AN EVALUATION OF ATTENTIONAL SCANPATHS ACROSS DRUG LABELS USING CHANGE DETECTION AND EYE TRACKING

By

Cory Jay Wilson

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ABSTRACT

AN EVALUATION OF ATTENTIONAL SCANPATHS ACROSS DRUG LABELS USING CHANGE DETECTION AND EYE TRACKING

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Medication errors can occur when drug labeling fails to communicate critical information necessary for safe and effective use. Tracking the eye's visual scanpath across drug labels affords investigation into attentive behavior to identify attention assets and deficits. Eye-tracking and change detection methodologies were combined in this study to examine attentive behavior in the context of drug labeling during visual search. Twenty-six participants viewed images on a computer screen of six mock drug labels that were designed based on 6 commercially available pharmaceutical products.

Labels were sectioned into a 3 x 3 grid (9 square zones, top-left, bottom-right, center, etc.) during analysis. Post hoc pairwise comparisons indicated the center zone (zone 5, center of label) garnered significantly more visual hits ($P<0.0001$) and time in zone ($P<0.0001$) than any other zone. The center zone was also the fastest zone fixated on by participants ($P<0.0001$). Scanpath data showed agreement and also indicated frequent fixation on the center zone throughout the visual search task. The bottom-right zone (zone 9, bottom-right corner of label) was consistently grouped among the lowest in terms of attention. Information design implications are discussed.

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CHAPTER 1 – LITERATURE REVIEW

Introduction

In a report that gained national attention in 1999, the Institute of Medication (IOM) estimated that at least 7,000 deaths occur each year in hospitals alone due to medication errors [1]. In the time since, the prevalence of medication errors and issues of noncompliance have been well documented [2] and federal prevention programs have been charged with reducing error rates.

Medication error is defined as “any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in control of the health care professional, patient, or consumer” [2]. Labeling is one way to convey information critical to the safe and effective use of a drug. The importance of this strategy cannot be underestimated due to the fact that it stays with the product, providing timely information at the point of use [3], in an accessible and affordable way [4]. Drug labels are intended to convey critical information to health care providers, pharmacists and consumers; thus the noticeability of this information is essential for safe and effective use [1, 5]. The noticeability of information is dependent on its capacity to garner an individual’s visual attention [6].

Visual Attention

Visual attention is a process through which awareness is obtained by cognitively organizing and then interpreting visual elements, or stimulus information, within the

visual field. The process of visual attention operates by means of parallel and serial processing of information. During parallel processing, visual attention is broadly distributed wherein multiple stimuli can be spatially processed in terms of contextual organization of information. Visual attention can also narrow selectively during serial processing where details of specific visual elements are the focus. Parallel and serial processing of information distinguish two functionally independent hierarchical stages of visual attention [7].

Pre-attentive parallel processing

The first stage is described as a pre-attentive state where parallel processing occurs across the entire visual field. Processing during this pre-attentive state functions simultaneously across various spatial locations, divorced of strategic control and in unlimited capacity [8]. Spatial orientation of rudimentary information is elucidated such that prominent characteristics of stimuli in the visual field can garner selective attention.

Attentive serial processing

The second stage of visual attention is a focused, attentive state where serial processing of a selected spatial location occurs. Processing during this stage operates with limited capacity and within a limited spatial area [8]. During the first pre-attentive stage, multiple visual elements have the potential to garner attention, while attentive serial processing represents the focused extraction of information once an element has gained selective attention.

Selective Visual Attention

Selective visual attention operates by appropriating available visual field processing resources from a broad field to a more concentrated spatial locus. There are at least two prevailing models that describe the general behavioral mechanisms of selective visual attention [9].

The Spotlight Model

The spotlight model describes selective visual attention as comprised of a focus, fringe, and margin elements [10]. The focus is a geometrically centered and limited area of high resolution from which visual attention is precisely directed and detailed information can be extracted. Low resolution gradations that extend from the outer boundary of the focus area form the fringe area and predispose visual attention to rudimentary information. The margin frames the limits of the fringe area (See Figure 1).

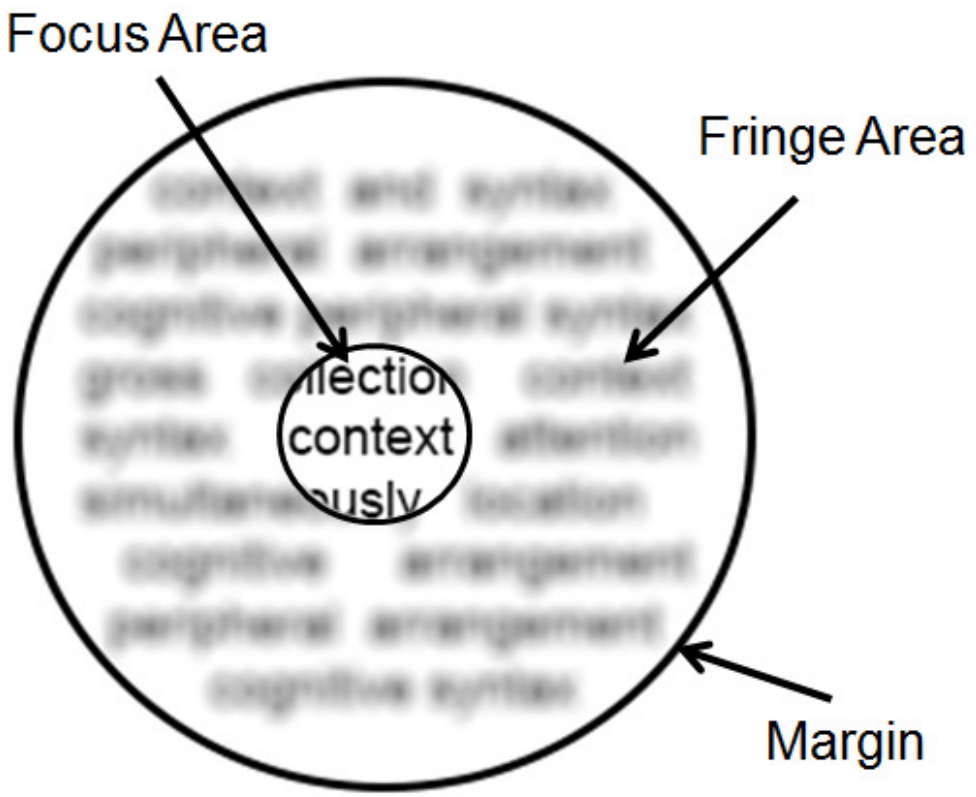


Figure 1 – Spotlight Model Representation

The Zoom-lens Model

The zoom-lens model incorporates all three focus, fringe and margin elements of the spotlight model with a size-change mechanism [11]. Under this model, the range of selective visual attention can be enhanced by changing the size of the focus area. Reducing the focus area allows for efficient processing of smaller visual elements while increasing the focus area allows larger visual elements to be comprehensively encompassed. The zoom lens, in essence, is a "sliding scale" between pre-attentive processing, where many things are attended but not focally processed, and selective visual attention, where limited items are selectively attended but heavily processed.

The processing capacity of the human visual system is limited by the distribution of finite resources. An increase in the size of the focus area will slow or reduce processing efficiency because our limited amount of processing resources will be distributed over a larger area. Thus, selective visual attention is characterized by focus area sizes that allow for a dense distribution of processing resources and facilitates fine detail extraction (See Figure 2).

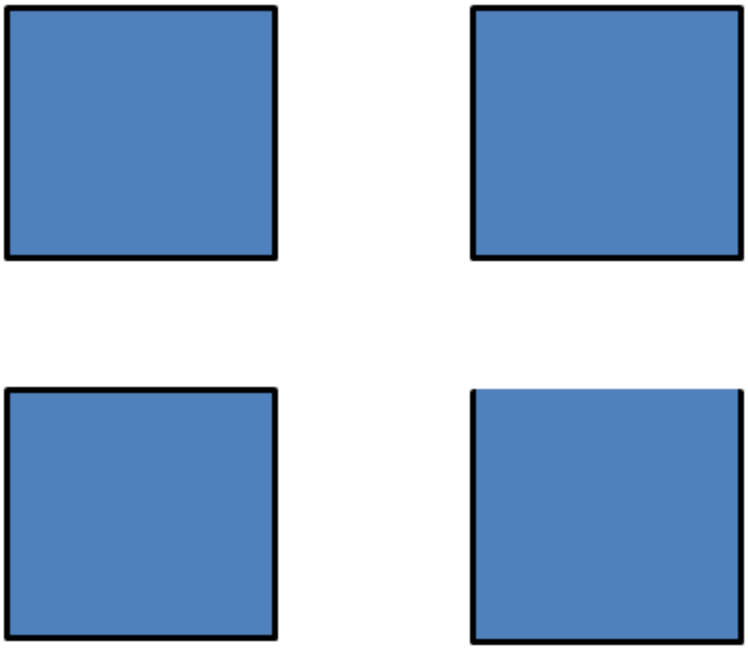


Figure 2 –Broad and selective attention: How many squares are pictured above? A broad distribution of attention allows you to easily see there are 4 squares that appear to be similar. Selective attention facilitates detail extraction; if you focus on the bottom-right square you can see it is missing the top of its black border. For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.

Inattentional Blindness

A consequence of visual attention that is directly selective is that in order to maintain avid focus, peripheral fringe information must be ignored. Inattentional

blindness occurs when elements that fall into range of our visual field fail to be noticed [12]. It is not possible to pay attention to everything we see because minimal processing resources are available to the fringe area of the visual field.

Fixation

To overcome our visual attention distribution limitations without losing detail resolution, the eye moves by shifting the locus of the focus area from one location to another. Fixation is a metric that can be used to measure visual attention by comparing relatively static eye behavior to dynamic eye movement. Fixation occurs when the locus of the focus area remains at a relatively stationary spatial location for a given amount of time. Specifics of fixation duration and location dispersion are arbitrarily defined and lack general consensus because our eyes are constantly in motion [13-16]. Very rapid involuntarily micro movements (micro-saccades, ocular drifts, and micro-tremors) of ocular motor behavior occur as part of our natural physiology [17]. The generally accepted practice is to define fixation with relation to saccadic movements.

Saccadic movements

Saccades are the linear bridges of eye movement between fixations. While fixations are relatively stationary, saccades are characterized by their displacement length and directional velocity over a very short period of time. Information extraction is not a principal function of saccadic movement although low level rudimentary processing may occur. Eye movements are generally distinguished as either saccades or fixation components that help illustrate visual search dynamics and, ultimately, demonstrate visual attention behavioral patterns (See Figure 3).

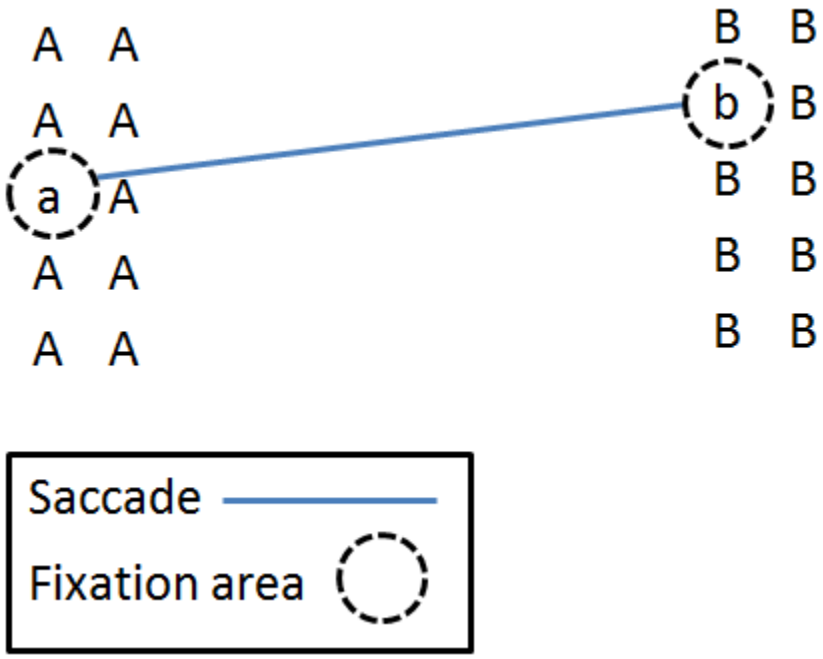


Figure 3 – Fixation and saccade components demonstrating visual attentive behavior

Visual Search

Mapping visual search can give researchers insights into behavioral models of visual attention. Search behavior can be primarily guided by the noticeability of elements in our visual field or by goal oriented control of the viewer [18-20]. There are two processes that describe these effects.

Bottom-up processing

Bottom-up processing refers to involuntary, stimulus-driven attentive behavior. Prominent attributes, such as a sudden motion, can capture attention whether we want to attend to it or not. Visual attention is spatially directed by stimuli attribute cues within the visual field.

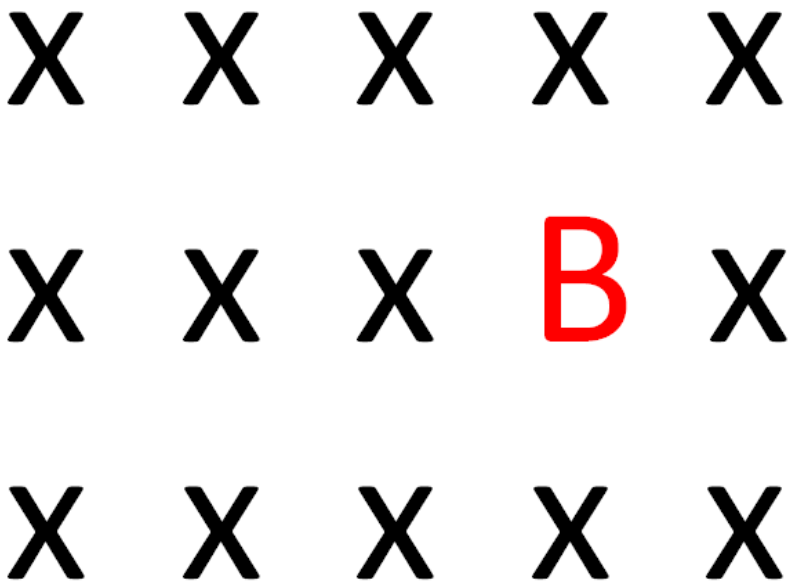
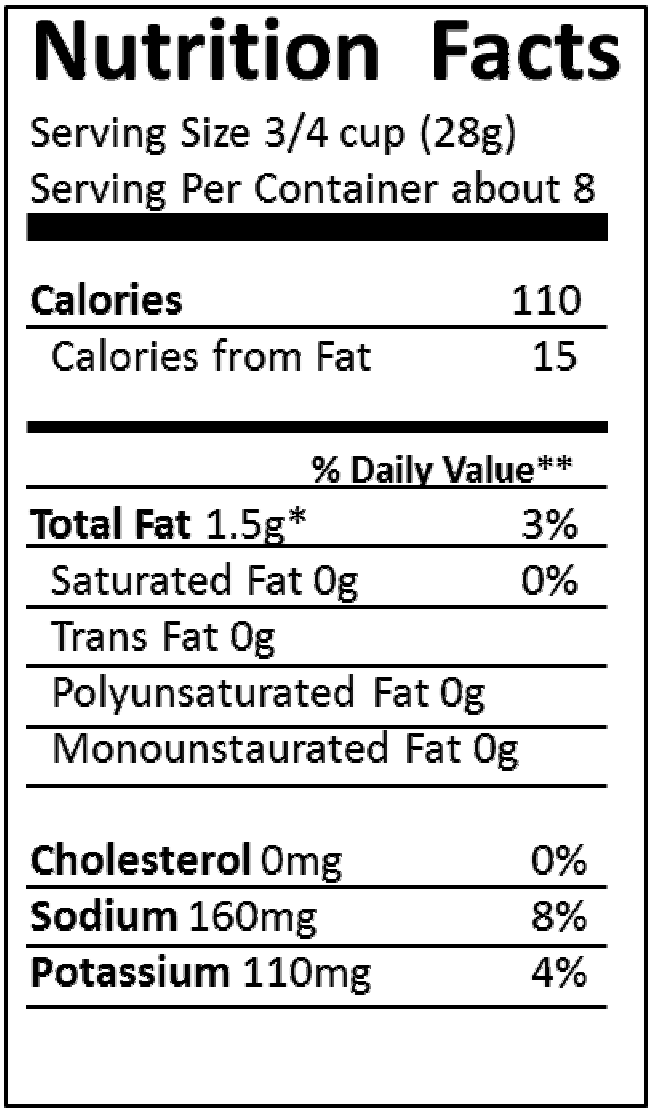


Figure 4 – Bottom-up processing example: The prominent features of the large red letter B directs and draws your attention more readily than any of the individual X's.

Top-down processing

Visual search can also be goal-driven. Top-down processing directs search behavior contextually under the viewer's explicit control. Goal-driven search behavior involves cognitive processing aspects of conflict resolution, working memory and inhibition to parse information and cultivate attentive decisions while pursuing a related objective.



Nutrition Facts

Serving Size 3/4 cup (28g)
Serving Per Container about 8

Calories	110
Calories from Fat	15
	% Daily Value**
Total Fat 1.5g*	3%
Saturated Fat 0g	0%
Trans Fat 0g	
Polyunsaturated Fat 0g	
Monounstaurated Fat 0g	
Cholesterol 0mg	0%
Sodium 160mg	8%
Potassium 110mg	4%

Figure 5 – Example of Top-down processing: Specific nutrition information draws contextual attention. A hypertensive person concerned about sugar consumption would implicitly decide to direct their attention towards carbohydrates information when making a purchasing decision.

Center of Gravity

Another important element of visual search is the tendency to cognitively balance the sum total of stimulus elements in our visual field and orient (or gravitate) towards the

center of their collective mass [21, 22]. This center of gravity tendency allows the visual system to frame information and begin to build spatial relationships.

Figure 6 – Center of gravity example: The eye tends to drop lower to center its vision as we look from left to right at each individual square, even though both squares sit on the same plane.

Studies of Visual Attention and Drug Labeling

Studies of drug labeling related to visual attentive behavior investigate the relative prominence and effective communication of label information. Researchers employ methodological approaches that attempt to characterize the conspicuousness and comprehension of drug label information.

Conspicuousness and Comprehension

As previously mentioned, fixations are generally employed as measures that can describe characteristics of visual attentive behavior. The faster a stimulus is visually fixated on suggests greater conspicuousness or attention capturing properties [23]. The number of fixations a particular stimulus receives and the duration of each fixation are also descriptive of attention. However, it is an important to understand that attention

does not necessarily signify comprehension, but comprehension issues can affect attentive behavior.

Studies investigating comprehension distinguish attention as a precursor to comprehension and develop structured tasks amenable to analysis of specific goals and objectives. In one study participants were asked to perform several tasks that required them to visually fixate on a stimulus, extract information from it and make a response based on the assimilated stimulus information. Results suggested a link between fixation duration and stimulus processing time [24]. Prolonged fixation duration can indicate difficulty in extracting information. In another study, it was also found that high rates of fixation to a particular area can be indicative of difficulty extracting meaningful information [25]. As such, researchers must consider comprehension issues as a dynamic that can influence attentive behavior. Several factors that can influence visual attentive behavior by affecting the conspicuousness and/or comprehension of information are commonly researched in drug label studies, including health literacy, legibility, content format, and content accentuation.

Legibility

Drug labels contain a myriad of information such as warnings, instructions for safe and effective use, active ingredients, expiration date, etc., that all have to compete for limited label space to be displayed. Several information design approaches exist to address this issue, including; using varying font sizes, relocating specific information to secondary labels, and the use of foldout or extendable labels and tags. Legibility

concerns arise when drug label content is constricted and lacks adequate print surface area conducive to discernable presentation and readability of information.

The prevalent focus of most drug label legibility studies is examining the characteristics of textual print. Research findings indicate font width, height and white spacing between lettering as key factors that impact drug label legibility. Studies have found proportionally smaller print sizes have negative legibility impacts on both young and elderly populations [26-28]. In one study, participants interacted with 12 labels of varying print sizes and white space amounts on two label formats (standard/extendable). Both young and elderly populations expressed preference for larger print types. Data suggested white space between lettering was more impactful on readability than print size for the younger population (likely because a wider range of print sizes were legible for that group); whereas for the elderly population print size was significantly more important in terms of legibility [29]. Although FDA (Food and Drug Administration) regulation for drug labeling specifies limits on minimum print font sizes, this is problematic because many font types of the same specified size vary proportionally.

Health Literacy

Low health literacy has increasingly become recognized as a patient safety issue. In one study [30] participants were presented with label instructions “Take two tablets by mouth twice daily”. Participants were tested to see if they could accurately read, recite and demonstrate the correct amount of medication according to the instructions. Only 34 percent of those at risk for poor health literacy could demonstrate

the correct amount of pills to take daily was four. The results of the study demonstrated an association between low health literacy and misinterpretation of instructions on prescription medication labels. Other studies evaluating people at risk for low health literacy and their ability to interpret instructions or warnings have found similar results [31-33]. The Institute of Medicine estimates that 90 million adults in the United States may have trouble comprehending medication labels [34].

Text and Pictorial Formats

Drug labels communicate information in the form of text and nonverbal graphic symbols or pictorials. Studies of visual attention related to text and pictorial formats have also shown that illustrations may increase visual attention, especially when the two formats communicate redundant information [35-37]. In one study, 234 patients who had visited an emergency room were given printed instructions after receiving treatment for lacerations. Patients were randomly given printed instructions with half receiving text instructions only and the other half given text instructions with the addition of illustrated information. Participants were interviewed by phone three days later and asked if they read the instructions, followed by a series of questions about the instructions. Patients who received printed instructions with illustrations were significantly more likely to report they paid attention to the instructions [38]. They also answered all the interview questions correctly at a significantly higher rate than those who only received text instructions.

In a related marketing study [39], participants were instructed to view print advertisements on a computer screen that contained both text and pictures while their

eye movements were tracked. Viewers were told to learn as much as they could about the products advertised under the guise of a purchase decision. Results showed participants fixated for longer durations on the images but had a greater number of fixations in the text part of the ad. More fixations do not necessarily mean more attention; higher fixation counts are typically observed when textual information is present because the eye fixates more when reading each word. It is important to distinguish text and pictorial information because visual attentive behavior varies between these presentation formats.

Content Accentuation

Products with similar looking and sounding drug names are common due to the abundance of products on the market that are constituted from the same drug families. For example, drug names Ephredrine and Epinephrine look similar while Benadryl and Benazepril sound similar. Drug name confusion is a known cause of incidents of medication error [40, 41]. Accentuation of drug names is a key part of strategic reduction of errors associated with drug name confusion.

The use of partial uppercase lettering known as “tall man” (I.E. ePHEDrine and EPINEPHrine) and the use of color are commonly researched. In one study [42], the use of highlight color versus tall man lettering against standard lettering controls was investigated across three experiments. In the first two experiments, participants were tasked with recognition of differences between word pairs that appeared on a computer screen. Data from experiment one and two demonstrated for recognition tasks tall man lettering does make look-alike drug names more distinguishable. The third experiment

consisted of memorizing a drug name list and recognition of names on the list when similar distractors were presented. Results from experiment three indicated tall man lettering and color do not make memory tasks less confusing but do increase attention. Tall man lettering has gained wide acceptance as a method to differentiate drug names that appear similar.

Study Approach

Visual search methodologies frequently characterize attention by presenting multiple visual stimuli and requesting that a viewer identify a particular stimulus as quickly as possible. Drug labels contain a large amount of information where comprehension issues can influence attentive behavior. To characterize attentive behaviors, we employed a change detection methodology combined with an eye tracking methodology.

Tracking a viewer's visual search behavior allows researchers to quantify visual attentive behavior and identify qualitative elements that influence it. Framing visual search tasks specifically with drug labels while tracking eye movement will afford investigation into visual attention as a contextual behavioral mechanism to identify attention deficits and assets that influence attentive behavior when viewing drug labels.

CHAPTER 2 – MATERIALS AND METHODS

The objective of this study is to determine the attentional scan paths of participants as they view novel designs, based on commercially available prescription drugs, in order to characterize attentive behaviors. Subjects were recruited with email fliers and by word of mouth to investigate this objective (See Appendix A for IRB approved flier). Subjects were excluded if they: were not at least 18 years of age, were legally blind, or had a known history of seizure.

Researchers provided participants with a verbal explanation detailing all test procedures. All participants were provided with an IRB approved consent form (IRB 11-980 - see Appendix A) which they were asked to review and sign. Consenting study participants were assigned a subject number and asked to wear any corrective eye wear they normally require for reading. After informed consent was obtained and subject number was assigned, demographic information was collected. All data collected from participants were identified by their subject number and no reference was made to subject number on the consent form. Collected data (See Appendix A for data collection form) included: gender, age, profession (work setting and history- if healthcare professional), education level, self-declared ethnicity, requirements for eyewear, prescription drug use, and familiarity with label brands the mock drugs were based on.

Subjects were then calibrated to the pan-tilt optics of our ASL (Applied Science Laboratories; Boston, MA) 504 eye tracker. This system consists of a small camera that sits in front of a computer monitor. The camera is equipped with a near infrared beam

that is directed into the eye of the subject that, upon calibration, enables the research team to detect where the subject is looking as they view images that appear on a computer screen.

Subjects were seated in a chair with no wheels at a desk with a large computer monitor (Hyundai 24.2 inch Model W242D). The desk was also equipped with an adjustable chin rest covered in foam to allow subjects to comfortably stay in position. Subjects were asked to rest their chin on the chin rest. Minor adjustments to the optics system and the chin rest were made, when necessary, so that they were comfortable for each subject. Researchers asked that the subject hold as still as possible while they calibrated the eye tracker using a nine-point calibration with a fixed grid. Having the subject remain relatively still (through the use of a chin rest) enabled the eye tracker to precisely track the position of the subject's eye in space and minimized parallax error.

After calibration, subjects viewed a series of “change detection” demo trials on the computer screen. Change detection tests were conducted with EPrime Software (Psychology Software Tools, Inc.). During change detection testing, a test image was shown on a computer screen, followed by a grey screen, then an altered image (the same as the first but slightly altered in a single locale) ending with another grey screen. This sequence: test image, grey screen, altered image, grey screen is shown in a continuous, iterating loop, giving the location of the change a “flickering” appearance. As such, change detection testing is sometimes referred to as a “flicker task.” (See Figure 7).

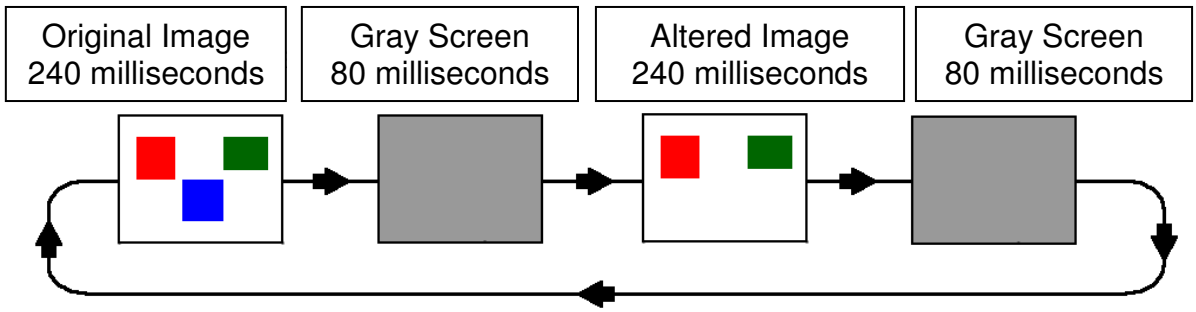


Figure 7 – Flicker technique sequence using change detection.

The EPrime software was set such that a test label image appeared on the computer screen for a period of 240 milliseconds, followed by a gray screen for 80 milliseconds, followed by the altered label image for a period of 240 milliseconds with a second gray screen at 80 milliseconds [6]. This sequence "loops," giving a "flickering" appearance in the area of change (See Figure 7) until the subject indicates that they have detected the change by pressing the space bar, or times out for the trial (at a period of 1 minute).

Subject testing commenced with two change detection “demo pairs” (See Figure 8). Researchers instructed, "This is a demonstration of the change detection software that will be used throughout testing. You will see two images flash over one another with a single change between the two. We are trying to see how long it takes people to notice changes in these images. Please hit the space bar on the computer as soon as you notice a change in the label." Timings from each of the two demo pairs were not analyzed in the final results, but used as an acclimation period as subjects became acquainted with the test protocol.

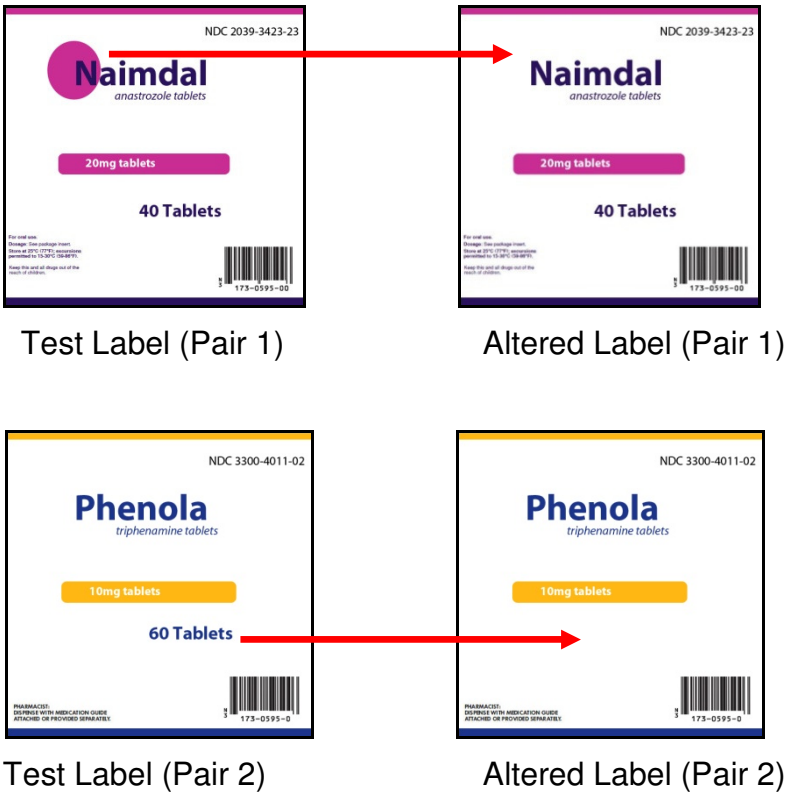


Figure 8 – Demonstration Labels: Two examples of demonstration label images and the change in the labels that takes place during the flicker technique. Visual layout example – text specifics are not pertinent.

After hitting the space bar, subjects were asked to click on the portion of the label that they saw change. The coordinates of the click relative to the label was recorded by the software enabling researchers to evaluate a correct (within a 50 x 50 pixel area) or incorrect response with regard to change location. The next trial started after the label had been clicked, regardless if the response was correct or incorrect. Correct and incorrect responses with regard to change location were coded (Yes/No) during analysis. In the event that subjects did not locate the change by pressing the space bar, the trial timed out after 1 minute, and the subsequent trial began.

After the demonstration trials, subjects viewed two sets of 27 flicker pairs (a total of 54 test trials) with a break between the two sets in order to allow for a period of visual rest. On-screen instructions “press any key to begin / continue” were presented and mirrored verbal instructions. After 27 flickers pairs were completed, an informational screen appeared instructing the participant to take a break to provide visual rest. During the break period, the subject’s visual acuity, color perception, and health literacy (a shortened version of the Rapid Estimate of Adult Literacy in Medicine REALM- R) were measured.

Each subject’s visual acuity was tested using a Dow Corning Ophthalmics Near Point Visual Acuity Card (See Figure 9). The card was placed approximately 16" from the subject’s eyes and they were instructed to read (aloud) the lowest line on the card that they could. In the event that the subject missed any of the letters within the line, they were asked to read the line above. This continued until they correctly identify all letters within a given line. Their visual acuity was recorded (20/20, 20/30, etc.) based on the results of this test.

Figure 9 – Dow Corning Ophthalmics Near Point Visual Acuity Card. Visual layout example – text specifics are not pertinent.

To examine the color perception of the subject, a set of 15 pseudo-isochromatic plates manufactured by Richmond products was shown to them during the break period. Subjects were instructed to indicate, aloud, what number, if any, is present on each card. Responses were recorded and tabulated. Each subject was classified as either at risk for color blindness or able to perceive color. (See Figure 10)

Figure 10 – Pseudo isochromatic plates (Richmond Products)

The Realm-R [43] is a shortened version of the REALM test (Rapid Estimate of Adult Literacy in Medicine). The original REALM test comprises a list of 66 words; the REALM-R consists of 11 words (See Table 1). The words were shown printed on a sheet of white paperboard using 20 pt. sans-serif font. Subjects were instructed to pronounce (aloud) each word on the list, and say "blank" if there was a word that they could not pronounce. They were scored based on their ability to correctly pronounce each word. However, the words fat, flu and pill were not scored because they served as an acclimation period. Subjects with a score of 6 or less were considered to be at risk for poor health literacy.

Table 1– Shortened version of the Realm-R word list

Realm-R (shortened version) word list	
fat	fatigue
flu	directed
pill	colitis
allergic	constipation
jaundice	osteoporosis
anemia	

As mentioned, during testing subjects were asked to perform two series of "flicker tests" that consist of 27 trials each, for a total of 54 flicker trials per subject with a brief visual break between the two sets. Subjects were recalibrated to the eye tracking equipment before beginning the second set of trials. Time to detect visual changes in a series of mock prescription drug labels was recorded as the dependent variable of interest for the change detection trials. Six mock drug brand labels were developed so that each a brand had nine images for a total of 54 tests per subject (See appendix B). Visual changes were distributed equally across all mock brands in order to examine the effect of location on a change's noticeability. To identify varied locations, grid lines were created such that nine zones were created. Each label image was broken down into a 3 x 3 grid, or 9 zones (not visible to the participants during testing, but used during the analysis, see Figure 11). Each square zone within the grid measured 200 x 200 pixels; as such, the total image/package was 600 x 600 pixels. Changes were created so that

they were approximately equivalent in each zone; i.e. the same number of pixels disappeared within each of the nine zones of the images.

All 54 pairs of stimulus images (six brands x nine zone locations) were created using Adobe Photoshop CS5. Square images were scaled to 600 pixels x 600 pixels so that the images appeared square at a screen resolution of 1024x768. The six mock brand labels consisted of white backgrounds and a black border. Each mock brand was designed such that all graphical and text elements distributed across the label were roughly equivalent (7,632 pixels/zone (+/-5%) in each of the nine zones of the label when it is apportioned into a 3 x 3 grid.

Figure 11 – Square format mock drug label image example: sectioned into a 3 x 3 grid, each zone contains approximately 40,000 pixels. Visual layout example – text specifics are not pertinent.

Each change was composed of 1,789 pixels (+/-4%) that represented graphic elements and/or text and “flickered” disappearing within a single zone. Order of presentation of the 54 trials was randomized across subjects.

Change detection provided two response variables for potential analysis (time to detect a change- variable data and binary data; ability to detect within the allotted time- detect yes/no). Multiple response variables were captured with the eye tracker for potential analysis. These included: the time spent in each zone, number of visual hits in each zone, time until each zone was first fixated on, and the order of gaze, i.e. which zone did the eye fixate on first, second, third etc. Order of gaze was analyzed via a 10 sequence scanpath because beyond the 10th sequence the data lost resolution due to the number of subjects tested and incremental complexity of each sequence.

Eye (gaze) tracking was conducted concurrently with change detection testing, and fixation was defined as four or more coordinate readings (66 milliseconds or greater) occurring within a 20 x 20 pixel range. These settings were based on the sensitivity of our equipment and previous research [44]. Visual hits, or when the eye’s gaze enters a zone, were defined as at least one reading within a given zone. Response variables characterized the attentional scan paths of subjects as they viewed prescription drug labels in order to establish “viewing patterns” so that placement of pertinent information can be identified.

CHAPTER 3 – ANALYTICAL METHODS AND RESULTS

Demographic Statistics

A total of 35 participants were tested for this research study. Four participants could not be calibrated and tracked due to the refractive properties of their eyewear or the size of their pupils. Five additional participants were eliminated from the data analysis because post-hoc evaluation of tracking indicated that for at least 10% of their total trial time their eye was not tracked. As such, demographic information and generated data for the remaining 26 participants were analyzed.

Of the 26 participants, 13 were male and 13 female. Twenty-two participants reported their ethnicity as Caucasian, two reported African American and two identified as Asian. Two participants reported their native language was not English. Table 2 provides frequencies by age and gender.

Table 2 – Number of participants by gender and by age

	18-24	25-34	35-49	50+	Total
Male	9	1	3	0	13
Female	6	3	3	1	13
Total	15	4	6	1	26

Prescription Medication Use

Participants were asked about their use of prescription drugs as part of the data collected form (See appendix A). Fifteen participants reported that they did not currently take prescription medication (57.7%), nine reported taking 1-2 prescriptions

daily (34.6%) and two reported taking 3 -4 prescriptions on a daily basis (7.7%). Participants were further polled about their familiarity with the products upon which the stimulus materials were based. Table 3 provides frequency reports of the participants, by gender, who indicated familiarity with these brands, which have been listed as A-F.

Table 3 – Participant Product Familiarity: Participants by gender that were familiar (I.E. brand name recognition) with the genuine brands upon which the mock designs were based.

Participants	Product A	Product B	Product C	Product D	Product E	Product F
Male	0	0	5	1	7	10
Female	0	0	5	0	5	7
Total	0	0	10	1	12	17

Perceptual Aptitude

Participants were tested for visual acuity, color perception and health literacy. Eleven participants indicated they wore either contact lenses or glasses (42.3%) when reading; these participants were instructed to wear correction during the testing. Thirteen participants tested at 20/20 vision (50%), 12 at 20/30 (46.2%) and one at 20/40 (3.8%). None of the 26 participants tested as at risk for color blindness. Three participants of the 26 (11.5%) tested at risk for poor health literacy based on the REALM-R results. Table 4 indicates characteristics of participants (labeled A, B and C) who were at risk for health literacy.

Table 4 - Participants who were at risk for health literacy

Participants	Gender	Age	Ethnicity	Native English Speaker	Visual Acuity	Product Familiarity
A	Male	18-24	Caucasian	Yes	20/30	None
B	Male	35-49	Asian	No	20/20	None
C	Female	18-24	Asian	No	20/30	None

Gaze Tracking Results

Each of the 26 participants viewed a series of 54 images (See appendix B) for a total of 1,404 change detection trials, as described in the Methods chapter. Zones 1 through 9 refer to specific equilateral sections (600 x 600 pixels) of the stimulus images (See Figure 12). Statistical analysis was carried out using The SAS System (SAS Institute Inc., Cary, NC, USA). The model included product (6 levels), gender (2 levels), zone (9 levels) and their interactions as fixed independent variables, while subject was considered a random factor in the analysis of variance.

Figure 12 - Zone spatial orientation and correspondence to square shaped stimulus images. Zone 1 (200 x 200 pixels) corresponds to the top left corner area of the image. Visual layout example – text specifics are not pertinent.

Visual hits to a given zone (an ordinal response), time spent in zone (a continuous response), and time to each first discrete zone fixation (a continuous response) were evaluated as dependent variables to characterize attentional behavior over the entire duration of the change detection trials. Analysis of residuals indicated that response variables time in zone, time to zone fixation, and zone hits were positively skewed. In order to fulfill model assumptions, time in zone data were square root-transformed for analysis, while zone hits and time to zone fixation were log-transformed.

Time in Zone

There was no evidence to suggest that gender impacted time in zone ($p = 0.9727$). Analysis indicated that the interaction term, product x zone was significant ($p < .0001$). The significant effects interaction term can be partially informed by the variance (See Figure 13) in the frequency of failed stimulus detection for products 3 and 6. Despite the fact that changes were purposefully created with the intent of being equal across all products (See methods, page 24), changes in products 3 and product 6 (See appendix B) were likely too difficult or subtle for people to detect, leading to significantly higher time in overall search (See Figure 14) for these items.

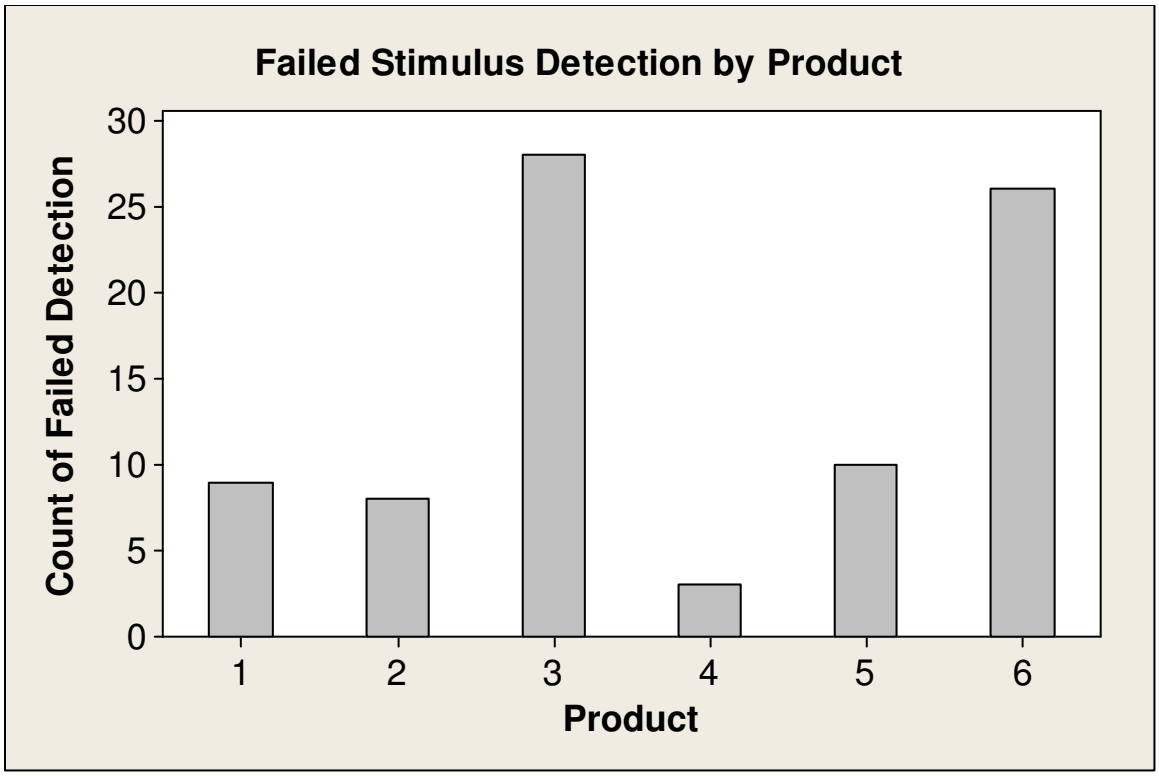


Figure 13 – Failed stimulus detection counts for each product. Certain change task stimuli in Products 3 and 6 were likely too difficult or subtle for people to detect.

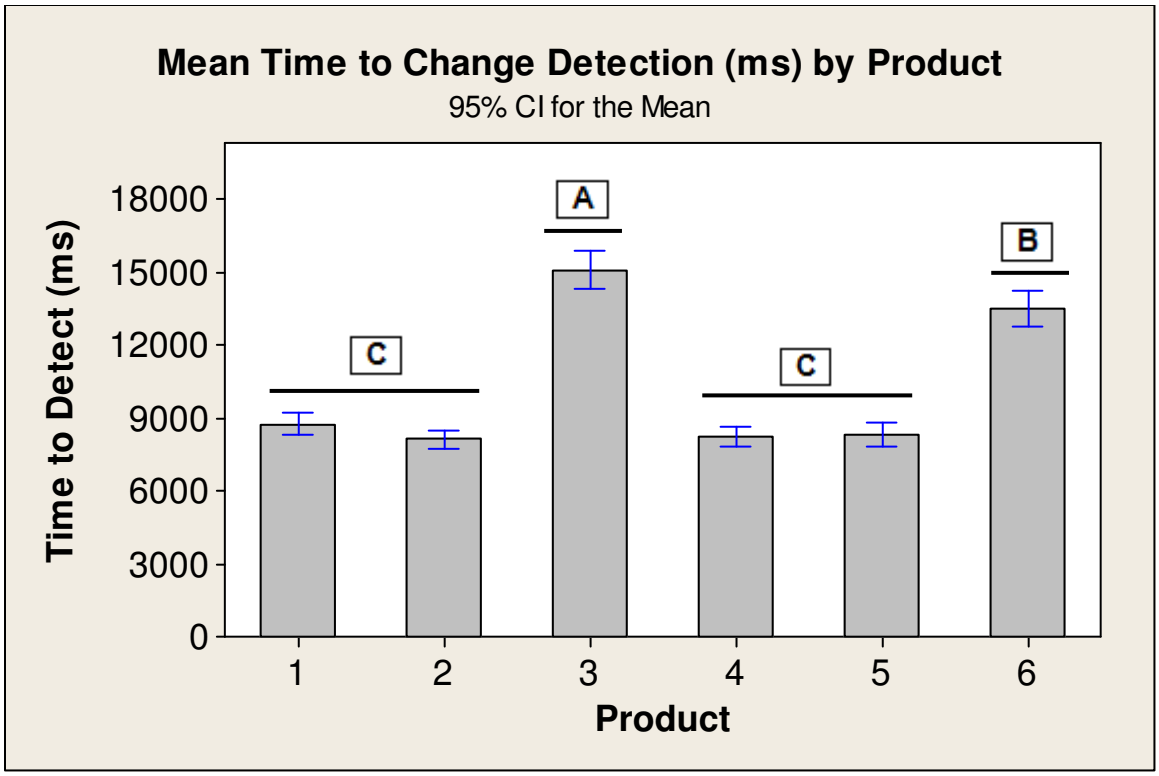
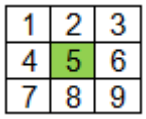
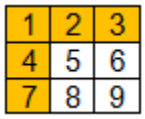
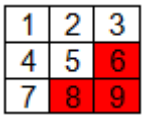


Figure 14 – Mean trial time to change detection by product (with 95% confidence intervals). Products 3 and 6 garnered significantly longer mean trial time due to higher rates of failed stimuli detection (different letters indicate statistical significance at α=0.05).

To account for product effects, time spent fixating in each of the nine zones was characterized as the average percentage of each trial's total time; in essence standardizing the response variable. Post hoc zone comparisons using Tukey HSD suggested three "thresholds" of viewing interest. The average percentage of time spent in zone 5 was significantly greater than any of the other 8 individual zones *($p < 0.001$)*. This zone, located directly in the middle of the package, accounted for approximately one-fifth (20%) of the time spent by subjects. Pairwise comparisons of the percentage of time spent in zones 1-4 and zone 7 did not yield evidence of significant difference (α=0.05), and as a group, three-fifths of the total time was spent by participants on

these five zones. A third threshold group was comprised of zones 6, 9 and 8 (the three zones that comprise the lower right corner of the stimulus images (See Table 5)). Study participants spent a significantly lower percentage of their viewing time in these areas and in aggregate only account for one-fifth of total fixation time).

Table 5 – Average percentage of time spent fixating in zones (sqrt transformed data; different letters indicate statistical significance at α=0.05).

Zones	Time in Zone (%)	ANOVA (Tukey)	Zone Representation
5	21.14	A	Greatest Attentional Time: 
7	12.66	B	
2	11.78	B	
3	11.55	B	
4	11.13	B	Intermediate Attentional Time: 
1	11.13	B	
8	7.98	C	
9	7.17	D	Minimal Attentional Time: 
6	5.47	E	
Total	100	*p<0.001*	

Visual Hits

Consonant with our previous results, when the response variable was visual hits to a given zone, there was no evidence of a significant effect of gender (p=0.6664), but a significant interaction term product x zone (p<0.0001) was indicated. However dropping product from our model did not increase the error associated with our means or impact our ability to observe significant effects within the response variable. When all products were considered in aggregate, post hoc zone comparisons using Tukey HSD indicated zone 5 (the center zone, see Table 6) garnered a greater percentage of hits

than any other zone, while zones 9 and 6 received the least amount of hits ($p < .0001$), with zones, 1-4 and 7 and 8 intermediate; following a similar pattern to that evidenced in the standardized time in zone data.

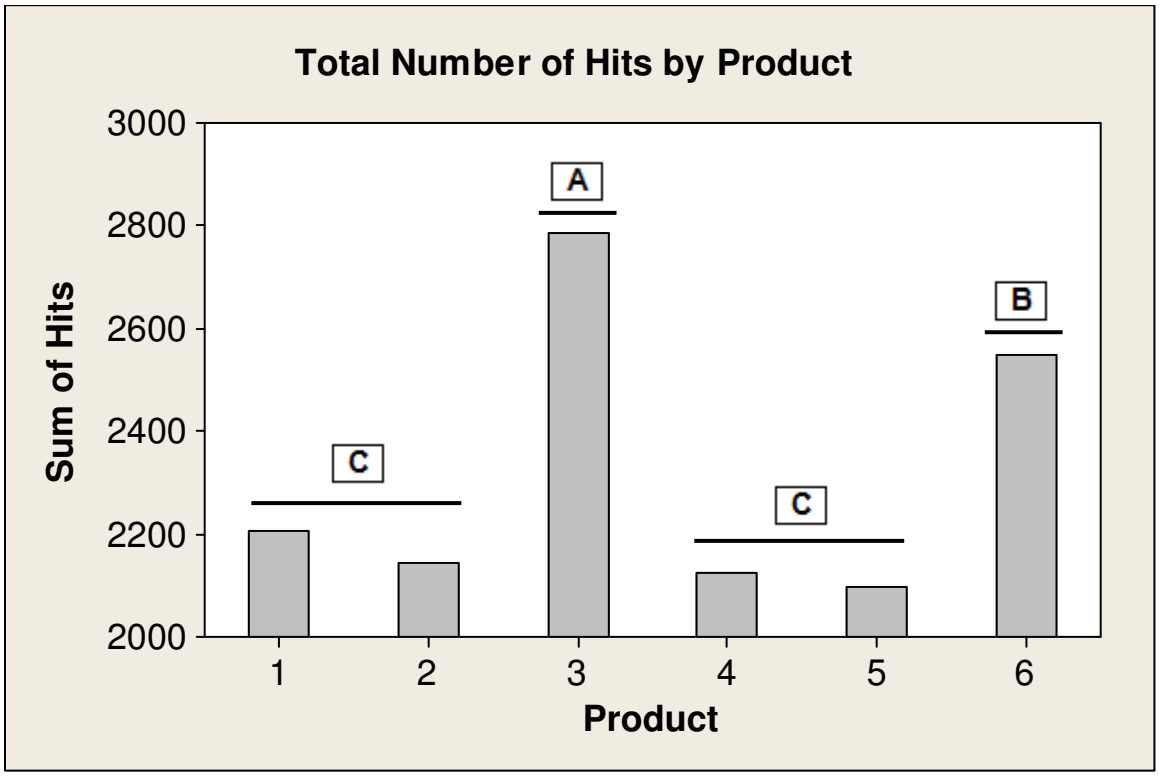
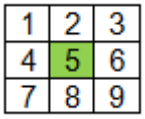
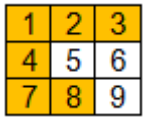
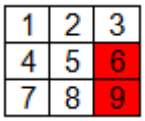


Figure 15 – Total number of visual hits across all subjects (back transformation of log-transformed data) categorized by product. Products 3 and 6 demonstrated significantly higher zone hit rates than the other 4 products, due to higher rates of failed detection (different letters indicate statistical significance at α=0.05).

Table 6 - Average percentage of hits by zone (log transformed data; different letters indicate statistical significance at α=0.05).

Zones	Hits per Zone (%)	ANOVA (Tukey)	Zone Representation
5	26.91	A	Highest Attentional Hits: 
4	12.34	B	
2	11.75	B	
7	10.87	BC	
1	9.55	C	Intermediate Attentional Hits: 
8	9.50	CD	
3	8.02	D	
9	5.72	E	Lowest Attentional Hits: 
6	5.34	E	
Total	100	*p<0.001*	

Time to Zone Fixation

When the response variable was time to zone fixation (or how long it took until a given zone received its first fixation) only zone 5 ($p < 0.0001$) was shown to be significant. Pairwise comparisons yielded six groupings of statistically significant unique zones based on the time to first fixation (See Figure 16). Zone 5 was fixated the fastest, while zones 1, 2 and 4 (the upper left hand corner) took significantly longer than zone five, but less than the next group comprised of zone 3, which induced statistically faster fixation than zone 7. There was no evidence of difference when zones 8 and 6 were compared but they were fixated significantly faster than zone 9 which was the last zone visually fixated. This suggests the possibility of a specific directionality or ordered search behavior within the context of the stimulus images.

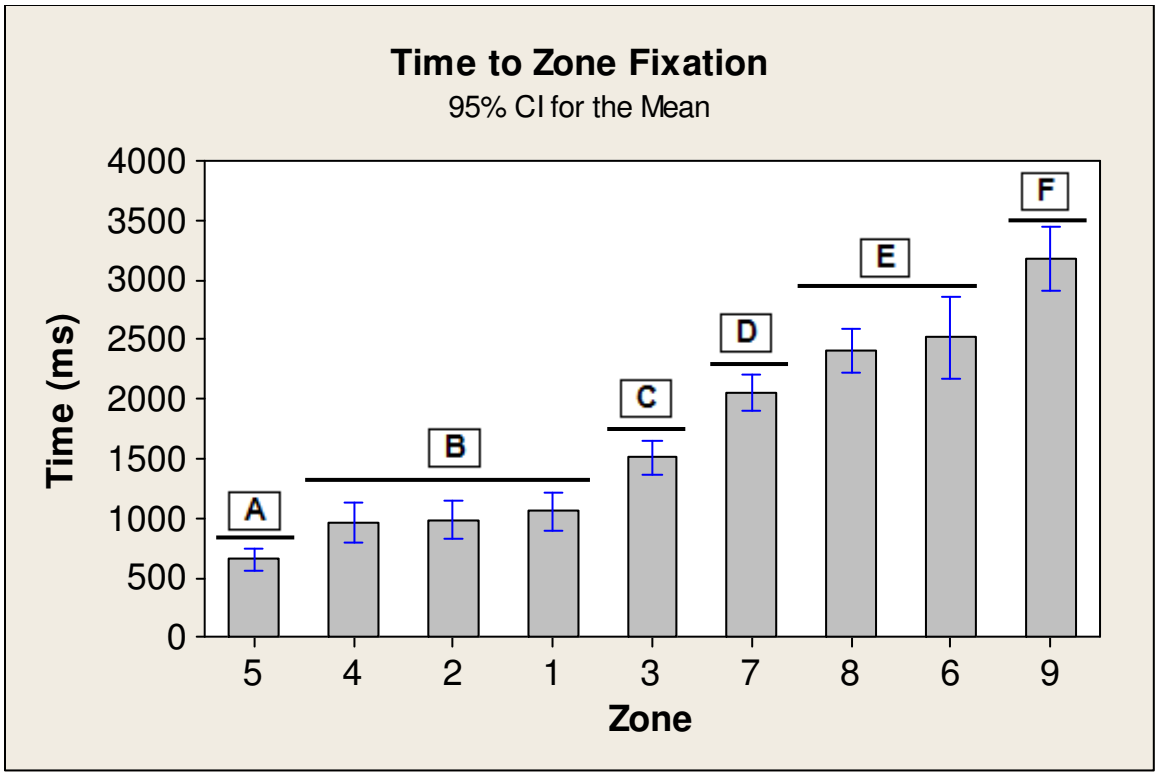


Figure 16 – Time to Zone Fixation: Mean elapsed time (log transformed data; with 95% confidence intervals and significance; different letters indicate statistical significance at α=0.05) until a particular zone is first fixated in.

Order of Gaze (Discrete Zone Fixation Order)

Directed by the previous results, order of discrete zone fixations (scanpath) was analyzed in a 10-sequence transition matrix. The first element in the scanpath indicates the specific zone where the first fixation occurs when a participant is viewing an image. The nth element indicates the nth discrete zone that is fixated (See Figure 17). Thus the scanpath represents sequential search order by zone.

Consider, for instance, the example scan path provided below:

Raw scanpath sequence: 6, 6, 6, 6, 4, 4, 4, 5, 5, 7, 7, 7, 7, 7, 7
Registered scanpath sequence: [1] 6, [2] 4, [3] 5, [4] 7

Figure 17 - Top: Raw scanpath output. Bottom: Numbers in brackets represent each sequential category (first discrete zone fixation, second… third.., etc.) in a 4-sequence scanpath; values to the right of the brackets indicate the actual discrete fixation zones obtained from the raw scanpath.

Scanpath Length

Length of scanpath sequences varied by trial due to variation within and between participants in visual scanning behavior, combined with nature of the change detection task, where the trial ends when the participant identifies the stimulus. Table 7 identifies the number of trials that generated a scanpath (by scanpath length: unique zone fixations). Four trials of the total 1,404 did not generate data due to user error or noncompliance (I.E. inadvertently pressing the spacebar in quick succession at the end of a trial thereby skipping the subsequent trial). Trials where the subject identified an incorrect detection area for the change stimulus were included as long as the trial generated a scanpath preceding detection.

Table 7 – Number of trials that generated a scanpath (by length which corresponds to the number of unique zone fixations recorded); Note: Four trials of the total 1,404 did not generate data due to user error or noncompliance.

Scanpath Length (unique zone fixations)	Number of Trials
--	1404
1	1400
2	1382
3	1343
4	1258
5	1173
6	1107
7	1026
8	950
9	875
10	795

Discrete Zone Fixation Order

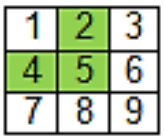
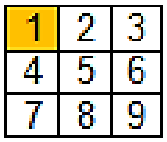
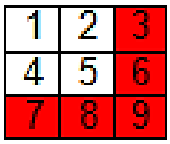
The dependent variable is the order in which discrete zone fixations occur. Chi-Square Goodness of Fit Test was used to determine if the distribution of discrete zone fixations fit the assumptions of a random distribution model. Chi-Square Contribution and Chi-Square Contribution Compliment were calculated to determine which specific zones were significant relative to the contribution of a particular outcome. Each of the nine zones can be described in terms of one of three outcomes. Discrete zone fixations for each zone can (1) occur at a frequency that is statistically significantly greater than a random distribution, (2) occur at a frequency that is not statistically significantly different from a random distribution or, (3) occur at a frequency that is statistically significantly less than a random distribution. Each of the nine zones of interest were analyzed and

described at each sequential category (first discrete zone fixation, second… third.., etc.) across a 10-sequence scanpath.

Scanpath: 1st Discrete (Zone) Fixation

There is evidence that the distribution of the first zone fixation across the nine zones of interest is not random c^2 (8, N = 1400) = 1549.09, p < .001. The first region participants fixated in was more likely in zones 5, 4, and 2, respectively, than the other six zones (See Table 8).

Table 8 (to 17) – First Zone Fixation: Zones with observed values greater than the expected values (of a random distribution model) and that have a chi-square contribution greater than the chi-square critical value (or chi-square contribution plus compliment if the contribution alone is not greater than the critical value) have a significant magnitude of effect that contributes to a non-random effect.

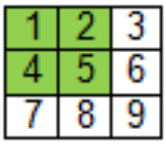
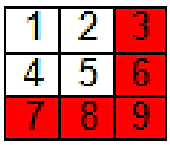
1st Discrete (Zone) Fixation		
Most Likely:	Random:	Least Likely:
		

Zone (Proportion = 0.1111)	Observed (Expected = 156)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	558	1041.18	3.841	--
4	267	79.84		--
2	212	20.48		--
1	143	1.01		1.35
6	66	51.56		--
8	46	77.16		--
3	45	78.57		--
7	42	82.90		--
9	21	116.39		--

Scanpath: 2nd Discrete (Zone) Fixation

Among the nine zones of interest there is evidence that the distribution of second discrete (zone) fixation is not random c^2 (8, N = 1382) = 539.767, p < .001. Fixation was more likely to occur in zones 5, 4, 1, and 2, respectively, than the other five zones (See Table 9).

Table 9 - Second Zone Fixation: Significant magnitude of effect for individual zones.

2nd Discrete (Zone) Fixation		
Most Likely:	Random:	Least Likely:
		

Zone (Proportion = 0.1111)	Observed (Expected = 154)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	292	124.820	3.841	--
4	264	79.437		--
1	239	47.545		--
2	231	39.058		--
3	117	8.702		--
7	79	36.199		--
6	73	42.260		--
8	61	55.788		--
9	26	105.958		--

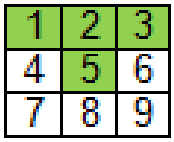
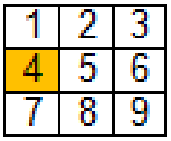
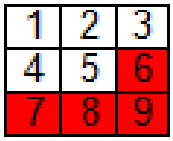
Scanpath: 3rd and 4th Discrete (Zone) Fixations

Distributions of the third discrete (zone) fixation c^2 (8, N = 1343) = 353.229, and fourth discrete (zone) fixation c^2 (8, N = 1258) = 210.202, $p < .001$ as indicated, were shown to be non-random. Fixation was more likely to occur in zones 5, 2, 1, and 3 across the third and fourth fixation distributions (See Table 10 and Table 11 respectively) than in the other 5 zones.

Table 10 - Third Zone Fixation: Significant magnitude of effect for individual zones.

3rd Discrete (Zone) Fixation				
Most Likely:		Random:		Least Likely:
1 2 3 4 5 6 7 8 9		1 2 3 4 5 6 7 8 9		1 2 3 4 5 6 7 8 9
Zone (Proportion = 0.1111)	Observed (Expected = 149)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
2	254	73.571		--
5	246	62.765		--
1	206	21.604		--
3	200	17.279		--
4	151	0.021	3.841	0.034
7	105	13.105		--
8	75	36.918		--
6	70	42.059		--
9	36	85.907		--

Table 11 – Fourth Zone Fixation: Significant magnitude of effect for individual zones.

4th Discrete (Zone) Fixation				
Most Likely:	Random:	Least Likely:		
				
Zone (Proportion = 0.1111)	Observed (Expected = 140)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	232	60.846		--
2	202	27.698		--
1	187	15.953		--
3	164	4.198		--
4	144	0.128	3.841	0.203
7	93	15.655		--
8	92	16.331		--
6	88	19.180		--
9	56	50.213		--

Scanpath: 5th Discrete (Zone) Fixation

The distribution of the fifth discrete (zone) fixation across the nine zones of interest also demonstrated non-random effects c^2 (8, N = 1173) = 159.223, p < .001. Fixation was more likely to occur in zones 5, 3, and 2 than the other six zones (See Table 12).

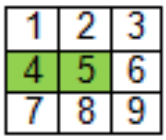
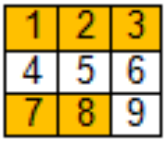
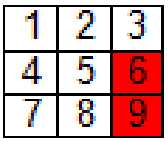
Table 12 – Fifth Zone Fixation: Significant magnitude of effect for individual zones.

5th Discrete (Zone) Fixation				
Most Likely:		Random:		Least Likely:
1 2 3 4 5 6 7 8 9		1 2 3 4 5 6 7 8 9		1 2 3 4 5 6 7 8 9
Zone (Proportion = 0.1111)	Observed (Expected = 130)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	224	67.315		--
3	177	16.709		--
2	163	8.188		--
1	129	0.0136		--
7	128	0.0418	3.841	--
4	116	1.576		2.509
8	95	9.579		--
6	78	21.014		--
9	63	34.786		--

Scanpath: 6th Discrete (Zone) Fixation

The distribution of the sixth discrete (zone) fixation demonstrated evidence of non-random effects c^2 (8, N = 1107) = 99.252, p < .001. Fixation was more likely in zones 5 and 4 than the other seven zones (See Table 13).

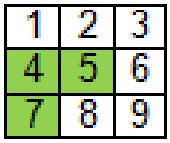
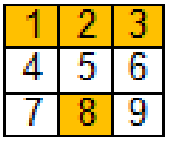
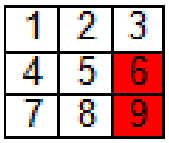
Table 13 - Sixth Zone Fixation: Significant magnitude of effect for individual zones.

6th Discrete (Zone) Fixation				
Most Likely:	Random:	Least Likely:		
				
Zone (Proportion = 0.1111)	Observed (Expected = 123)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	197	44.520		--
4	145	3.935		--
2	137	1.594		2.522
8	131	0.520		0.823
3	126	0.073	3.841	0.119
1	122	0.00		--
7	110	1.374		--
6	76	17.959		--
9	63	29.268		--

Scanpath: 7th Discrete (Zone) Fixation

Non-random effects were also evident across the distribution of the seventh discrete (zone) fixation c^2 (8, N = 1026) = 76.456, p < .001. Fixation was more likely in zones 5, 7, and 4 than the other six zones (See Table 14).

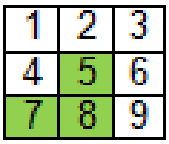
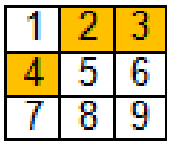
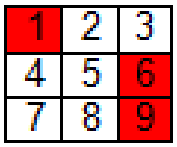
Table 14 - Seventh Zone Fixation: Significant magnitude of effect for individual zones.

7th Discrete (Zone) Fixation				
Most Likely:	Random:	Least Likely:		
				
Zone (Proportion = 0.1111)	Observed (Expected = 114)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	170	27.509		--
7	141	6.394		--
4	132	2.842		4.565
2	118	0.140		0.232
8	116	0.035	3.841	0.058
1	107	0.430		--
3	106	0.561		--
9	77	12.009		--
6	59	26.535		--

Scanpath: 8th Discrete (Zone) Fixation

Among the nine zones of interest the distribution of the eighth discrete (zone) fixation indicated non-random effects c^2 (8, $N = 950$) = 78.236, $p < .001$. Fixation was more likely in zones 5, 7, and 8 than the other six zones (See Table 15).

Table 15 - Eighth Zone Fixation: Significant magnitude of effect for individual zones.

8th Discrete (Zone) Fixation				
Most Likely:	Random:	Least Likely:		
				
Zone (Proportion = 0.1111)	Observed (Expected = 106)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	159	27.060	3.841	--
7	141	11.901		--
8	133	7.136		--
3	102	0.120		--
2	96	0.865		--
4	92	1.741		3.093
1	86	3.623		6.500
9	82	5.26		--
6	59	20.53		--

Scanpath: 9th Discrete (Zone) Fixation

Distribution of ninth discrete (zone) fixation by zone within the scanpath demonstrated non-random effects c^2 (8, $N = 875$) = 93.266, $p < .001$. First fixation was more likely to occur in zones 5, 7, 4, and 8 than in the other 5 zones (See Table 16).

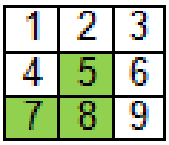
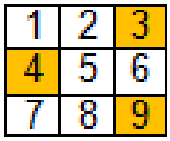
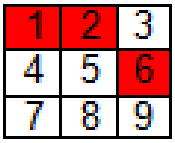
Table 16 - Ninth Zone Fixation: Significant magnitude of effect for individual zones.

9th Discrete (Zone) Fixation				
Most Likely:		Random:	Least Likely:	
1 2 3 4 5 6 7 8 9			1 2 3 4 5 6 7 8 9	
Zone (Proportion = 0.1111)	Observed (Expected = 97)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
5	148	26.520		--
7	139	17.952		--
4	120	5.337		--
8	114	2.895		4.604
2	81	2.707	3.841	4.646
9	76	4.633		--
3	73	6.035		--
1	71	7.072		--
6	53	20.115		--

Scanpath: 10th Discrete (Zone) Fixation

Similar to the eighth fixation distribution, the distribution of the tenth discrete (zone) fixation distribution indicated non-random effects among the nine zones of interest c^2 (8, N = 795) = 61.o, p < .001. Fixation was more likely in zones 5, 7, and 8 than the other six zones (See Table 17).

Table 17 - Tenth Zone Fixation: Significant magnitude of effect for individual zones.

10th Discrete (Zone) Fixation		
Most Likely:	Random:	Least Likely:
		

Zone (Proportion = 0.1111)	Observed (Expected = 88)	Chi-Square Contribution	Chi-Square Critical (df= 1) (P=0.05)	Chi-Square complement +contribution
7	130	19.654	3.841	--
5	115	8.050		--
8	114	7.458		--
4	92	0.152		0.253
9	81	0.609		--
3	75	2.012		3.456
6	69	4.231		--
2	61	8.458		--
1	58	10.416		--

CHAPTER 4 – DISCUSSION

Discussion

Data for our three response variables characterizes each of the nine zones in terms of attentional behavior. Zone 5 (the center zone) was statistically significantly more effective at garnering attention ($\alpha = 0.05$) than any other zone as evidence by: (1) the highest average percentage of zone fixation time, (2) the greatest number of visual hits, and (3) the fastest average zone fixation time.

A viewer's inclination to gravitate towards the center of the elements in their visual field (known as center of gravity) is well recognized [21, 45-47]. When viewing an image a viewer's gaze initially gravitates towards the center of the elements in the image in order to orient their attention to the whole of the image. Two mechanisms, parallel processing (wide distribution of attention) and serial processing (narrow or focused distribution of attention), facilitate the extraction of visual information. Parallel processing allows the viewer to grasp the gist of the image as a whole but not the specific elements that comprise it. This is because the human visual system has limited available cognitive processing resources and it is not possible to focus on every detail at once.

Serial processing allows detailed information to be extracted, when attention is selectively focused. Research indicates selective visual attention is thought to function like a spotlight with a zoom-lens mechanism that can vary its focus over time [10, 11]. If visual search is carried out primarily by a spotlight with a zoom-lens mechanism we would expect that the time it takes to shift the spotlight of attention between elements in

the visual field would be influenced by the distance between them. However, Kwak et al.[48] found that shifts in visual attention are independent of time; attention can be immediately directed to new elements in the visual field, regardless of distance.

Other researchers have refuted the notion of spotlight or zoom-lens model functionality. Egly and Homa [49] demonstrated that when visual attention is directed to a particular location, stimuli outside the range of the spotlight area were no less detectable than stimuli inside the spotlight. However, Theeuwes [8] showed that when attention is focused visually, abrupt stimuli outside the spotlight do not readily draw attention whereas inside the spotlight they do. This discrepancy infers that visual attention is comprised of multiple mechanisms that operate on different functional levels of attentional distribution.

Analysis of data from our ten-sequence-scanpath suggests a centralized search mechanism for visual search. In our experiment, attentional preference was characterized in terms of zones that represent specific subdivisions of the product image. Zones that showed attentional preference at a given scanpath succession (first zone participants viewed, second zone, etc.) were identified as regions (See Figure 18) that were characterized by evidence of statistical difference using varied dependent variables. All regions were composed of two or more zones. Scanpath data showed agreement with response variable data promoting the attentional prominence of zone five (the center zone). Zone 5 demonstrated attentional preference in every one of the first ten regions sequentially fixated on by participants (See Figure 18). This data suggests the center of the label frequently and quickly garnered visual attention.

If we consider the effects of inattentional blindness and resource allocation on search behavior it may be necessary for a viewer to frequently reorient broad visual attention to the center of gravity of the image (our center zone, zone 5). Humphreys & Bruce [50] offer evidence that serial processing is a self-terminating process. During serial processing in order to visually focus on any specific element and extract detailed information, other elements in our visual field must be ignored [12]. Inattentional blindness towards other elements may lead to a brief discontinuous state of inattention (in the absence of a cue to attend another element within spotlight proximity) between the currently attended element and the next element that is selected to be attended. This condition may characterize the transition between serial and parallel processing during visual search. Jonides [9] indicates effective visual search must include a mechanism that frequently and swiftly reallocates resources and Remington[51] suggests this is accomplished by shifting gaze or fast processing concentration on a new location in the visual field. Our scanpath data suggests the center zone is an integral allocation hub during visual search. Frequently reorienting to the center of gravity of the image with a broad distribution of attention reduces cognitive processing load and can explain how shifts of visual attention are independent of time regardless of their distance in the visual field. The viewer reacclimatizes to the whole of the image and any visual element has the potential to garner selective attention. This continuous loop of parallel and serial processing during visual search would also explain how elements outside the spotlight effect are not readily attended until serial processing terminates (Figure 19).

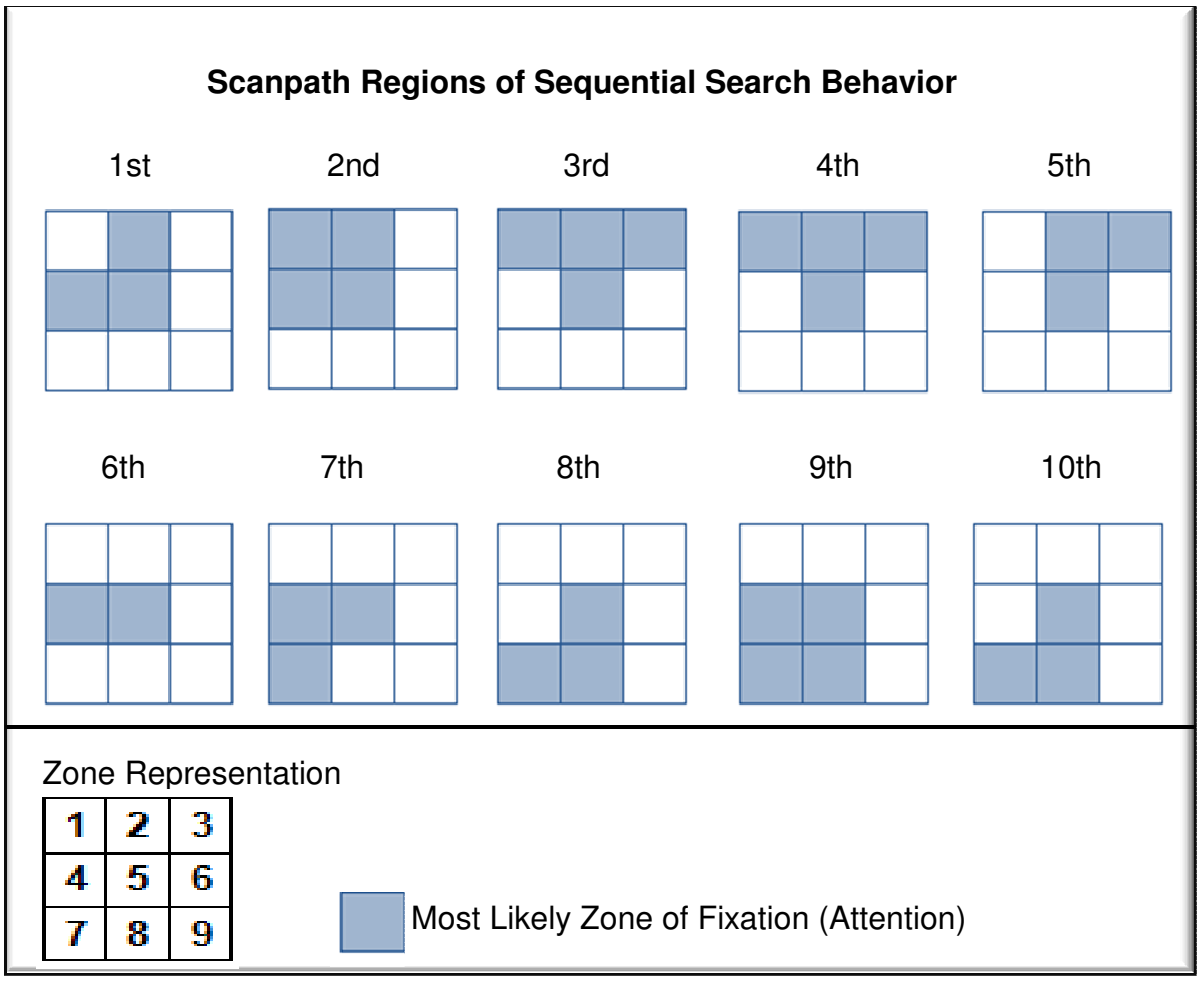


Figure 18 – Fixation regions and sequential search behavior with zones demonstrating the likelihood of attention (zones with high frequency of discrete zone fixation and individual magnitudes of effect that significantly contributes to a non-random distribution).

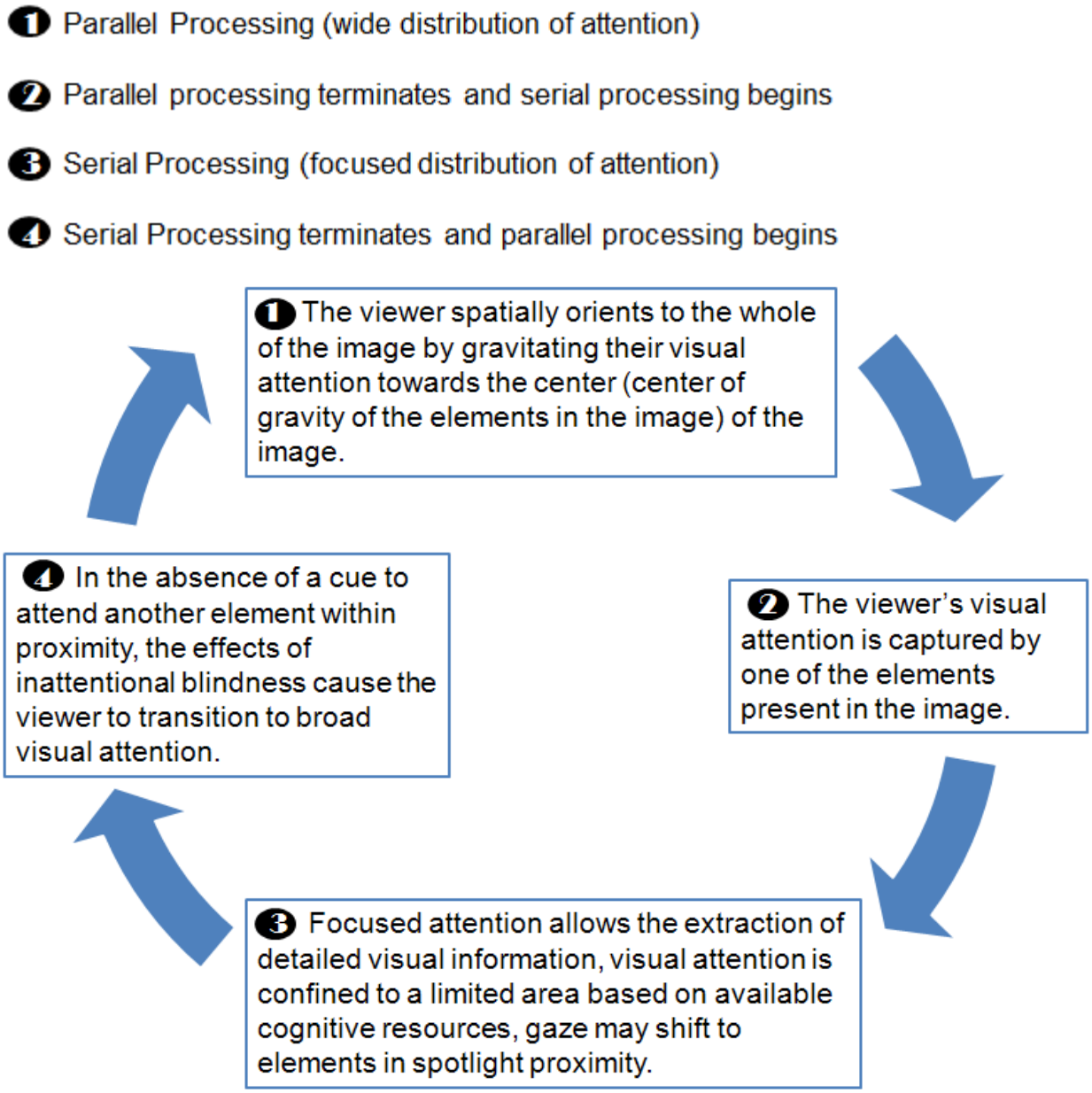


Figure 19 - Theoretical centralized visual search mechanism: The effects of inattentional blindness and resource allocation on search behavior may cause a viewer to frequently reorient their visual attention to the center (center of gravity of the elements in the image) of the image.

Zones demonstrating the least amount of attention were also identified. Zone 9 was consistently grouped in the lowest attention capturing zones. Zones 8, 9, and 6 combined only represented twenty percent of the total time fixating in all zones by

participants (for comparison zone 5 individually accounted for twenty percent, See Table 54). Zones 9 and 6 also garnered the lowest amount of visual hits and zone 9 took the longest amount of time to fixate on. Scanpath tracking results for the first 10 regions participants fixated on (where did they look first, second, third, etc.) showed zones 1 through 5 exclusively demonstrated attentional preference within the first six fixation regions. Zone 7 does not demonstrates attention preference until the seventh region and onward. Zone 8 did not show attentional preference until the eighth region while zones 9 and 6 did not show attentional preference in any of the first ten regions participants fixated on. This pattern suggests zones 9 and 6 are likely the last zones to be viewed by participants (See Figure 18).

Zone 9 is of particular note because many packages place warnings, critical information, or overt labeling in the bottom right corner (zone 9) of the label such as: Do not take with nitrates, refrigerate after opening, shake well, do not consume with alcohol, avoid prolonged exposure to the sun, may cause drowsiness, chew before swallowing, etc. This research indicates there may be a positional effect related to the noticeability or attentional priority of information within the context of a drug label (square display format). The attentional prominence of zone 5 (the center zone) suggests the placement of critical information may be innately more effective in the center zone and least effective in zone 9 (the bottom right corner).

APPENDICES

APPENDIX A – Example Content of IRB Documents

Recruitment Flyer

Re: Opportunity to participate in a research study

This email is to inform you of the opportunity to participate in a research study at the School of Packaging. You are under no obligation to participate.

To participate you must:

- Be at least 18 years of age
- Have no history of seizure
- Not be legally blind
- Have transportation to the School of Packaging, where the study will take place

You are being asked to participate in a research study regarding the labeling of prescription drug products that is being conducted by Cory Wilson for his Master's thesis. He is using an eye tracking system which consists of a small camera in front of a computer screen and change detection software, or "Flicker" program to conduct this research. The eye tracking system will be calibrated with your eye. You will be asked to look at a computer screen and hit the space bar when you detect a change in the labels. (During the flicker task a photo will alternate with a second photo that has one small change; these two photos will be separated by a brief, blank display and will continue "flickering" until you detect the change in the two). The time to detect the change will be recorded as a way to quantify how prominent the change is to the scene and the eye tracker will record your gaze and attentive behavior.

Your color blindness, visual acuity, and health literacy will also be tested. These tests involve viewing a series of cards. You will also be asked to fill out a brief survey which includes information about your ethnicity, gender, age, educational background, usage of and familiarity with prescription medications.

The test should take no longer than 1 hour. In exchange for your participation, you will receive your choice of a $10 Starbucks gift card OR 2 points extra credit in PKG 480, whichever you choose.

If at any time you are uncomfortable with the testing or wish to discontinue the data collection process, you may discontinue participation without penalty. You will still receive the $10 Starbucks gift card or 2 points extra credit in PKG 480.

If you are interested in pursuing this opportunity, please contact Cory Wilson at wilso279@msu.edu to make an appointment.

If you have questions or comments regarding this study, please contact Dr. Laura Bix, Assistant Professor or Packaging at Michigan State University at 517-355-4556 or bixlaura@msu.edu.

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 202 Olds Hall, MSU, East Lansing, MI 48824.

Consent Form

Michigan State University
School of Packaging

INSTRUCTIONS AND RESEARCH CONSENT FORM – Applying eye tracking and change detection to test the noticeability of components of prescription drug labels

You are being asked to participate in a research study. Your participation in this study is voluntary. To participate in the study you must:

- Be at least 18 years of age
- Have NO HISTORY OF SEIZURE
- Not be legally blind

In exchange for your participation in this study, you will receive your choice of a $10 Starbucks gift card OR 2 points extra credit in PKG 480.

As part of this research, we will record your gender, ethnicity, educational background, age, eye wear requirements, and information about your professional history. We will also test your visual acuity (20/20, 20/30, 20/40, etc.), health literacy (word identification), and color perception. These tests will be conducted by asking you to view a series of cards and asking you to decipher images or read aloud common words related with healthcare to the best of your ability. You will also be asked to fill out a brief survey regarding your usage of and familiarity with prescription medications. We are interested in the things that people look at prior to medication usage, and whether or not labeling design can be manipulated in ways that draw your attention to important directions or information.

All information will be tied to a subject number; you will not be identified by name and your confidentiality will be maintained to the maximum extent of the law. Information retrieved during this entire study will be stored in a password protected computer in a locked laboratory in the School of Packaging at Michigan State University for a MINIMUM of 3 years. The room will be accessible only to authorized researchers of Dr.Laura Bix's research team. This study will take no more than one hour, and poses little risk to your health and well-being.

For eye tracking and change detection testing, Cory Wilson from the School of Packaging, will ask you to view a series of labels on a computer screen, and will time how long it takes you to find changes in the images. You will be seated at a desk. The desk is equipped with an adjustable chin rest made from foam for support and comfort while testing. The pan-tilt optics ASL 504 eye tracker, which consists of a small camera that sits in front of a computer screen, will be calibrated with your eye. You will have 1 minute to view each label in succession, the eye tracking device will record what your eye sees. This is a test of attentive behavior.

Two images will alternate on the computer screen in rapid fashion, with a blank screen between the two. One of the images is slightly different than the other, and you will be asked to hit the space bar as soon as you detect the difference in the two images. If you correctly identified the change, the program will advance to another pair of images; if not correctly identified, the previous images will play again until you are able to detect the change. This is not a test of your speed, but of a test of the ability of the change to draw your attention.

Important: You are free to discontinue your participation in the study at any time without penalty. You may discontinue participation at any time and still be eligible for a $10 Starbucks gift card OR 2 points extra credit in PKG 480.

There is no direct benefit to you in exchange for participating in this study. The hope is that through studies like this, we will gain an understanding of the design features that garner attention, so that this information can be used to make important information, such as directions and warnings, prominent.

There is a possible risk of seizure that is associated with viewing flashing images. If you are injured as a result of your participation in this research project, researchers from Michigan State University will assist you in obtaining emergency care, if necessary, for your research related injuries. If you have insurance for medical care, your insurance carrier will be billed in the ordinary manner. As with any medical insurance, any costs that are not covered or in excess of what are paid by your insurance, including deductibles, will be your responsibility. The University's policy is not to provide financial compensation for lost wages, disability, pain or discomfort unless required by law to do so. This does not mean that you are giving up any legal rights you may have.

You may contact Laura Bix at 517-355-4556 with any questions or to report an injury. You are aware that the results of the study will be treated in strict confidence and that you will remain anonymous. Raw results from your trials will be available to the Institutional Review Board (IRB) at MSU and the research team that is conducting this research. Your confidentiality will be protected to the maximum extent allowable

by law. Within these restrictions, results of the study will be made available at your request.

If you have any concerns or questions about this research study, such as scientific issues, how to do any part of it, or if you believe you have been harmed because of the research, please contact the researcher Laura Bix 517-355-4556; 153 Packaging Building East Lansing MI 48824 bixlaura@msu.edu.

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 202 Olds Hall, MSU, East Lansing, MI 48824.

I voluntarily agree to participate in the study of prescription drug labels.

Name: _____ Date: _____

You will be provided with a copy of your signed consent form.

I choose (circle 1) $10 Starbucks gift card 2 points extra credit in PKG 480

If you choose the $10 Starbucks gift card, please indicate receipt of the money with signature and date below.

Name: _____ Date: _____

Data Collection Form

Demographic Information

1. Gender
   ❑ Male ❑ Female

2. Profession
   ❑ Health Field Professional _____
   ❑ Student
   ❑ Other _____

3. Years of Experience in healthcare related field _____

4. Age
   ❑18～24 ❑25～34 ❑35～49 ❑ 50+

5. Eye wear
   ❑None ❑Glasses ❑Contact lenses ❑Other

6. Highest level of Education Achieved
   ❑High school ❑Associates ❑Bachelors ❑Graduate ❑Other

7. Ethnicity
   ❑White ❑Black ❑Hispanic ❑Asian ❑Other _____

8. Native Language _____

Prescription Drug Information

Please answer the following questions:

9. Please list any prescription medications that you are currently taking:

_____

_____

_____

_____

_____

_____

10. Circle the names of the drugs that are familiar to you and indicate if you have taken them before, or (if you are a healthcare professional) prepared the drug for a patient.

- ❑ Bystolic _____
- ❑ Campral _____
- ❑ Lexapro _____
- ❑ Namenda _____
- ❑ Nasonex _____
- ❑ Viagra _____

APPENDIX B – Mock Drug Label Stimulus Images

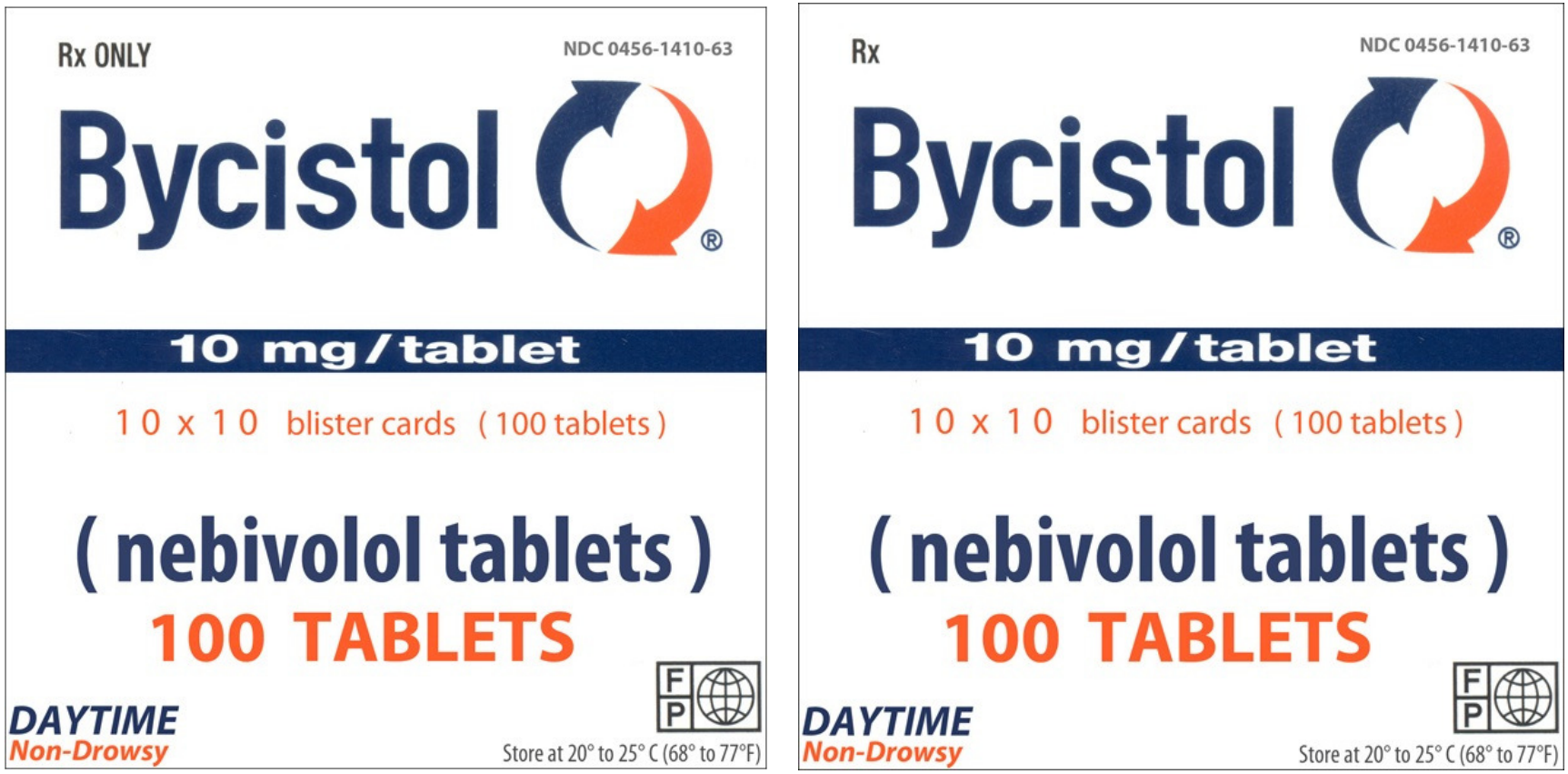


Figure 20 – Altered Mock Drug Labels 1 and 1.1: Left – Product 1 label, Right – Product 1 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

Figure 21 – Altered Mock Drug Labels 1.2 and 1.3: Left – Product 1 Zone 2 (top center), Right – Product 1 Zone 3 (top right). Visual layout example – text specifics are not pertinent.

Figure 22 – Altered Mock Drug Labels 1.4 and 1.5: Left – Product 1 Zone 4 (center left), Right – Product 1 Zone 5 (center). Visual layout example – text specifics are not pertinent.

Figure 23 – Altered Mock Drug Labels 1.6 and 1.7: Left – Product 1 Zone 6 (center right), Right – Product 1 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.

Figure 24 – Altered Mock Drug Labels 1.8 and 1.9: Left – Product 1 Zone 8 (bottom center), Right – Product 1 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

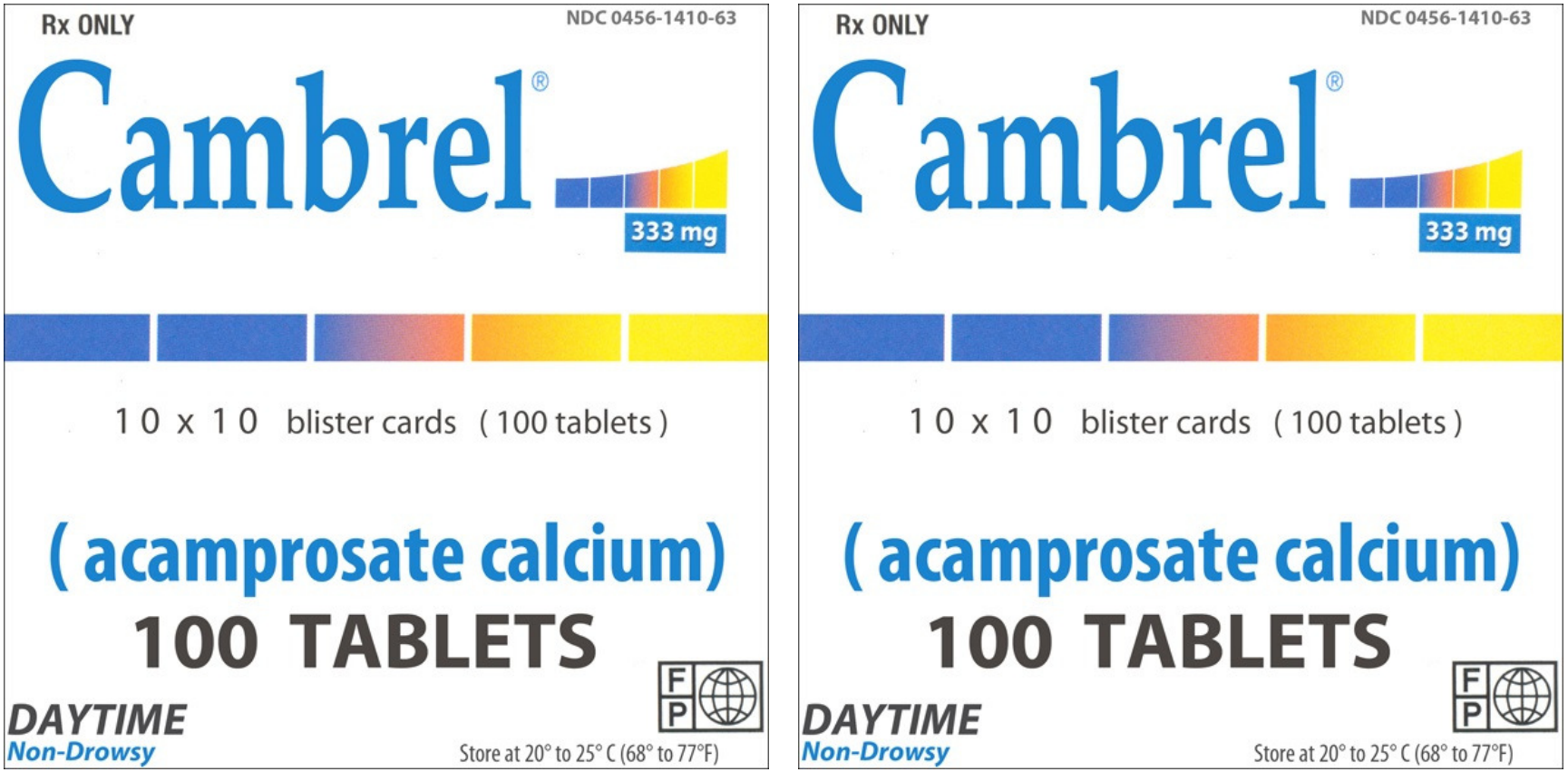


Figure 25 – Altered Mock Drug Labels 2 and 2.1: Left – Product 2 label, Right – Product 2 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

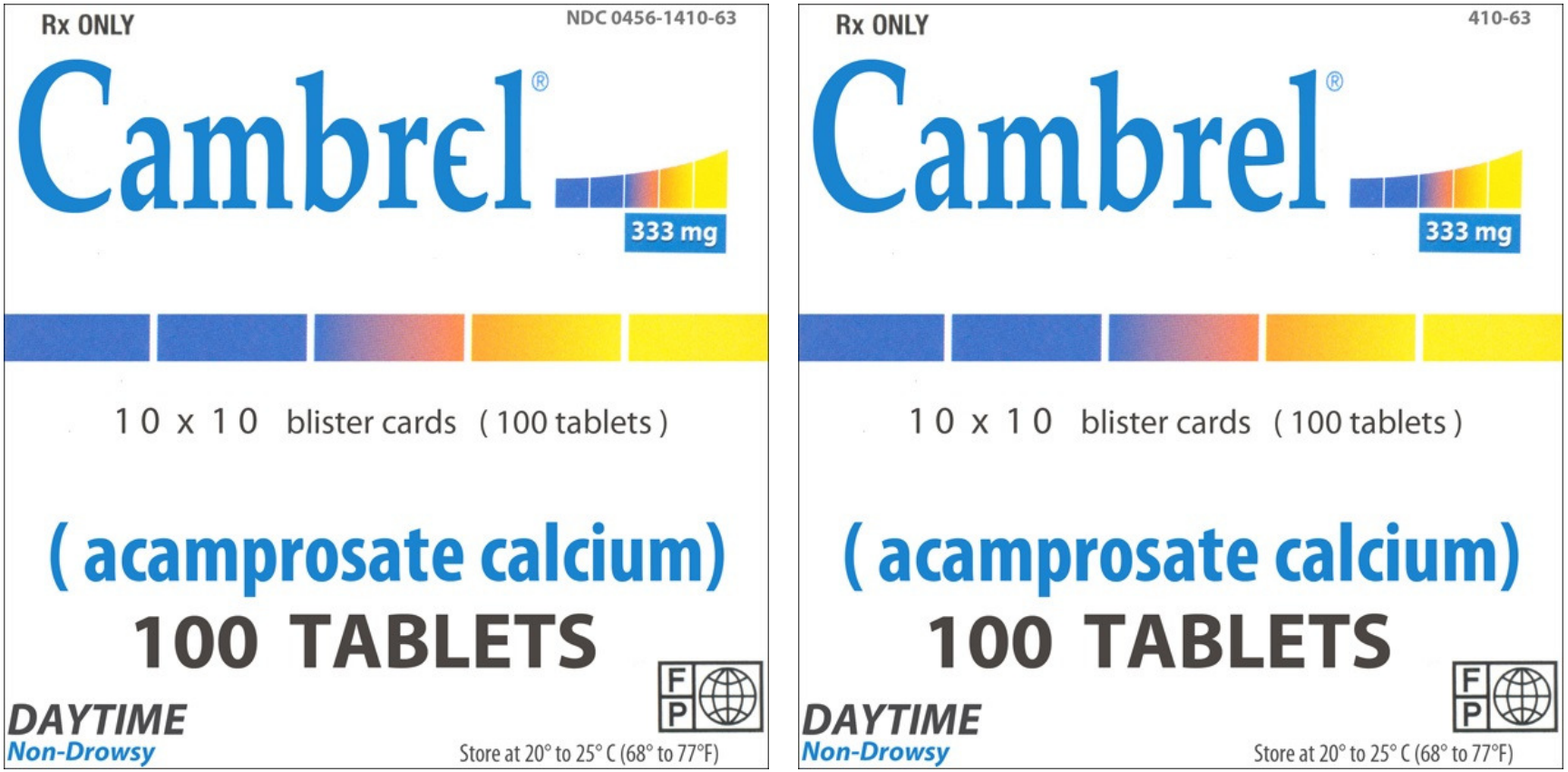
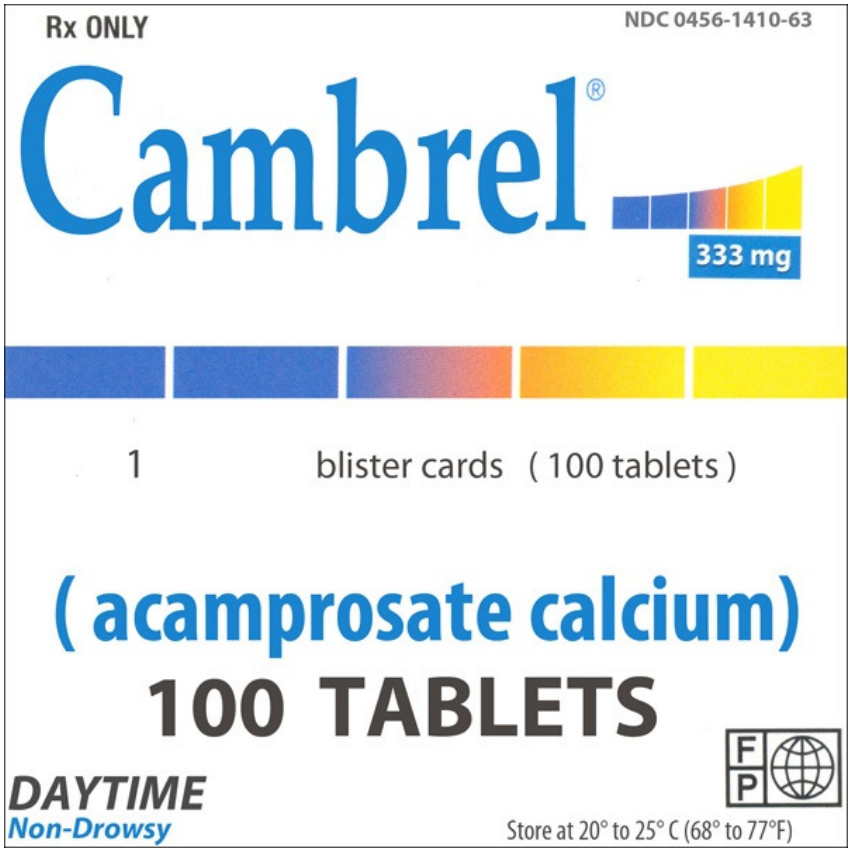


Figure 26 – Altered Mock Drug Labels 2.2 and 2.3: Left – Product 2 Zone 2 (top center), Right – Product 2 Zone 3 (top right). Visual layout example – text specifics are not pertinent.



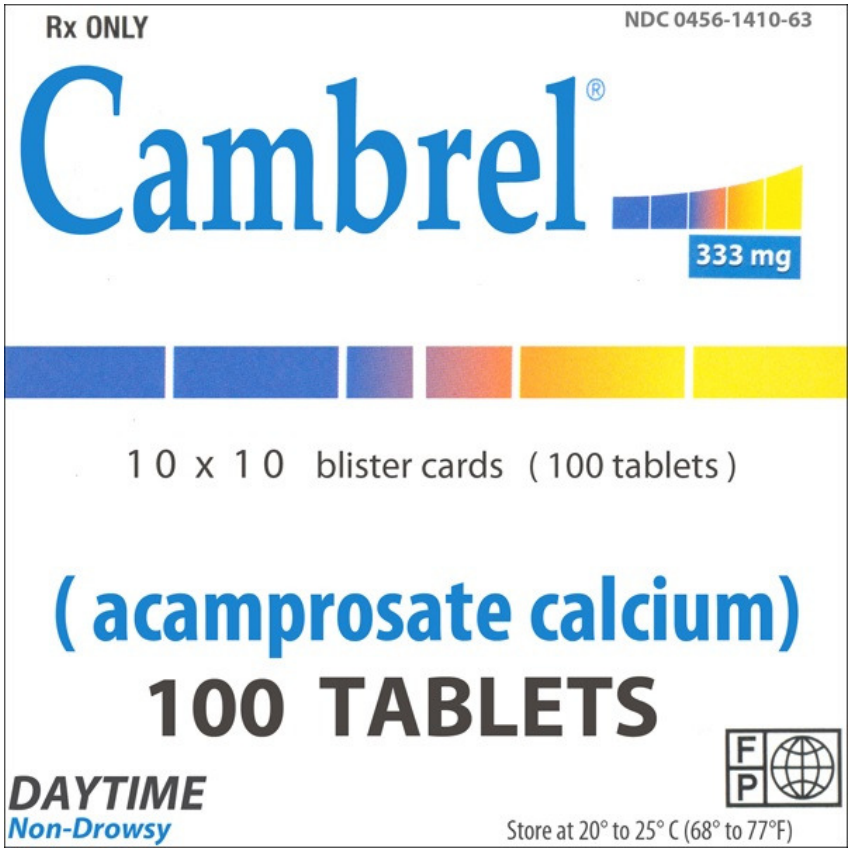


Figure 27 – Altered Mock Drug Labels 2.4 and 2.5: Left – Product 2 Zone 4 (center left), Right – Product 2 Zone 5 (center). Visual layout example – text specifics are not pertinent.

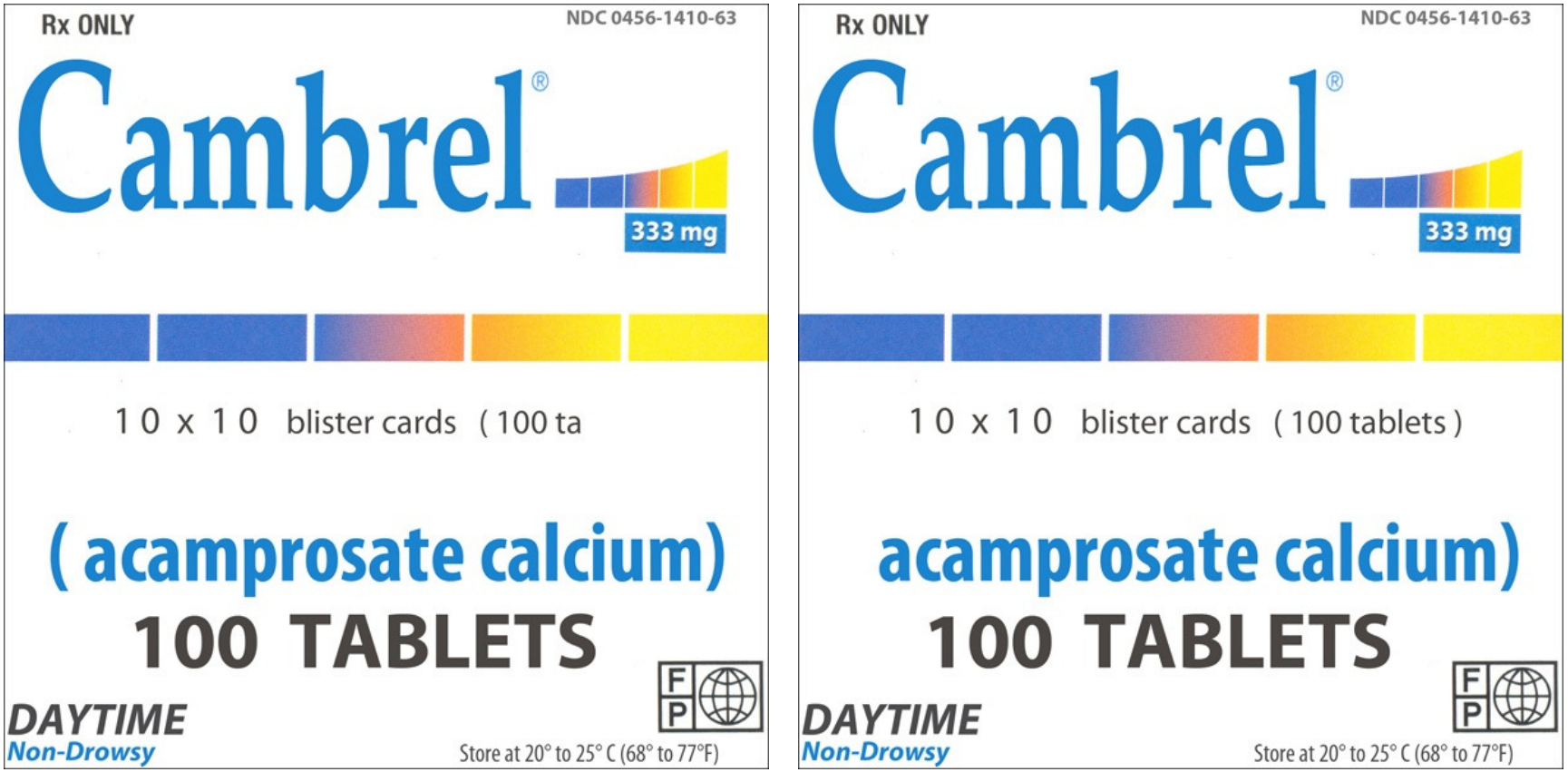


Figure 28 – Altered Mock Drug Labels 2.6 and 2.7: Left – Product 2 Zone 6 (center right), Right – Product 2 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.

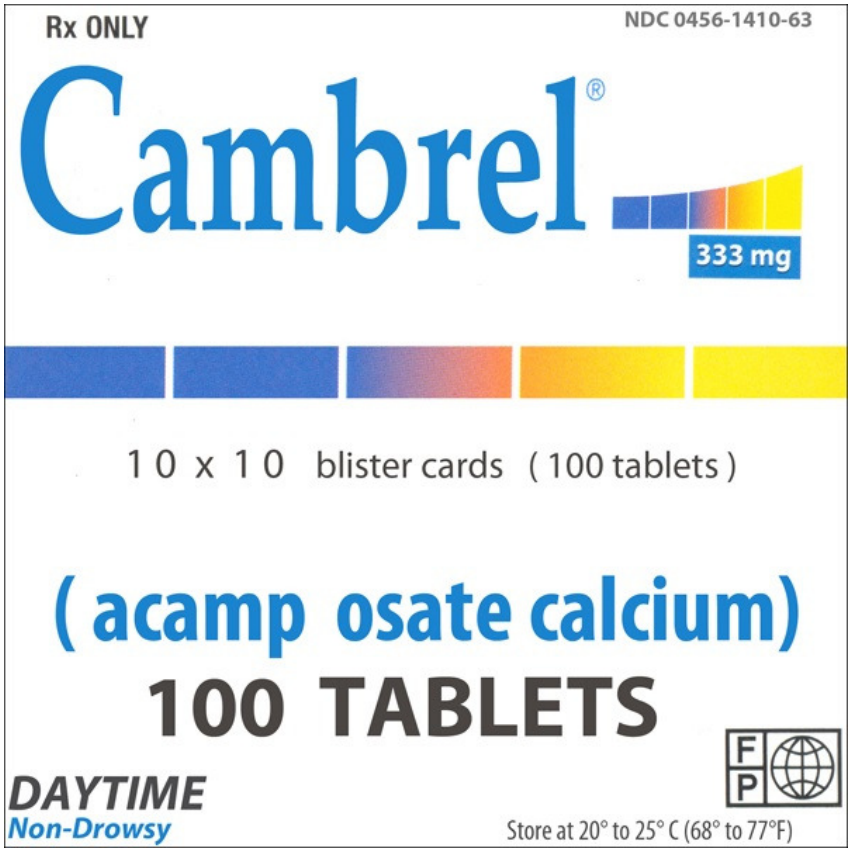


Figure 29 – Altered Mock Drug Labels 2.8 and 2.9: Left – Product 2 Zone 8 (bottom center), Right – Product 2 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

Figure 30 – Altered Mock Drug Labels 3 and 3.1: Left – Product 3 label, Right – Product 3 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

Figure 31 – Altered Mock Drug Labels 3.2 and 3.3: Left – Product 3 Zone 2 (top center), Right – Product 3 Zone 3 (top right). Visual layout example – text specifics are not pertinent.

Figure 32 – Altered Mock Drug Labels 3.4 and 3.5: Left – Product 3 Zone 4 (center left), Right – Product 3 Zone 5 (center). Visual layout example – text specifics are not pertinent.

Figure 33 – Altered Mock Drug Labels 3.6 and 3.7: Left – Product 3 Zone 6 (center right), Right – Product 3 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.

Figure 34 – Altered Mock Drug Labels 3.8 and 3.9: Left – Product 3 Zone 8 (bottom center), Right – Product 3 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

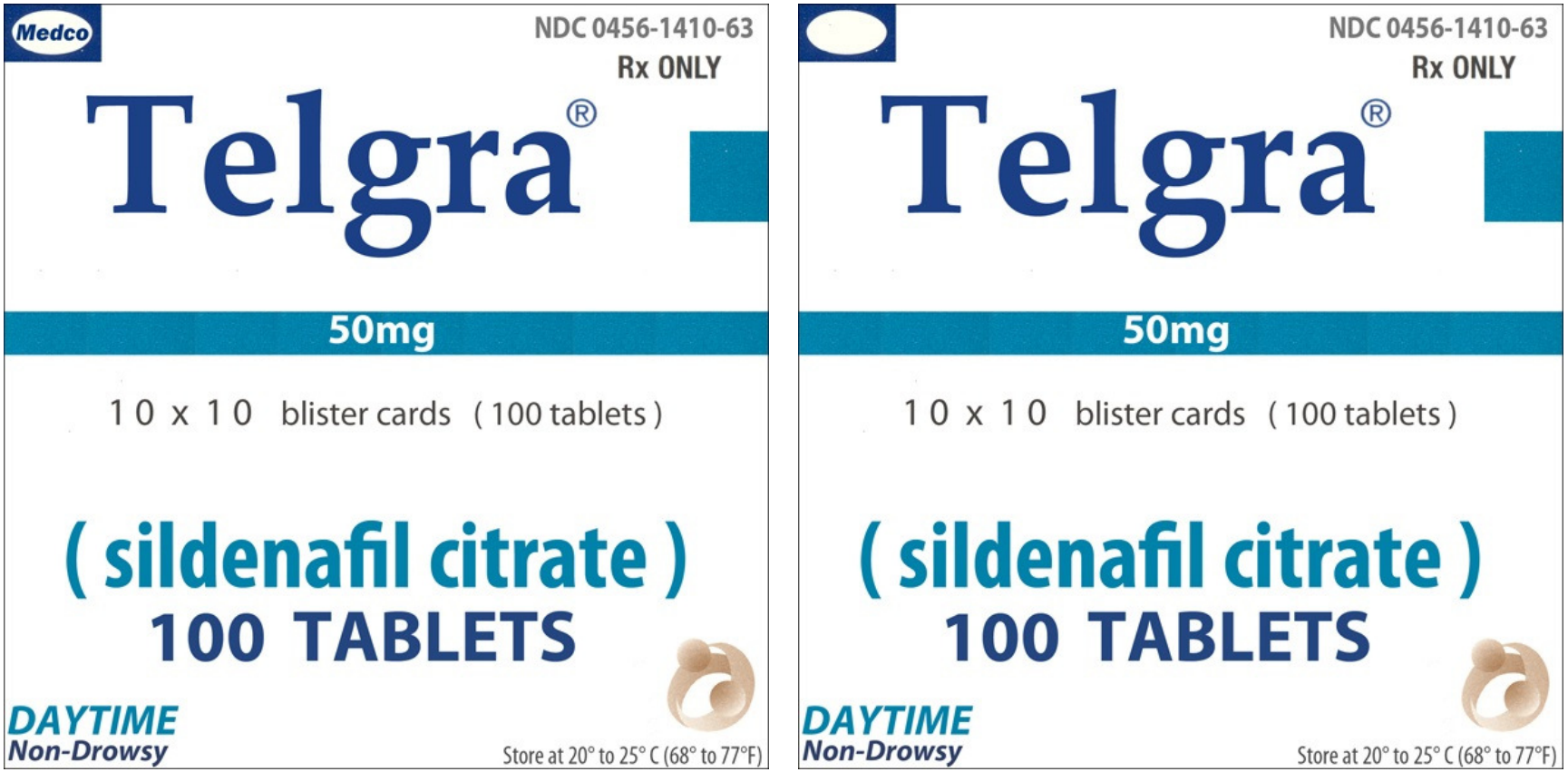


Figure 35 – Altered Mock Drug Labels 4 and 4.1: Left – Product 4 label, Right – Product 4 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

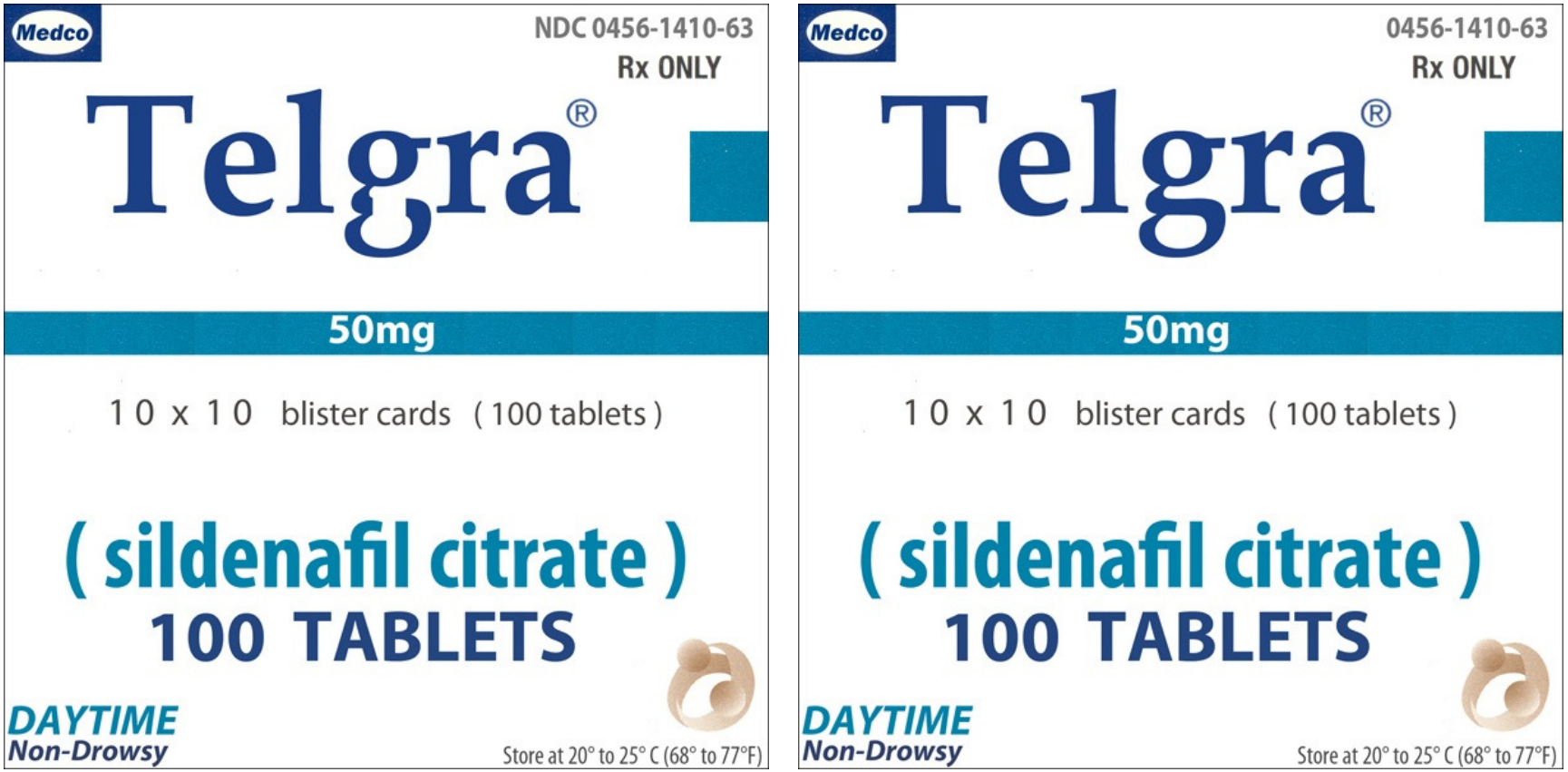


Figure 36 – Altered Mock Drug Labels 4.2 and 4.3: Left – Product 4 Zone 2 (top center), Right – Product 4 Zone 3 (top right). Visual layout example – text specifics are not pertinent.

Figure 37 – Altered Mock Drug Labels 4.4 and 4.5: Left – Product 4 Zone 4 (center left), Right – Product 4 Zone 5 (center). Visual layout example – text specifics are not pertinent.

Figure 38 – Altered Mock Drug Labels 4.6 and 4.7: Left – Product 4 Zone 6 (center right), Right – Product 4 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.

Figure 39 – Altered Mock Drug Labels 4.8 and 4.9: Left – Product 4 Zone 8 (bottom center), Right – Product 4 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

Figure 40 – Altered Mock Drug Labels 5 and 5.1: Left – Product 5 label, Right – Product 5 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

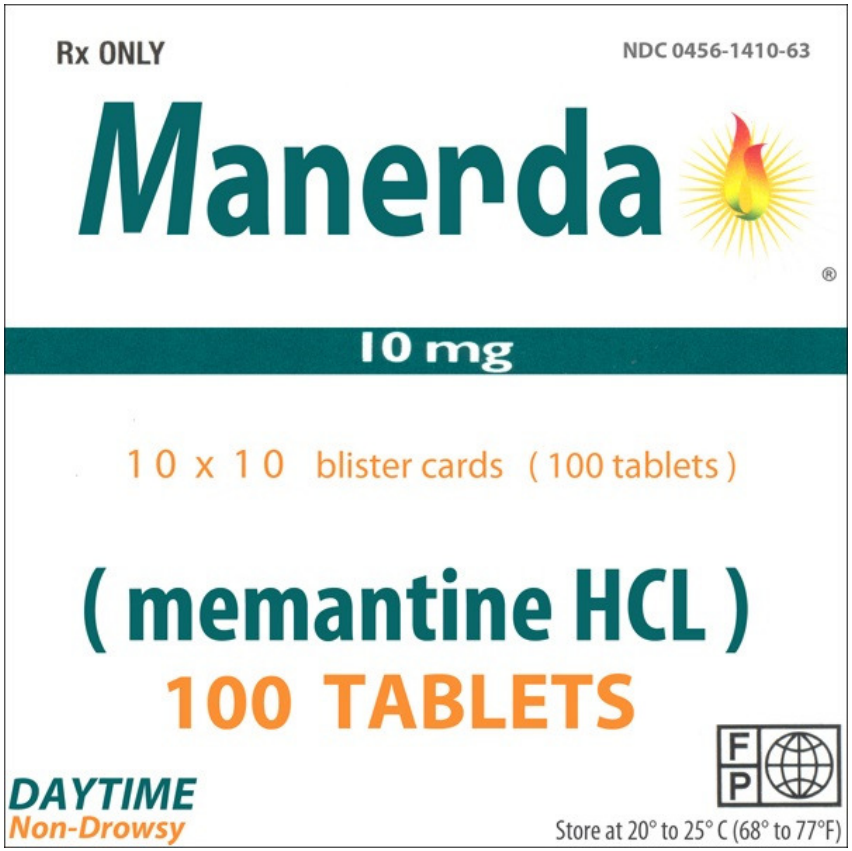


Figure 41 – Altered Mock Drug Labels 5.2 and 5.3: Left – Product 5 Zone 2 (top center), Right – Product 5 Zone 3 (top right). Visual layout example – text specifics are not pertinent.

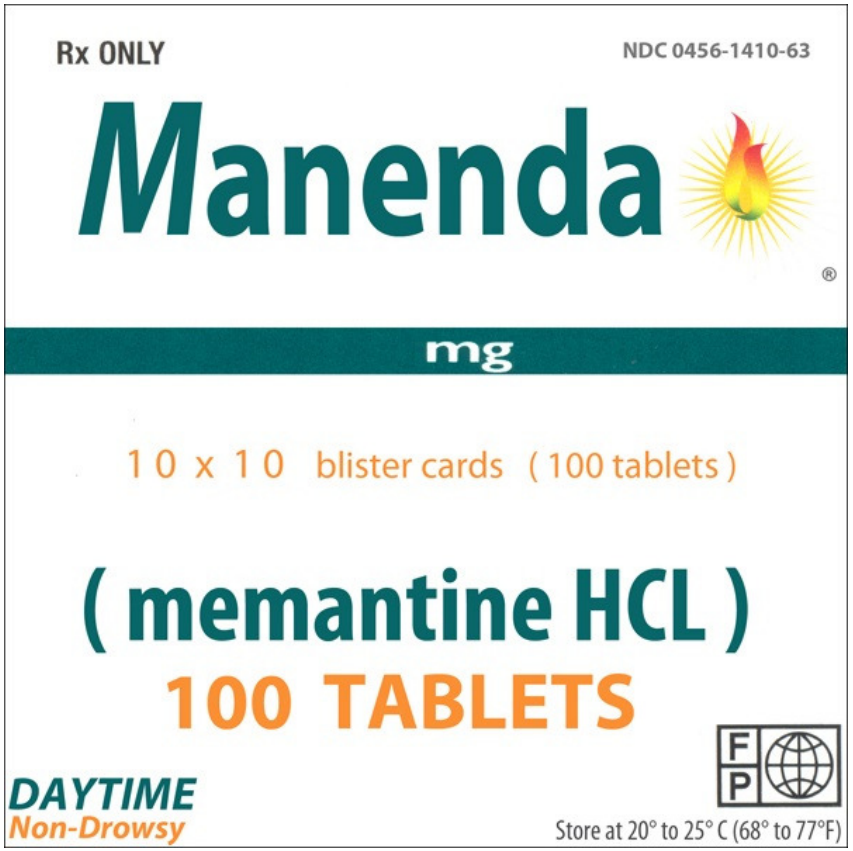


Figure 42 – Altered Mock Drug Labels 5.4 and 5.5: Left – Product 5 Zone 4 (center left), Right – Product 5 Zone 5 (center). Visual layout example – text specifics are not pertinent.

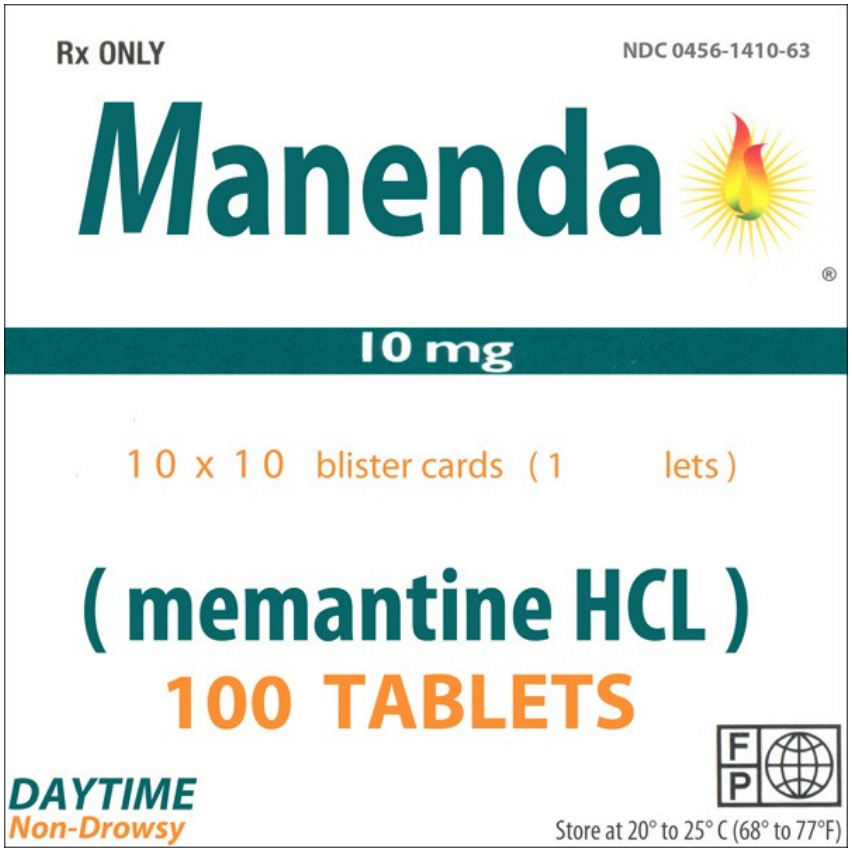
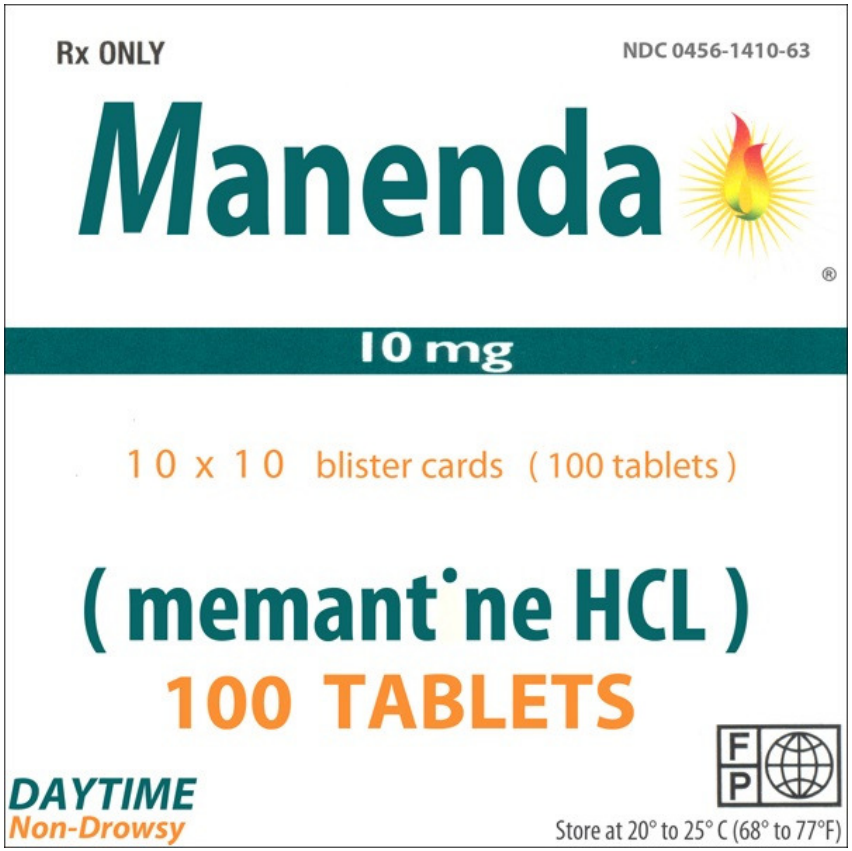


Figure 43 – Altered Mock Drug Labels 5.6 and 5.7: Left – Product 5 Zone 6 (center right), Right – Product 5 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.



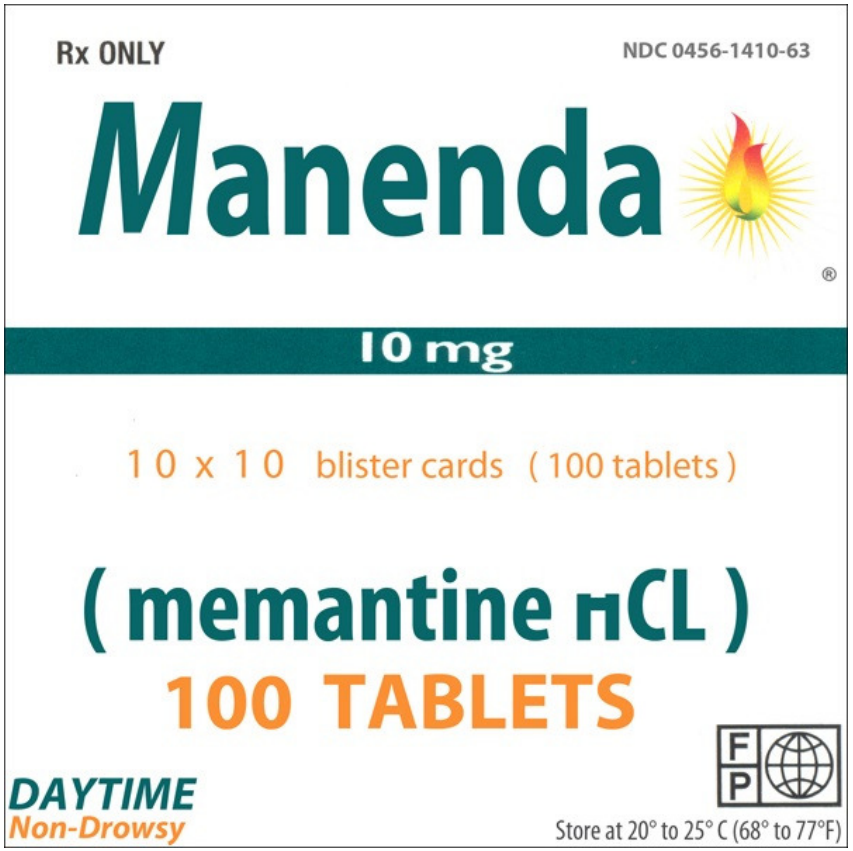


Figure 44 – Altered Mock Drug Labels 5.8 and 5.9: Left – Product 5 Zone 8 (bottom center), Right – Product 5 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

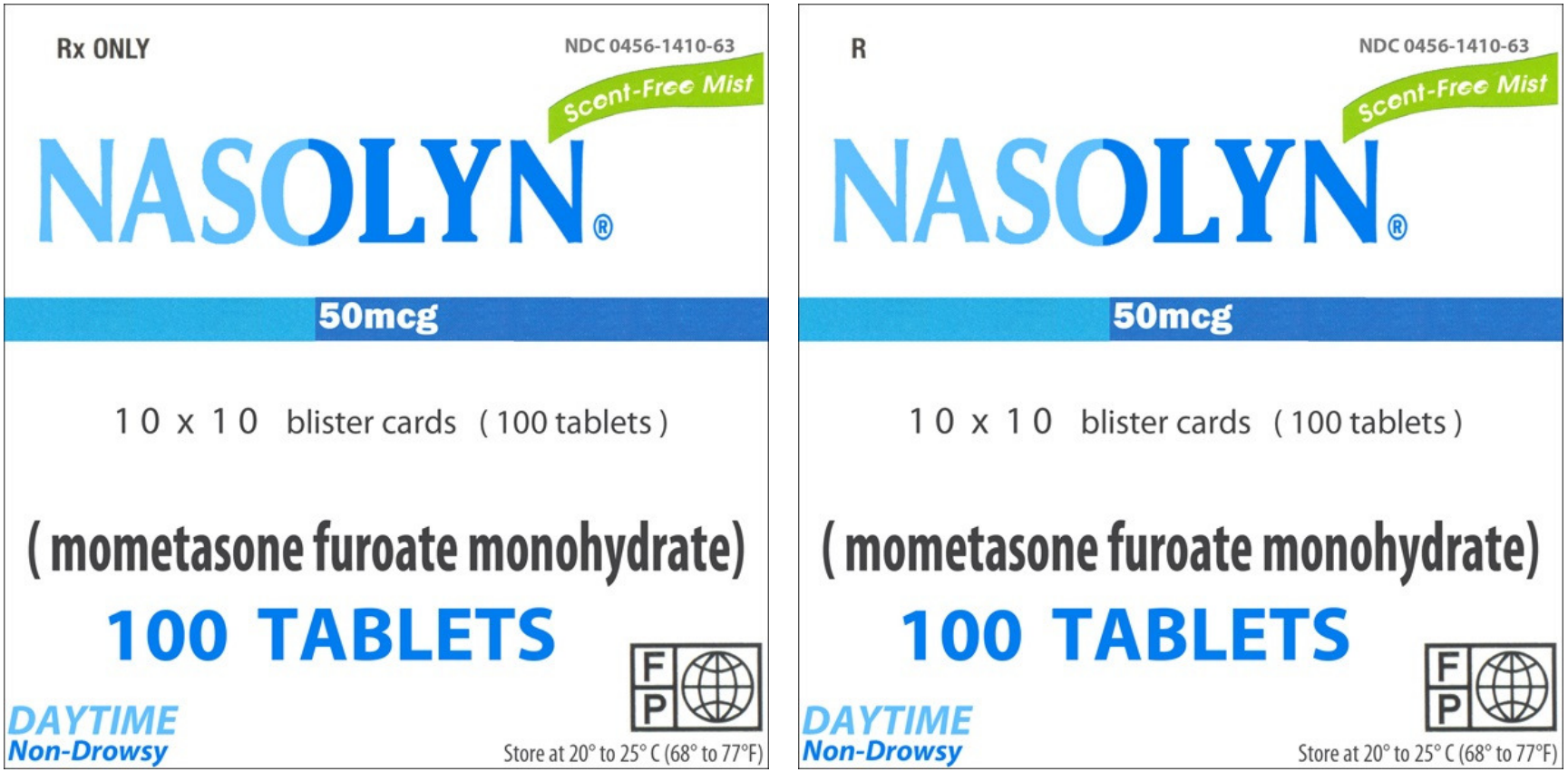


Figure 45 – Altered Mock Drug Labels 6 and 6.1: Left – Product 6 label, Right – Product 6 Zone 1 (top left) altered. Visual layout example – text specifics are not pertinent.

Figure 46 – Altered Mock Drug Labels 6.2 and 6.3: Left – Product 6 Zone 2 (top center), Right – Product 6 Zone 3 (top right). Visual layout example – text specifics are not pertinent.

Figure 47 – Altered Mock Drug Labels 6.4 and 6.5: Left – Product 6 Zone 4 (center left), Right – Product 6 Zone 5 (center). Visual layout example – text specifics are not pertinent.

Figure 48 – Altered Mock Drug Labels 6.6 and 6.7: Left – Product 6 Zone 6 (center right), Right – Product 6 Zone 7 (bottom left). Visual layout example – text specifics are not pertinent.

Figure 49 – Altered Mock Drug Labels 6.8 and 6.9: Left – Product 6 Zone 8 (bottom center), Right – Product 6 Zone 9 (bottom right). Visual layout example – text specifics are not pertinent.

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