & Derenne, 2011; Miller, Reed, & Critchfield, 2015).

Second, patient-education efforts use verbal stimuli (descriptions of the health consequences of untreated melanoma) in an apparent attempt to manipulate motivating operations. For example, a brochure produced by the Melanoma Research Foundation, refers to melanoma as “life threatening” and “the deadliest form of skin cancer” (Fig. 1). The assumption underlying this approach appears to be that invoking aversive outcomes establishes negatively reinforcing functions for medically useful responses such as engaging in skin examination, detecting problem lesions, and contacting a physician (e.g., Meyerowitz & Chaiken, 1987). Unfortunately, a recent meta-analysis suggests that this approach actually has little to no reliable effect on the occurrence of behaviors like skin self-examination (O’Keefe & Jensen, 2009), and we are aware of no research on the effects of such messages on the efficacy of such behaviors when they do occur.

What *is* clear from the behavior analysis literature is that aversive stimuli control behavior in multiple ways. As anticipated in patient-education efforts, words like “cancer” tend to have pre-existing aversive associations (Barnes-Holmes, Maynooth, Barnes-Holmes, & Smeets, 2000; Mogg, Bradley, & Williams, 1995; Reinecke, Becker, Hoyer, & Rinck, 2010) that may support negative reinforcement. But aversive stimuli also generate emotional responses (Donovan, Jalleh, & Jones, 2003; Dunn, Patterson, Butow, Smartt, McCarthy, & Tattersall, 1993) that can create general behavioral disruption (e.g., Estes & Skinner, 1941). Moreover, in keeping with the tenets of stimulus relation theory, pairing cancer-related verbal behavior with example

ABCDEs of Melanoma

A Guide to Spotting Melanoma

ABCDEs of Melanoma
These basic guidelines are used by many dermatologists to help identify melanoma, the deadliest form of skin cancer.

Catching melanoma early could mean the difference between life and a life-threatening cancer. Knowing what to look for and performing regular self-skin exams may help you become more aware of unusual spots that should be brought to the attention of a dermatologist.

If you notice an unusual spot or a spot that has one or more of these characteristics, make an appointment with a dermatologist – preferably one who has experience with melanoma.

A – Asymmetrical Shape Melanoma lesions are often irregular, or not symmetrical, in shape. Benign moles are usually symmetrical.
B – Border Typically, non-cancerous moles have smooth, even borders. Melanoma lesions usually have irregular borders that are difficult to define.
C – Color The presence of more than one color (blue, black, brown, tan, etc.) or the uneven distribution of color can sometimes be a warning sign of melanoma. Benign moles are usually a single shade of brown or tan.
D – Diameter Melanoma lesions are often greater than 6 millimeters in diameter (about the size of a pencil eraser).
E	E – Evolution (or Change) The evolution of your mole(s) has become the most important factor to consider when it comes to diagnosing a melanoma . Knowing what is normal for YOU could save your life.

***It is important to note that not all melanomas fall within these parameters.**

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Fig. 1 Example of a patient-education brochure describing melanoma symptoms. Common features of patient-education media include a description of melanoma symptoms, one or more images illustrating those symptoms, and a description of health consequences associated with untreated melanoma. Reproduced by permission of the Melanoma Research Foundation and downloadable from <http://www.melanoma.org/sites/default/files/u13882/2015FactSheetUpdated3-16-15.pdf>

stimuli could transform images of skin lesions into aversive stimuli (Dymond & Rehfeldt, 2000). This constellation of outcomes makes it difficult to predict exactly how “cancer language” might influence stimulus control over melanoma detection behavior, and the present study was a first attempt at examining this.

As typically is the case in melanoma education interventions, our participants first became familiar with an example image showing moderately pronounced melanoma symptoms. Some participants were informed that the experimental stimuli represented melanoma symptoms and were told about melanoma's unpleasant health consequences. Other participants were shown the images free of this melanoma context. The resulting control by the example stimulus over detection behavior was evaluated in a generalization-testing protocol involving images of lesions ranging from less to more symptomatic.

Method

Participants

For participating, potential volunteers were offered bonus credit in Psychology courses. Upon expressing interest in the experiment, potential volunteers were given access to the online environment in which the study was conducted and asked to enter it within a week of volunteering. After 1 week, a reminder about the experiment was sent via electronic mail. Volunteers who did not begin the experiment within 2 weeks were excluded from participating.

A total of 173 undergraduate students (ages 18 to 23 years) volunteered. Because the images presented in the experiment were based on Caucasian skin, only individuals who self-identified as Caucasian or White were retained in the study. This reflected the heavily Caucasian demographics on the college campus where the study was conducted, and the fact that, although anyone can get melanoma, by far the most cases and deaths occur in persons with white skin (Centers for Disease Control and Prevention, 2016).

To limit the investigation to naive participants, those who indicated on a post-experiment questionnaire that that they, or someone they knew, had had skin cancer, were dropped from the experiment. Also dropped were participants in the neutral context groups that indicated on the post-experiment questionnaire that they recognized the stimuli as images of skin cancer. Twenty-eight individuals were excluded on these bases. An additional six participants were excluded when they showed no generalization to any stimuli and were therefore deemed to be a poor test of stimulus control as conceived here. Results from 139 participants (93 female, 46 male) are reported, in three groups of $N=34$ and one of $N=37$.

Settings, Apparatus, and Stimuli

Using Blackboard®, a web-based course delivery system used on many college campuses, participants completed the experiment from any convenient internet-enabled computer at a time of their choosing.

Two sets of stimuli were employed as a check of generality. The stimuli were created using a morphing software program (Morpheus Photo Morpher®; for more on stimulus construction, see Dalianis et al., 2011). For each set, a pair of benchmark images, obtained from melanoma education websites, showed an asymptomatic lesion and a clearly symptomatic lesion. Photo-editing software was used to separate each lesion

image from its original background and to substitute a pale pink background approximately the color of some Caucasian skin.

Stimulus set 1 and stimulus set 2 were based on different benchmark images (different pairs of lesions). For each stimulus set, the morphing program employed a linear algorithm to create a series of 98 intermediate images that combined features of the relevant benchmark images, with each step in the progression reflecting an equal amount of change from the previous image. In this sense, the images could be assumed to represent a fairly constant progression of symptom severity. We will refer to the stimuli as stimulus 1 (asymptomatic) through stimulus 99 (clearly symptomatic). On a 38-cm computer screen, the lesions ranged in diameter from about 4 mm (stimulus 1) to about 8 mm (stimulus 99). The stimuli varied in size because increase in diameter is one of the common symptoms of melanoma. Note that in public service media (e.g., Fig. 1), the example images often show four common melanoma symptoms intermingled: asymmetry of shape, border irregularity, varied coloration, and a size larger than about 6 mm (Friedman, et al., 1985). Ours did the same.

Based on the finding by Dalianis et al. (2011) that participants similar to ours could detect differences between stimuli separated by about seven steps in the symptom-severity progression, the present experiment employed stimuli 1, 8, 15, 22, 29, 36, 43, 50, 57, 64, 71, 78, 85, 92, and 99. Because of copyright protections, the actual images cannot be reproduced here. Figure 2 (based on low resolution, black-and-white art work rather than high resolution color photographs) provides a general illustration of how symptom severity increased with stimulus number, and how each stimulus set showed changes in each of the four major visual symptoms of melanoma (asymmetry of shape, border irregularity, color variation, and size).

Fig. 2 Images similar to those employed in the experiment, showing a continuum of melanoma symptom severity. See text for details

Procedure

To reduce the chances of past participants informing future ones about the purposes of the research, the neutral context groups were run first. As they volunteered, participants were assigned randomly to work with either stimulus set 1 or stimulus set 2. When a participant was dropped for any of the reasons noted above, the next volunteer was considered a replacement and assigned to the same group. Next, the cancer context groups were run. Participants were assigned as just described. Due to experimenter error, one group included three more participants than the other groups (stimulus set 1/ cancer context group, $N=37$).

Familiarization Phase

Familiarization with the “original image” and subsequent generalization testing were structured similarly to a procedure employed previously by Dalianis et al. (2011) and Miller et al. (2015). Participants entered Blackboard® using the same identifier and password used for online access to their confidential university academic and financial information. Upon entry, they provided informed consent and then read the following general instructions.

This is a study of visual perception. To begin with you’ll be shown a shape, called the “original shape,” and asked to familiarize yourself with it. Then you’ll see a series of additional shapes. For each, you’ll be asked to say whether it is the same as the original shape.

Four groups of participants were distinguished by the stimuli they viewed and the presence versus absence of “educational” text presented prior to viewing the stimuli. Participants in two groups viewed stimulus set 1 and those in two other groups viewed stimulus set 2. For each stimulus set, one group (neutral context) was given no explanation of the nature of the stimuli, while the other (cancer context) read the following printed information before stimulus presentation began:

Melanoma is the deadliest skin cancer. Among people who allow melanoma to spread to internal organs, the death rate is 80 % within 5 years. When melanoma is caught early, however, it most often is successfully treated. Thus, early detection of melanoma can save lives. Most cases of melanoma can be found by inspecting moles on the skin. Moles affected by melanoma tend to show the following symptoms: asymmetrical shape; irregular borders; variation in color; and diameter bigger than a pencil eraser. The “original shape” that you will see next illustrates all of these features.

For both stimulus sets, stimulus 50 was chosen as the “original stimulus” because it reflected a moderate level of symptom severity, allowing for measurement of participant responses to images showing both more and less extreme symptoms. During the familiarization phase, stimulus 50 from the appropriate set was presented along with this instruction: “This is the original image. Please study it until you are very familiar

with it. When you have accomplished this, click the GO ON button to proceed to the next part of the experiment.” Each participant was free to examine the image for as long as desired.

Discrimination Training

In order to verify attention to the “original image,” participants completed a ten-trial discrimination procedure, on each trial of which was displayed either stimulus 50 or a black square on the same background as used for the main experimental stimuli. Trials employed the quiz function of Blackboard® and presented match-to-sample trials in the form of multiple-choice questions. On each trial, one stimulus was presented and the response options, or comparison stimuli, were the statements, “Same as the original image,” and “Different from the original image.”

A trial lasted until a response was made, which produced printed feedback indicating that a participant’s choice had been “Correct” or “Wrong.” All but nine of the participants answered correctly on all trials; those participants were required to repeat the ten-trial block to get a perfect score, which demonstrated that, according to conventional definitions, stimulus 50 was an S+ that differentially controlled responding.

Generalization Testing

Generalization testing, using stimuli from the same set as the “original stimulus,” proceeded identically for all participants and began with these instructions:

Now it is time to use what you have learned about the original image. You will see a series of images. For each, please say whether it is the same as the original image. You will not be told whether your answers are correct. Please just do the best you can. This test is broken into three parts. After each part you are encouraged to take a brief break.

Each of the generalization test’s three parts consisted of three 15-trial blocks (grand total of 135 trials). In each trial block, the 15 stimuli from the relevant set were presented in random order without replacement. After the first 45 trials, a message stated, “That concludes Part 1 of the test. This is a good time to stretch your legs or take a brief break.” After the next 45 trials a similar message prompted another short break. After the final 45 trials a message stated, “That concludes the test. There is only one more brief task left in the experiment. Click GO ON to proceed to the final task.”

Because Blackboard® does not include temporal controls for creating a conventional intertrial interval, test trials were separated by a filler item that presented an image of an animal and asked whether the participant found the image to be “pleasant” or “unpleasant.” The purpose of these trials was to separate melanoma trials by brief interval (approximately 2 s in duration during pilot testing) and to force visual attention to something other than melanoma lesions, thereby creating a mask that could reduce carryover of stimulus control between melanoma trials.

Questionnaire

In the final task, participants were asked to provide demographic information (age, gender, academic major, and self-identified racial and ethnic categories) to indicate which of a list of medical conditions, including skin cancer, had been experienced personally or by someone they knew and to say what they thought the images represented. Thereafter a message stated, “Thank you for participating in our study. You may now exit from Blackboard.”

Results

Figure 3 shows the mean number of times, out of a possible 9, that participants in the four groups selected “like the original image” in the presence of each of the 15 test stimuli (hereafter, for economy of presentation, we will refer to this as *endorsing* each stimulus as “like the original”). As is typically reported in stimulus generalization research (Ghirlanda & Enquist, 2003; Honig & Urcuioli, 1981), participants in the neutral context groups most often endorsed S+ (the original image). Endorsement of other images was a positive function of their degree of similarity to S+, and mean generalization gradients were approximately symmetrical, with patterns of endorsement roughly similar for stimuli that were less and more symptomatic than S+. More symptomatic stimuli were slightly more likely than less symptomatic stimuli to be endorsed as “like the original.” Such mildly asymmetrical gradients are common in stimulus generalization research (Ghirlanda & Enquist, 2003) and our previous studies involving melanoma images have yielded similar gradients (Dalianis et al., 2011; Miller et al., 2015).

Mean generalization gradients for the cancer context groups were distinctly asymmetrical, with enhanced endorsement of images that were more symptomatic than S+. To verify the visually apparent effects in Fig. 3, for each stimulus set, the number of endorsements of each stimulus was compared for the neutral context and cancer context groups using one-tailed *t* tests for unpaired scores with Welch’s correction. On the

Fig. 3 Gradients of stimulus generalization. Numbers on the abscissas represent the position of a stimulus on a continuum of symptom severity. Stimulus sets 1 and 2 were constructed using the same morphing procedure but based on different pairs of images. See text for details about the stimuli. Asterisks below a stimulus number indicate that outcomes were significantly different for the cancer context and neutral context groups

abscissa of each panel of Fig. 3, an asterisk designates a comparison in which the groups were significantly different with alpha set at 0.05. For both stimulus sets, significant differences were found for several of the more symptomatic stimuli (right side of the generalization gradient), with cancer context participants more frequently endorsing these stimuli. For both stimulus sets, cancer context participants also were significantly less likely to endorse S+ and at least one of the less symptomatic stimuli (left side of the gradient).

Interparticipant variability is common in generalization research (Ghirlanda & Enquist, 2003), and Table 1 shows that, for the number of endorsements of each stimulus as “Like the original,” standard deviations often exceeded the means, especially for the stimuli that were most different from S+. Thus, there were considerable differences in the generalization gradients produced by individuals in the same experimental group. Figure 4 summarizes the types of generalization gradients produced by individual participants. For each participant, the difference was determined between the number of total endorsements for stimuli 1 through 43 (generalization to stimuli that were less symptomatic than S+) and the number of total endorsements of stimuli 57 through 99 (generalization to stimuli that were more symptomatic than S+). This difference was then considered as a percentage of the total number of endorsements of all stimuli other than S+ (i.e., the amount of total measured generalization). If the resulting value was within the range of $\pm 33\%$, the individual’s gradient was labeled as roughly symmetrical. Participants with more extreme values were labeled as showing differential generalization to less symptomatic stimuli (consistent with a leftward gradient shift in the presentation format of Fig. 3) or to more symptomatic stimuli (consistent with a rightward gradient shift in the presentation format of Fig. 3). As

Table 1 Mean (standard deviation) number of endorsements of each stimulus during generalization testing

Stimulus	Stimulus set 1		Stimulus set 2	
	Neutral	Cancer	Neutral	Cancer
1	0.50 (1.52)	0.08 (0.28)	0.24 (0.61)	0.06 (0.34)
8	0.56 (1.56)	0.05 (0.23)	0.56 (1.56)	0.06 (0.24)
15	0.44 (1.50)	0.16 (0.37)	0.21 (0.59)	0.26 (0.71)
22	0.68 (1.67)	0.38 (0.83)	0.38 (1.13)	0.15 (0.50)
29	0.82 (1.57)	0.57 (1.39)	0.21 (0.69)	0.50 (1.14)
36	2.34 (2.51)	1.05 (1.29)	1.44 (2.29)	0.91 (1.82)
43	4.06 (2.83)	2.62 (2.60)	2.27 (2.63)	3.06 (3.06)
50	6.21 (2.66)	4.65 (2.83)	6.12 (2.90)	4.27 (3.13)
57	3.38 (3.23)	4.08 (3.02)	3.79 (2.89)	3.94 (3.14)
64	2.85 (3.32)	4.92 (2.79)	1.88 (2.50)	2.82 (3.36)
71	2.21 (2.87)	4.41 (2.95)	1.50 (2.45)	2.91 (3.42)
78	1.21 (2.09)	4.05 (3.83)	1.32 (2.31)	2.44 (3.22)
85	1.62 (2.62)	3.19 (3.45)	0.68 (2.14)	2.21 (3.44)
92	0.88 (1.98)	2.84 (3.38)	0.68 (2.07)	1.82 (3.10)
99	0.38 (1.58)	2.49 (3.44)	0.68 (2.17)	1.88 (3.24)

Fig. 4 Summary of individual outcomes, collapsed across the two neutral context and two cancer context groups. Abscissa labels refer to the type of gradient shift (if any) exhibited by individuals. See text for further explanation

expected based on Fig. 3, there was a slight tendency for neutral context participants to show a rightward shift. This tendency was magnified noticeably in the cancer context, with and about 50 % more participants showing differential generalization to more symptomatic stimuli (and about 50 % fewer participants showing differential generalization to less symptomatic stimuli).

Discussion

Traditional melanoma patient education usually includes a description of adverse health consequences, apparently in attempt to motivate more and better skin self-examination. Specifically, the goal of using “cancer language” in patient education is to facilitate the detection of subtle melanoma symptoms and thereby support early treatment that could improve medical prognoses. The present results suggest that “cancer language” influences stimulus control, although perhaps not always in ways that are clinically useful. Generalization testing evaluated the extent to which participants endorsed novel images of lesions as “like the original stimulus” (an image of a moderately symptomatic lesion). Verbal stimuli similar to what often is presented in patient education (Fig. 1) produced a gradient shift involving two effects: reduced endorsement of stimuli that were less symptomatic than S+, which runs counter to the goal of early detection, and enhanced endorsement of images that were more symptomatic than S+, which is medically appropriate but not relevant to the goal of early detection. Our results thus suggest that speaking of cancer and its unpleasant consequences (something that is hard to avoid in melanoma education) may actually reduce the odds that patients will detect subtle symptoms.

An interesting feature of our results is that, for many cancer context participants, the stimulus most frequently endorsed as “like the original” was not S+ but rather a

stimulus showing more extreme symptoms. This effect was evident in mean results for one cancer context group, and in the individual results of 45 of 71 cancer context participants overall. In this respect, gradients for cancer context participants bore similarity to those typically observed following discrimination training which contrasts an S+ stimulus in the moderate range of a stimulus dimension with an S– at one of the dimension's extremes (Ghirlanda & Enquist, 2003; Honig & Urcuioli, 1981). Recently, Miller et al. (2015) replicated this gradient-shift effect with melanoma stimuli similar to those of the present study, and the results were very similar to those of the present cancer context groups, for which there was no experimentally programmed S–. Thus, many participants in the cancer context groups behaved *as if responding to an S–* that was not part of our procedure, at least not in the way that S– conventionally is defined (e.g., Dinsmoor, 1985).

That the preceding occurred is evident. Why it occurred is unclear but, speaking loosely, it is possible that once our participants learned what *is* dangerous, the “cancer language” instructional set helped them derive (“know”) what is not dangerous. We can identify at least three kinds of verbal effects that could have contributed to this outcome. First, it is known that instructions can establish simple discriminative functions (Catania & Shimoff, 1998), which could include establishing an otherwise neutral stimulus such as Stimulus 1 as S–. Second, it is known that instructions can create equivalence classes (e.g., Smyth, Barnes-Holmes, & Barnes-Holmes, 2008), and some aspect of the current instructions could have placed Stimulus 1 into a class with extra-experimental stimuli that function as S– for different stimulus dimensions. Discriminative functions can propagate through the members of stimulus classes (e.g., Barnes & Keenan, 1993), and stimulus 1 could have acquired an S– function in this way. Third, it is known that relational repertoires can become generalized and therefore applicable to novel stimuli when the right contextual cues are in place (e.g., Healy, Barnes-Holmes, & Smeets, 2000), and words could function as a contextual stimulus for generalized non-equivalence relations such as “not” or “opposite to.”

Given that words acquire their behavioral functions via a lengthy, and largely unknown, extra-experimental history, it is difficult to determine which aspects of the cancer context instructional set might have influenced responding in what way, but we can suggest two features that may be worthy of attention. First, the instructions described critical features of S+ (asymmetrical shape, irregular borders, variation in color, and a diameter bigger than a pencil eraser). Second, consistent with a common practice in public service media, our cancer context instruction set stated that, “When melanoma is caught early... it most often is successfully treated.” When presented adjacent to text indicating that untreated melanoma is deadly, this could be taken as describing an “opposite to” relation, suggesting that stimuli with symmetrical shape, regular borders, uniform color, and small diameter (as per stimulus 1) should be responded to differently than S+. The preceding suggests that gradient shifts were created, not by “cancer language” per se, but by contrasting cancer information with information about more desirable health outcomes. If this is correct, the rather counterintuitive implication is that better outcomes could be achieved with patient-education materials that invoke cancer and its unpleasant health consequences but do not mention the benefits of early detection. A logical extension of the present research, therefore, would be to replicate while omitting any reference to normal moles and desirable health outcomes.

Another avenue of investigation concerns whether verbal modulation effects we reported are dependent on peculiar features of our procedures. For example, if the effects depend on an association between words and adverse consequences of cancer, would the strength of that association depend on the severity of the example lesion that is displayed? Quite possibly, the gradient shift we observed would have been reduced with a less symptomatic S+. Also potentially relevant are the presence of an explicit S– stimulus during discrimination learning (recall that some public service media display both symptomatic and asymptomatic lesions). For example, as Miller et al. (2015) found, an S– stimulus at one extreme of the dimension in which S+ is centered tends to shift the gradient toward the other extreme. In the present case, had an asymptomatic lesion served as S–, would this have magnified the verbal modulation effect we report here? Had a severely symptomatic lesion served as S–, would this have counteracted the verbal modulation effect? Or would some complex interaction be observed? Clearly this is a useful focus for future research.

Any effort to replicate and extend the present study must contend with the substantial interparticipant variability that we observed. This variability could exist because the relevant effects are inherently weak, as might be expected when a manipulation involves only antecedent control, or because the effects vary in strength with participants' idiosyncratic verbal histories. At least part of the variability in our results probably traces to the uncontrolled environments in which our participants worked (many reported working at home or in public places like the library and student union). This feature of the study was inspired by the fact people at risk of developing skin cancer probably examine their own skin in similarly uncontrolled settings. Obviously, more orderly effects are expected in better controlled settings (Miller et al., 2015), which would be simple to employ in future investigations.

In conclusion, standard melanoma patient education is an inherently verbal intervention but, as the present findings suggest, one that is not adequately understood. The tools and principles of behavior analysis have only just begun to be employed toward determining how to establish effective repertoires of melanoma symptom detection. Before useful interventions can be developed, translational research (Mace & Critchfield, 2010) is needed to determine the behavioral processes that are involved. The needed research would have an obvious applied focus but would also have theoretical relevance. Ironically, although a considerable amount of research has examined the role of verbal relations in complex stimulus control (e.g., Dymond & Rehfeldt, 2000; Horne & Lowe, 1996; Lowenkron, 1989), relatively little attention has been devoted to the impact of verbal relations on primary stimulus control. Existing studies cannot be considered a coherent literature because they rarely refer to one another and they rely on varied theoretical frameworks and experimental procedures (e.g., Buss, 1962; Dymond & Barnes, 1998; Galizio & Baron, 1976; Howard, 1979; Spiker, Croll, & Miller, 1972; Thomas & Thomas, 1974; Vervliet, Kindt, Vansteenwegen, & Hermans, 2010). Yet if verbal relations can override and modify the effects of consequences (Catania & Shimoff, 1998), they are likely to matter in the primary stimulus control phenomena that consequences help to establish, and some of the aforementioned studies can be interpreted as indicating that they do. In the most general sense, then, the present results may be useful in drawing attention to this potentially fertile area for future research.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no commercial or other conflicts of interest relevant to this manuscript.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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