The Effect of Color Combination on Visual Attention and Usability of Multiple Line Graphs

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Abstract

Multiple line graphs that represent a large amount of everyday data are commonly used in business and in the finance industry. Color has become a useful addition to such complicated graphs to allow graph-readers to obtain relevant information quickly and easily. Although previous color research revealed that color contrast attracts human attention, the use of multiple color combinations for drawing attention has not been clearly evident in a graph reading context. This study examines the effect of three color combinations on the user’s perceived attentiveness level and usability of using a three-line graph. This research aims (1) to theoretically contribute color science domain with a graph comprehension aspect, (2) to design a quantitative experiment by measuring objective usability and subjective affective state, and (3) to understand the moderating effects of task types on reading of a pop-out line graph.

Keywords: Color Combination, Attention, Luminance

1. Introduction

The role of color is of importance in visual information design [1]. Multiple color labeling is used in financial charts and trend analysis to rapidly interpret information through visual displays. The ability to capture and interpret large volumes of attention-demanding data, within a limited timeframe, is found to be enhanced by using visual color associations. Over time a color reader acquires a ‘color vocabulary’ [2]. Here, certain colors have near universal acceptance. In the financial industry, a green color is associated with uptrend markets or that a share price is increasing, while a red color stands for downtrend. A use of a green color or unusual colors, such as purple or yellow, for deceasing stock price presentation may cause viewers to reduce their reading performance. Therefore, color is a fundamental element in the design of diagrams, charts, and information visualisation [3].

Color selection in areas, such as medical attention, security, or finance, is often used to convey important imagery to the reader when faced with a critical environment. In MRI scan images, distinct colors in a ‘rainbow’ scale are used. Stone [4] explained that a ‘rainbow’ scale for MRI scan images was less effective and to some readers this was seen to be offensive [5]. In contrast, Kase [6] discovered a carry-on luggage inspector using ‘rainbow’ scale X-ray images, rather than a single color scale, more readily detected potential threatening devices. In the cases above, the viewer’s performance may rely on how the decision support system designer build color interaction between the system and the end-user.

To date, consideration of color theories has had low significance in the design of color required decision support system solutions, and system developers have generally resorted to the Red-Green-Blue (RGB) combination to match with three data values [3]. This leads readers (or computer end-users) to become ‘habituated’ and to accept without-question whatever colors are set as default. In financial displays, color is important, and universally recognized. A white background with blue or red lines remains a traditional representation for line graphs. The Australia Stock Exchange price charts use RGB combinations [7]. Slight expressive color combinations to this fixed color pattern have emerged with Google Finance [8] using red-blue-yellow lines for and Bloomberg [9] using a blue background with a white line. Thus, existing information systems reveal inconsistencies in rules to select effective color labels for charts.
Furthermore, the usability of color combinations for graphs has rarely been examined in the reading context. A single color or even two-color combination has been studied [10, 11], but empirical studies on three-color combination have seldom been conducted.

Hence, this study aims to investigate what three-color combination attracts the reader’s attention and therefore may best enhance the user’s performance when interpreting graphical information. The effect of color combinations, and the overall graph interpretation experience of the reader, is also investigated. The effect of color combinations on the reader impacts on the reader’s visual perception, which in-turn also effects usability, which then influences reader satisfaction. This study first defines three sets of three color harmonies representing different color contrasts from the literature review. This experiment measures the user’s affective response and usability in terms of response time, accuracy, attention, likability, and satisfaction.

Another focus of this study is to investigate the effect of task types as a moderator on the impacts of color combination. Here, a task-specific target item with a distinctive color is compared to one with an indistinctive color. This multiple color study, unlike a single-line color, investigates the impact of color interaction upon the reader.

In the next section, color theories pertinent to this study are discussed. The hypotheses development is explained in Section 3. Session 4 explains the research design and, lastly, this study concludes by guiding future and on-going research agenda in Session 5.

2. Theoretical background

2.1. Color in information display

Color plays a vital role in information visualization. Fundamental uses of color in information displays are: 1) to label to distinguish one from another, 2) to measure quantity, 3) to represent or imitate reality, and 4) to attract viewers by decorating graphic information [3, 12]. Graphs are traditionally used as color interpretation devices for data displays such as in population density topology maps, or for a purpose of mathematics and science education for young students, whereas line graphs are commonly used to convey financial and business information. Color is a useful addition to such complicated graphs, and color often labels different graphical features so that the graph-reader can obtain relevant information quickly and easily.

Color has been a core consideration in fine arts and design fields for a long time. Color has also been studied across interdisciplinary fields. Here for example, combinations of psychology, cognitive science, Information Technology (IT), business, and consumer behavior may be captured into a net graphical display. The effects of digital color combinations on web usability and e-commerce is another active domain [13-15].

In this web-based setting, Hall and Hanna [16] found that the user perceived aesthetic quality higher when they preferred the colors used for the website. For website visitors, the color combination does not appear to affect their retention, but the website’s aesthetic quality, including colors, can stimulate the user’s intention to purchase the product [16]. Gorn [17] mapped relaxing colors (e.g. blue) against others (e.g. yellow) and compares these to download speed perception and likability. Gorn suggested that with a relaxing background color, the user notes its downloading speed faster. Consequently the user likes the website more than the other one they perceive the downloading speed slower.

Color studies concerning the effect of single or duo-colors on emotion as well as attention [11, 17-20] have largely focused on the primary colors (red, blue, yellow) and occasionally on secondary colors (orange, green, violet), but the studies on three-color combination including tertiary colors (red-orange, yellow-orange, yellow-green, blue-green, blue-violet, red-violet) are rare.

Attention remains a major research topic in assessing large amounts of data and within time-critical environments. Attention to target information, versus irrelevant information, has been assumed a key-ability pathway in dealing with time-critical tasks. Although others have investigated many ways to increase the user’s attention, this study focuses on attention through an aspect of color theory. The way to attract visual attention using color is based on the creation of color contrast [21].

Color contrast is defined as a color appearance phenomenon that causes stimuli to shift in color appearance to the opponent dimensions when interacting with the color of their neighbor or
background [22]. In other words, a light background induces a stimulus to appear darker, a red color induces green appearance, a yellow induce blue, and so on. However, the factors that create contrast, including which colors best create multiple line graphs, depending on specific task types, are not well researched. This study targets types of contrast combination that enhances the graph reader’s performance and overall satisfaction. The color contrast combinations of this graph-reading experiment are designed based on a literature review of the following theoretical domains: 1) luminance, 2) legibility, and 3) color combination.

2.1.1. Luminance and attention

Luminance is perceived power of light and it is correlated with the perceived brightness of a color [3]. Fairchild [22] described luminance as the effectiveness of the various stimulus wavelengths in evoking the perception of brightness. The terms of brightness and lightness are distinguished in color terminology. Brightness is defined as the absolute level of visual sensation for an area from a similarly illuminated area [22]. Consequently, only related colors demonstrate lightness [22].

Objects with radiating zones or auras attract human vision. Human visual perception has been found to be more sensitive to bright light than dull light or low illumination objects [23]. Hence we predict light with higher luminance will attract more visual attention. The luminance function (L*) has been used as a measure of normalized luminance and measured on 0 to 100 scale [1]. The L* of fundamental colors from a standard RGB displays ranges from a white color at 100, yellow at 98, cyan at 91, green at 88, magenta at 60, red at 54, blue at 30, and black is equal to 0, as derived from Adobe Photoshop color picker. These values show cyan and yellow are considered stimulating computer screen colors that evoke perceptions of brightness, and so the user is more likely to be alert to cyan and yellow, than low luminance of color, such as blue.

Luminance has been discussed in computer graphics, particularly as computations converting the RGB colors to luminance [3]. This process is useful for converting color images to gray scale images. Luminance has been paid attention in software application development, but has received little attention from academics. The relationship between luminance and visual attention has seldom been studied.

Although visual attention using color has been studied [24], previous research on color has often focused on the ‘hue’ of color itself, such as the comparison of colors yellow and blue. The comparison of warm colors (red-yellow family) and cool colors (blue-indigo family) is a major area of color studies and has lead to the conclusion that the user pays more attention to warm colors than cool colors [25]. Although the previous findings seem valid, the reasons why warm colors receive more attention have not been explained. Hence, this finding might actually be caused by a color hue factor, or possibly even by luminance factors.

The high luminance values may be too bright and stressful on the eye when applied to websites. Hence, when viewing website screen colors, the reader may experience painful eye sensations when looking at bright colors such as cyan or yellow, and so may withdraw from this website.

In addition, using a color with luminance close to white light, such as a yellow text, when placed on white background shows a low readability, but yellow on a black or on a contrasting background improves readability. Hence, the relationship between luminance and website usability should consider whether luminance alone can attract or impede the user’s attention, and so impact on the user’s performance on the website, and is there an optimal relationship between luminescence and usability.

2.1.2. Legibility and contrast

Legibility captures the clarity of character or the text in the eyes of the reader [26], whilst readability captures the ease of reading experienced by the reader [27]. Depending on the context of the study, some studies have interchanged legibility and readability [16]. Legibility may also encapsulate objects as text or drawings, and legibility is the ability to discriminate shapes [3]. Because of its characteristic in assisting with the discrimination of one shape from another, contrast is believed to aid with legibility [27].
Color scientists have measured contrast levels between background and foreground texts, and have tested the relationship of contrast and legibility. For example, Arend [28] tested legibility against color changes. He set the green color of texts from 0% (that is, black #000000 as a hexadecimal value) to 100% of green (#00FF00) and from top to bottom, with a gray scale background from white (#FFFFFF) to black (#000000) operating from left to right. An ambiguous band interestingly appeared along an oblique direction and the vagueness or ambiguous area exactly demonstrated almost no contrast between two colors. This gradation showed higher contrast as one progressed towards the edge.

The International Organization for Standardization (IOS) for website legibility is recommended a 5:1 contrast of value (lightness) defined by luminance. The minimum legibility is suggested 3:1 contrast and ideal contrast for small texts is recommended 10:1 contrast. Considering legibility and its use (or usability) in information systems, where the computer screen or website information in the display is illegible within a certain distance, the system is of little value to the reader or end-user.

Hall and Hanna [16] examined readability of color combinations capturing web fonts against different backgrounds. They discovered colors with higher level of contrast delivered higher readability. For example, white texts on black background were easier and faster to read than light blue texts on dark blue background. Considering these two situations from a value contrast perspective, the white text on black shows a greater than 10:1 contrast, whilst the light blue on dark blue represents an approximately 4:1 ratio in luminance contrast. Hence, white on black is easier to read.

Although text color and contrast legibility have been tested across many combinations [16, 17], other elements used in information visualization, such as graphs, and their legibility have received little attention.

In graphing, a two-color contrast of (a line and a background) is important in determining the graph legibility. Where more trend lines are added to the graph, consideration of color contrast and legibility becomes increasingly complicated – i.e. in addition to contrast between each line and background, contrast between one line and another is also important. Hence, where large amounts of data or many trend lines are visually displayed across many related graphs, a color strategy should be developed and then employed color codes for two graphs are selected in terms of unique colors designed tasks of interpreting information from the graph.

2.1.3. Color combination

Color combination is a major topic in color science. Color combinations remain closely related to everyday life. Fashion, building ambience, advertising appeal, urban design all engage color as a key design element. Nature also displays color. Vegetation, animals and even the sea and the sky all display color. Certain color combinations give the reader a sense of harmony, and color science explains basic color combinations as follows.

Hue Combination (HC): The twelve hues on the color wheel capture red, yellow, blue (primary colors), orange, green, purple (secondary colors), and the tertiary colors with hues between of primary and secondary colors [2]. A hue combination represents a combination of color wheel colors. A hue combination does not have to be limited to the twelve pure hues but can use the basic colors form distinguishable and categorical combined colors. A hue separation of one color and another color between 60° and 90° [29] is commonly used in presenting categorical information visualization. Color researchers have argued that diverging color schemes assist in labeling of information and provides quick grabbing of observation [3, 29].

Analogous Combination (AC): Analogous color combinations are consecutive hues or any of their tints and shades on the color wheel [30]. These may be varied using white (tints) or black (shades) or gray addition (tones) [2] and remain as analogous colors if their separation are located within 10° to 40° of the color wheel [2]. Analogous colors display unity because their variation appears under the same or closely related color family. Kobayashi [21] categorized color tones for large four groups. A tint group includes bright, pale, very pale, a gray-tone group includes light grayish, light, grayish, dull, and a shade group includes deep, dark, dark grayish. A hue group includes vivid and strong tones. As for its characteristic, vivid or strong tones display more hue combinations whilst other tones display more analogous combinations.
**Split Complementary Combination (SCC):** A split complementary combination includes a hue and the hues on either side of its complement, that is, on the opposite side of color in the color wheel [30]. This combination is believed to display dynamic harmony. Color combination in information systems are used for aesthetically pleasing and effective visual communication at the same time. Vivid tones of hue combinations show almost equal perceptible features, but similar tones are less perceptible. When tones of SCC colors are effectively controlled, perceptible features depending on task types may be designed. While HC and AC are naturally restricted to control their tones, it is possible to design SCC that can manipulate tones. The SCC is an important consideration when testing for effects of color combination and attention on usability of graph reading tasks. Color codes for two graphs are selected in terms of unique colors designed tasks of interpreting information from the graph.

### 2.2. Visual attention

The impacts of attention on human behaviour have been researched by many prior cognitive and neuro-scientists. The traditional research interests on the relationship of attention and memory or human attitudes [25, 31] has been changed gradually in response to impacts of attention on a visual searching ability [32]. Cognitive psychologists have discovered that perceptual visual features attract attention on the computer screen [24]. Here, visually unique scenes and unexpected features hold attention. Brockmole and Boot [33] found as the colours of all objects changed, an unexpected novel colour or a single unique colour (e.g. a blue colour surrounded by red items) captured more attention. This feature applies even when the distinctive items are task-irrelevant stimuli.

Older visual search studies show users perform effectively faster when they obtain information of items with a perceptible feature [32]. In the perceptible color feature, the user may easily distinguish a red item from other grey-tone items. Thus, the distinctive feature is a key factor of attention capture in information displays.

Unique, distinctive, and special features have also been used as the means of attracting attention in visual communication. A vivid color among pale colors, a different shape from surroundings, and an opposite orientation to the one of background are examples of perceptible features for attention capture.

### 2.3. Task completion time and accuracy

Traditionally, task completion time and accuracy have been two classical measurements for efficiency and effectiveness respectively in information systems research [34-36]. It is assumed that the user can complete the task in a shorter duration when the information displays are designed properly to convey the information [34]. Here, efficient systems enhance the user’s performance and allow them to complete tasks faster [34]. In addition, accuracy is typically used by counting errors the user made [35]. Here, spatial accuracy or distance from the correct position may be useful for a graph-reading context. In contrast, precision indicates the ratio between correct information and total amount of retrieved information. Precision delivers exact and specific answers retrieved from the graph and let the user infer exact values from it.

### 2.4. Likeability and satisfaction

The construction of satisfaction has been varied in prior studies including preference, user attitudes, and likeability [35]. Usability is a core measurement for satisfaction in the IT domain [35]. Easy-of-use, usefulness, and effectiveness are frequently measured for the fulfilment of any system design, and furthermore its system quality and the user’s intention to use in future are also considered as influential attributes in this technical view [37, 38]. For the view of the user’s affective experience, reliability (trust) and hedonic quality have measured for a part of user satisfaction [39, 40]. Attractiveness, preference, and the index of fun and enjoyment have gradually become important [39].

Satisfaction in this research not only includes mechanical measurements for traditional usability but also focuses on a sophisticated level of the user’s emotional satisfaction. Perceived enjoyment while carrying on tasks has been measured [18, 41] in information systems. Enjoyment has been extended to exciting, pleasant, interesting, and enjoyable to use for measuring overall user satisfaction [18, 42].
Likeability, preference, pleasant, agreeability, in short overall positive affect is another essential element for the user to express whether they like the system in general including its appearance [35, 39].

2.5. Task type

Task types are normally information retrieval systems that require specific extractions or other information retrievals that contains non-specific general task values applicable to displays [36]. A question such as “Is the trend of Line A increasing or decreasing?” is a general task. Detailed tasks are divided into elementary and advanced tasks depending on the level of complexity [43, 44]. Elementary tasks usually lead a simple-step of mental workload – i.e. “What is the value of Line A?” Relatively, advanced tasks require multiple combined processes involving more complicated mental workload. A question such as “For the period of 15th to 30th April, what is the difference between the range of Stock X and Stock Y?” requires combined searching and reading processes and then a little calculation using those values.

To sum up, this theoretical framework leads to the research model in Figure 1.

![Figure 1. The research model on the effect of color combination and attention on usability of graph reading tasks](image)

3. Hypotheses development

The graph-reading tasks associated with Figure 1 and used in this experiment include: tasks with a pop-out line, tasks with a non-pop-out line, and tasks with two lines of the three lines. In case of Split Complementary Combination (SCC), tasks with two lines include one pop-out line. The hypotheses associated with Figure 1 are now discussed.

3.1. Task completion time

The graph of three lines including a pop-out line provides a salient feature to the user. The feature allows the user to carry on the tasks easier and faster when working with a pop-out line, as described in hypothesis H1a, because this line attracts the user’s attention, which is shown as hypothesis H5. However, this pop-out line can distract the user from when working with a non-pop-out line. A Vivid-tone Hue Combination (VHC) presents more distinguishable vivid-tone hues. A Deep-tone Analogous Combination (DAC) presents a colour set with similarly deep-tones (see 2.1.3). The all three lines of VHC almost evenly pop out whilst the three lines of DAC present similar colour harmony constituting
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almost one family without high contrast between lines, as described in hypothesis H1b. Thus, distinguishing a line in the VHC and working with it is more likely to be faster than the one in the DAC. The user is more likely to look at the DAC lines repeatedly to distinguish one line and another.

\[ H1a: \text{Task completion time for tasks with a pop-out line will be shorter when SCC > VHC > DAC.} \]
\[ H1b: \text{Task completion time for tasks with a non-pop-out line will be shorter when VHC > DAC > SCC.} \]
\[ H5: \text{Task completion time for tasks with a pop-out line will be shorter than tasks with a non-pop-out line.} \]

3.2. Accuracy

The Colors with darker tones make the viewer more concentrated and serious [30]. This affective state enhances the user’s better performance for detailed tasks. In addition to an affective factor, the contrast of deep-tone lines against a white background is higher than the contrast between vivid-tones and the white color. This contrast causes better legibility for the DAC and the SCC. This is shown as hypothesis H2. A pop-out color of the SCC may stimulate the user’s excitement, but there are two deep-tone colors in it that let the user calm. This pop-out feature, which assists the user’s focus, may insignificantly affect accuracy, which is shown as hypothesis H6. Focused state requires more time to extract exact values, as described in hypothesis H9. Still the SCC is more likely to enhance the user’s concentration than the HCC.

\[ H2: \text{Response for tasks will be more accurate when DAC > SCC > VHC.} \]
\[ H6: \text{Attention will not significantly influence accuracy.} \]
\[ H9: \text{Response for tasks will be more accurate when task completion time is longer.} \]

3.3. Attention

Color contrast creates pop-out attention. The VHC includes distinct colours and moreover, the all three color demonstrate high level of luminance. This means the all three lines present alerting colors that can somewhat attract or distract at the same time. While the DAC may show less impact on visual attention, a pop-out line of the SCC attracts the user’s attention when working with it, but distracts the user from the tasks with a non-pop-out line. This is shown as hypothesis three, as H3a and H3b.

\[ H3a: \text{A target item with a pop-out color will attract the user’s attention when SCC > VHC > DAC.} \]
\[ H3b: \text{A target item with a non-pop-out color will attract the user’s attention when VHC > SCC > DAC.} \]

3.4. Likeability

The Likeability is normally influenced by the appearance of the system interface, but also possibly by perceived usability. Perceived usability and perceived aesthetic quality may vary depending on the task. The user is likely to feel positive affect from a pop-out interface when tasks require the user’s attention, as shown in hypothesis eight (H8). Some researchers believe hue pairs between 10°, 30°-40°, 130°-140°, or near to 180° creates better harmony than the one between 60°-90° [45]. Thus, the SCC and the DAC are considered more visually pleasing than the VHC. The aesthetics of the SCC is said in a modern and dynamic way [21], and the contrast of related harmony is believed is subtle and elegant [2] (H4a). Other researchers believe clear, vivid, primary colours generate classical aesthetics (H4b).

\[ H4a: \text{The user will like the interface of the graph for detailed tasks when: DAC > SCC > VHC} \]
\[ H4b: \text{The user will like the interface of the graph for general tasks when: VHC > SCC > DAC} \]
\[ H8: \text{The user will like the interface of the target item with a pop-out color when tasks require attention.} \]
3.5. Satisfaction

In general, user satisfaction is influenced by cognitive experience and affective experience. The SCC provides better usability, which is shown as hypothesis H10 and H11, by attracting the user’s attention as shown in hypothesis H7, through a salient feature of a pop-out line when working with it and also this colour combination is generally pleasing the user’s eyes as captured by hypothesis H12. The overall usability of the VHC and the DAC may be almost equal, but the VHC is better to grab the user’s attention for big-picture tasks while the DAC is better for advanced tasks that require the user’s concentrating in a controlled affective state. Overall the VHC is less likely to satisfy the user details graph-reading tasks.

\[ H7,10,11,12a: \text{Overall user satisfaction for tasks with a pop-out line will be greater when: SCC} \geq VHC = DAC. \]
\[ H7,10,11,12b: \text{Overall user satisfaction for tasks with a non-pop-out line will be greater when: DAC} > SCC > VHC. \]

4. Methodology

This study examines the effects of color combinations on the user’s attention and usability when using a line graph. In addition, the moderation effect of task types to the impact of color combination is also investigated. The user’s response to a graph of three lines with different color combinations is tested. Also, tasks with and without a ‘pop-out’ item are included for investigating the moderation effect.

4.1. Experimental design

The Participants will be randomly divided into three groups. They will be assigned the same tasks using a three-line graph, but the only difference is a colour combination of the three lines. A between-subjects design will be used for three experimental conditions: VHC, DAC, and SCC. High level of luminance of vivid-tones for VHC, high level of legibility of deep-tones for DAC, and a combination of VHC and SCC that creates a ‘pop-out’ effect for SCC will be used. The VHC includes orange (#FF9900), green (#00FF00), and cyan (#0000FF). These colors are bright and diverging. Another color set presents DAC that as purple (#330099), blue (#3333CC), and violet (#660066). The tones of these three colors are lower than the vivid ones so they display lower luminance. The average of the DAC colors’ legibility is 1:4.3 which as acceptable contrast 1:3 legibility difference. In contrast, the VHC is designed for low legibility with a 1:1.2 ratio. This displays unclear colors on white background.

The last color set of orange (#FF9900) from the VHC and blue (#3333CC) and violet (#660066) from the DAC demonstrates SCC. Due to the unique attributes of yellow, orange is used in this graph reading experiment. Orange produces a reasonably visible line, remaining the split complementary harmony with blue-purple sectors at the same time. The three-line graph is especially designed for this experiment. The size of the graph is 700 x 450 pixels to fit in the minimum screen resolution of 800 x 600 pixels. Each line of the graph is presented using 1px line thickness. Variations to the graph size, line thickness, and numerical scales are available to be conducted. The graph program is comparable with the following web browsers: Firefox, Explorer, and Chrome.
4.2. Experimental procedure

The webpage of this experimental study will be provided to the participants. A sample graph is shown in Figure 2. Participants will be required to perform both simple graph trend assessments and more advanced tasks such as calculation, interpretations from the graph. Some tasks are designed to use only a line A approach, while other tasks are asked to use only a line B approach. More complex tasks are also added for participants to use Line A and Line B together to compare values.

The user will be asked to complete all the graph reading tasks as quickly and as accurately as possible. After completing the task session, the user will be asked to respond to seven-scales about their perception of the graph user interface. Then the last part of the survey will allow the investigators to measure any individual differences that may affect the results.

5. Conclusion

This study on three color combinations explores the user’s perceived levels of attentiveness on the color depending on task types. The color combination that creates a perceived and salient feature of attention may facilitate the interpretation of graph tasks against other less important items. Thus, focused attention onto the important visual information may facilitate time-urgent tasks. The color combination should also reflect the level of time-critical situation. This application may be used in high-critical working environments for example in financial information displays, medical applications, energy trading displays, and air traffic control systems, especially where the effective control of human attention in these applications is crucial.

This study contributes in three areas. First, the comparison of color combinations, as an aspect of graph comprehension, is demonstrated. Second, this study examines objective usability of task completion time (H1) and accuracy (H2) as well as a subjective affective state of using a pop-out line graph (H3 and H4). Both significantly influence user satisfaction (via H7 and H10-12) of information displays as shown in Figure 1. The relationship between affect and easy-of-use and usefulness will be discussed in future research. Third, this research investigates the moderating effects of task types with the information presentation of a pop-out feature. This aspect has rarely received attention by researchers, particularly the connection between the salient feature and color contrast and the complexity of task types.
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7. References


