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The Effect of Infographics on Recall of Information about Genetically Modified Foods

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Abstract

Although multiple agricultural literacy campaigns exist, studies have found many people struggle to grasp agriculture topics. In order to process and learn information, individuals use a limited pool of cognitive resources. When topics or media messages are complex, those resources can be overwhelmed, thus hindering the learning process. Visual aids can prevent this from occurring. The purpose of this research was to test the use of infographics to communicate the topic of genetically modified foods. One-hundred-thirty undergraduate students were exposed to one of two randomly assigned stimuli. Both stimuli contained the same information about genetically modified foods, but one was presented in the form of an infographic, while the other was a text-only narrative. After viewing, participants were tested in a variety of ways on their ability to recall information. Sixty-nine of these participants took part in a delayed survey a week after stimuli exposure to again test recall and retention of the information they viewed. No significant difference was found in retention and recall rates when using an infographic versus a narrative to communicate a complex topic. However, this study provides several implications for future research in the area of visual communications in agricultural literacy.

Keywords: agricultural literacy; visual communication; infographics; information recall; genetically modified foods

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In general, the public is deficient in their knowledge about agriculture and natural resources and lacks feelings of personal relevancy toward those industries. For example, in a recently conducted, nationally-representative Food Literacy and Engagement Poll, one-third of Americans were unaware foods with no genetic modification still contain genes (Michigan State University, 2017). In spite of increasing genetically modified crop production over the past two decades, the majority of Americans say they have insufficient knowledge about genetically modified (GM) foods (Funk & Kennedy, 2016),

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commonly referred to as genetically modified organisms (GMOs). GMOs are fervently contested by many, and the public remains divided on the subject, regardless of scientific discoveries (Kuntz, 2014). The public perceives GMOs as potentially harmful to human health (Nunez et al., 2016). However, human health is not the only cited issue. According to Kuntz (2014), individuals reject GMOs based on religious beliefs, unnaturalness and threat to the environment, public exclusion from the scientific discussions about GMOs and their inclusion in the world market. These contentions create a need for effective message construction from agricultural and natural resources groups (Settle et al., 2017). "If U.S. agriculture is going to continue to meet the needs of the U.S. population and address growing global needs, agriculture needs to be understood and valued by all" (Spielmaker & Leising, 2013, p. 1). To gain this understanding of agricultural concepts, literacy in the subject of agriculture must be improved.

According to Vidgen (2016), the need for agricultural literacy is based on the urgency and importance for societies to have sustainable food manufacturing systems to feed a growing population. Additionally, if a person was literate in the subject of agriculture and natural resource systems, he or she would be able to "engage in social conversation, evaluate the validity of media, identify local, national, and international issues, and pose and evaluate arguments based on scientific evidence" (Meischen & Trexler, 2003, p. 44). With these abilities, individuals would be informed consumers educated about innovations in the products they purchase and voters who can make informed decisions.

To overcome low agricultural literacy levels and attempt to create a well-informed American population, there are multiple agricultural literacy campaigns in the U.S with a majority of those efforts focused on elementary and junior high aged children (Kovar & Ball, 2013; Pense et al., 2006). Vidgen (2016) reported that many times, older audiences, who are the voting population, are often altogether excluded from agricultural literacy efforts.

Notably, a few agricultural literacy studies have been conducted with young adults who attend college. Specht et al., (2014) used a survey to determine the students' level of agricultural awareness, which served as a proxy for agricultural literacy. Ultimately, the authors found agricultural literacy to be a successful indicator of respondent feedback, demonstrating that improved literacy reduces the chances of negative reaction toward reports and photos coming from the agriculture industry (Specht et al., 2014). Dale et al. (2016) surveyed college students to determine their agricultural literacy levels. The researchers found the overall score of participants did not represent a passing score, establishing that students did not having a passing knowledge of agriculture. These two studies illustrate a need to reach college-aged adults and understand how to improve agricultural literacy campaigns targeted at this demographic. A key research focus should be on how young adults process agricultural messages – the first step toward education.

Young adults, including those attending college, tend to be the largest segment of the population that feels the most negatively about GMOs. In a Pew Research Center survey (Funk & Kennedy, 2016), young adults in the age group of 18-29 held the strongest opinions that foods containing genetically modified ingredients were worse for health. Within this same study, more than half (65%) of respondents replied they did not follow news about GMOs too closely, or at all. So, while the public shows obvious apprehension about GMOs, they are not taking the time to educate themselves about the subject. Young adults specifically are fairly new to being involved in policy and the voting process, so it is vital they are well-informed when making decisions that will affect our country as a whole. "In order to meet the challenges of the future, it is imperative that young people and adults become informed, 'agriculturally literate' consumers, advocates, and policy makers regarding agricultural issues" (Spielmaker et al., 2014, p. 1).

While there are many methods and media through which agriculturists can convey information, the incorporation of visual communications is increasing. Visuals have the ability to reduce time spent learning, enhance intellectual capacity, and improve recall and memory (Kouyoumdjian, 2012). According to Dur (2014), information presented in a visual manner not only increases understanding, but also simplifies complex information. One tool used in visual communication that has receive attention in the digital era is the construction of infographics. An infographic is a form of communication created using graphic design techniques that incorporates graphs, charts, icons, ornamental fonts, and diagrams to represent information and data, resulting in a narrative consisting of illustrations (Matrix & Hodson, 2014). Infographics assist in improved visualization of information, which can decrease the time it takes to understand data and statistics, find correlations, and attain information (Aguilar et al., 2010). When presenting science-related topics, graphic depictions, such as infographics, have become important means for improving comprehension (Frankel & DePace, 2012).

A variety of studies have been performed to assess the effectiveness of infographics in an educational setting. Vanichvasin (2013) examined infographic use in the form of visual communication tools with undergraduate students in a knowledge management class. It was found that when used as visual communication tools, infographics could increase interest, understanding, and memory of information, thus making infographics effective communication devices. Ozdamla et al. (2016) incorporated infographics into an undergraduate anatomy course and found the majority of students evaluated the use of infographics in educational materials as positive. Almost 60% of respondents said, "infographics have more advantages than other visuals" (Ozdamla et al., 2016, p. 376), and 86% of respondents said infographics helped them understand concepts better.

Yildirim (2016) also studied infographic use in the classroom during a 20-week program with undergraduate students. In this program, computer education and instructional technology students learned about the different functions of infographics and had to design their own. The study reported infographics were educational and preferred to traditional methods of informational presentation. Infographics aid in the learning process and are considered more instructive than unaccompanied text (Yildirim, 2016). Rather than measuring student opinions of infographic use, Lyra et al. (2016) tested knowledge gained from educational infographics with undergraduate students. Ultimately, the researchers found, on average, students who viewed the infographics scored higher than students who viewed the alternative form of information. It was also found infographics increased information retention over a longer period of time than the students who viewed the combination of graphics and text (Lyra et al., 2016).

Although the results from these studies seem promising, research is lacking to confirm the effectiveness of visual communications, including infographics, used in the context of educational materials (Lyra et al. 2016). In agricultural education, Pennington et al. (2015) called for an expansion of visual communications use in the discipline and additional research on the impact visual communications has on agricultural education efforts. This study was conducted to evaluate what influence infographics could have on helping people learn more about agricultural topics and retain that information.

Theoretical Framework

In order to improve agricultural literacy, it is important to understand how literacy messages are first processed. Drawing from the literature in cognitive science and communication, Cognitive Load Theory (CLT) (Sweller, 1988) and The Limited Capacity Model of Motivated Mediated Message Processing (LC4MP) (Lang, 2000) served as the theoretical framework for this study.

CLT states cognitive resources in working memory are limited and finite (Jong, 2010). The mental exertion, or cognitive load, a learner applies to gain knowledge is an application of these cognitive resources (Sweller, 1988). Therefore, if a task requires too many cognitive resources to process, learning is hindered (Jong, 2010). According to CLT, the use of graphics in conjunction with text lessens the cognitive load; therefore, learners can focus on the content rather than trying to interpret the presentation format (Sweller, 1988). According to Clark and Lyons (2011), most people comprehend information more efficiently while viewing graphics than stand-alone text. This is because the human mind can cognitively distinguish visual information transfer faster and in a more efficient and perpetual manner as opposed to written or oral information transfer (Dur, 2014).

Like CLT, the LC4MP asserts that humans have a limited amount of cognitive resources; however, the model breaks down the steps of information processing. The LC4MP is a theoretical description of three distinct, but related, processes: encoding, storage, and retrieval (Lang, 2000). During the first subprocess of the LC4MP, encoding of information occurs at the initial exposure to the information (Lang, 2000). At this point, controlled and/or automatic cognitive resources allocation occurs. Controlled resource allocation occurs when the receiver intentionally and consciously makes an effort to place information into memory, while automatic resource allocation is subconscious and occurs if information is novel or relevant to the receiver (Lang, 2000). Automatic resource allocation occurs when information produces an orienting response (Lang, 2009). After one of these processes (or possibly a combination of) has occurred, the information is either learned or discarded (Felder & Silverman, 1988) or in Lang's model, stored in working memory through the second subprocess.

In the second subprocess, storage, a mental representation of a message is created and linked with previously encoded information to then create mental associations (Lang, 2000). As the receiver contemplates the new information, more associations form between incoming and previously stored information (Lang, 2000). The more associations that are made, the more wholly the information is stored, which makes it easier for the information to be retrieved in the final subprocess.

In the final subprocess, receivers search through information stored in long-term memory and bring it to working memory in order to start the continual LC4MP process over (Lang, 2000). It is important to note that information processing does not follow a uniform pattern; information may or may not be stored in full, or at all (Lang, 2000). In the end, "memory of a message is a composite of the outcome of all three subprocesses" (Lang, 2000, p. 50). Memory is one of the mechanisms in which we derive literacy. Therefore, understanding how information is processed through the LC4MP should help us understand how to improve agricultural literacy efforts.

A couple studies have used the LC4MP to study information retention. Meppelink et al. (2015) conducted a study with 231 participants who were classified as either having low or high health literacy. The researchers concluded the individuals classified as having low health literacy benefitted from information presented in a multimodal format where less information was presented textually and there were more visual elements. Additionally, Salazar (2009) tested the effects of text and graphics in science literature with the goal of increasing science literacy. The researchers found the best option for communicating complex topics among 136 college students was to use low complexity messaging. Based on their results, they suggested to use visuals when complex topics could not be put into simplistic terms. These studies demonstrate that complex topics can benefit from simplified text, along with visual information to effectively communicate a message without overwhelming the viewer. However, there is no current literature on the use of infographics in conjunction with the LC4MP to create increased information retention. Due to this gap in research, the current study tested the use of infographics to communicate an agricultural topic in hopes of reducing the amount of cognitive resources devoted to information processing and increase information retention.

Purpose and Research Questions

The purpose of this study was to determine the effect of infographics on processing information about genetically modified (GM) foods. The research questions guiding this study were:

1) What influence does the message stimuli have on participants' perceptions of GMOs?
2) Do participants freely recall more information when exposed to an infographic or textual narrative?
3) Is there a significant difference in participants' cued information recall when exposed to an infographic or textual narrative?
4) Is there a significant difference in participants' information recognition when exposed to an infographic or textual narrative?

Methods

This study employed a pretest-posttest experimental design (Wimmer & Dominick, 2003). The manipulated independent variable was the format of stimuli participants received. Two different stimuli were randomly assigned to participants. The dependent variables were three memory measures (free recall, cued recall, and recognition) and post-perceptions of GMOs. Learning was operationalized as the ability an individual had to retain and later recall information, therefore learning has taken place and information has been encoded and stored in memory.

Participants

The population for the study was undergraduate students at Texas Tech University. These participants were students who voluntarily chose to participate through the College of Media and Communication SONA system. The SONA system is a research management tool that allows researchers to recruit participants who earn course extra credit. Students in the SONA pool were sent an email that included the study recruitment announcement. Any student at Texas Tech can become a part of the SONA pool, though it was primarily made up of students within the College of Media and Communication at the time of the study.

Students were recruited to participate in the study during two waves of data collection. The first wave included 64 participants. After a review of the dataset, another wave of collection was initiated, adding 66 participants to the dataset.

In total, the post-test questionnaire was completed by 130 participants, of which five were removed due to lack of data. Of the remaining 125 participants, 82 (65.6%) identified as female and 43 (34.4%) identified as male. The average age of participants was 21.90 (n = 123, SD = 3.98); two participants did not report their age. The dominant demographics of participants were identifying as white (n = 79, 63.2%), reporting an academic classification as a junior (n = 38, 30.4%) and being enrolled in the College of Media and Communication (n = 82, 65.6%). The mean cumulative self-reported GPA of students was 3.20 (SD = .520); 16 participants chose not to provide their GPA.

One week after initial involvement in the study, participants were emailed a delayed post-test questionnaire using an email address they provided during initial participation so as to have the best means of contacting the participant. The delayed post-test questionnaires were completed by 69 participants. Forty-five of those responded to the delayed questionnaire about the narrative with 11 responses being thrown out due to lack of data. Therefore, responses from 34 participants exposed to the narrative stimuli were included for analysis. Twenty-four participants responded to the delayed questionnaire about the infographic, with two responses being thrown out due to lack of data, leaving 22 participant responses for analysis. A 53.08% attrition was experienced from the initial questionnaire to the delayed questionnaire, with just over half of the original participants providing data through the delayed questionnaire. As the study was not long or overly demanding, it is assumed the loss of participants is due to chance factors and does not threaten the internal validity of the study (Ary et al., 2014).

Study Procedure

The instrument for this study was an online questionnaire constructed in Qualtrics and administered to students in a computer laboratory setting. Upon giving consent to participate through the Qualtrics platform, participants were asked about their preexisting perceptions of GMOs. In the next portion of the questionnaire, participants were randomly assigned to view one of two stimuli, creating two independent groups. One stimulus was an infographic about GMOs (see Figure 1). The other stimulus was a text narrative containing the same information as the infographic but had none of the graphic design elements (see Figure 2). Sixty-two participants viewed the infographic, and 63 viewed the narrative. There were two treatment groups and no control group in this study.

Figure 1

GMO Infographic Used as a Stimulus in this Study

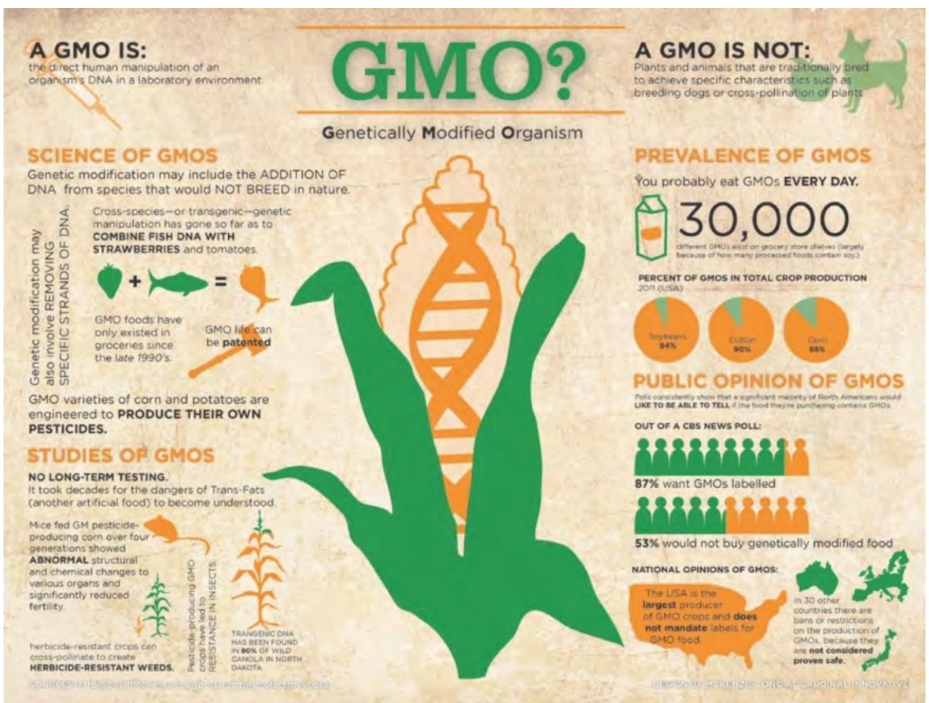


Figure 2

Narrative About GMOs Used as a Stimulus in this Study

Please read the following narrative:

Science of GMOs
A Genetically Modified Organism (GMO) is a human manipulation of an organism's DNA. Genetic modification may include the addition of DNA from species that would not breed in nature. The process may also involve removing specific strands of DNA. A cross-species – or transgenic – genetic manipulation has gone so far as to combine fish DNA with strawberries and tomatoes. Some GMO varieties of corn and potatoes are engineered to produce their own pesticides. GMO life can be patented. A GMO is not a plant or animal that has been traditionally bred to achieve specific characteristics such as breeding dogs or cross-pollination of plants.

Prevalence of GMOs
GMO have only existed in food since the late 1990's, but now you probably eat GMOs every day. More than 30,000 different GMOs exist on grocery store shelves (largely because of how many processed foods contain soy). In 2011, the GMOs compromised 94% of total crop production in soybeans, 90% in cotton, and 88% in corn.

Studies of GMOs
It took decades for the dangers of trans-fats (another artificial food) to become understood. Mice fed GM pesticide-producing corn over four generations showed abnormal structural and chemical changes to various organs and significantly reduced fertility. Pesticide-producing GMO crops have led to resistance in insects, and herbicide-resistant crops can cross-pollinate to create herbicide-resistant weeds. Transgenic DNA has been found in 80% of wild canola in North Dakota.

Public Opinion of GMOs
Polls constantly show that a significant majority of North Americans would like to be able to tell if the food they are purchasing contains GMOs. Out of a CBS news poll, 87% want GMOs labeled, and 53% would not buy genetically modified food. The USA is the largest producer of GMO crops and does not mandate labels for food containing GMOs. In 30 other countries, there are bans or restrictions on the production of GMOs because they are not considered proven safe.

Participants watched a 3-minute video immediately after stimuli exposure. The video served as a means of clearing working memory, so participants were not immediately answering the free recall question, which would demonstrate memory. Rather, the participants were required to access any information they had stored about the stimuli they viewed in answering the recall questions. There were no questions within the instrument about the video.

After exposure to the stimuli and distractor video, participants were directed to complete the questionnaire. Participants were not given a time limit to complete the questionnaire, but participants in the infographic condition took 18.06 minutes on average, while the narrative condition took 19.19 minutes on average. The instrument measured demographics, perceptions of GMOs, free recall, cued recall, and information recognition.

At the conclusion of their initial involvement in the study, participants were told they would receive another questionnaire via email in one week. A delayed post-test questionnaire was sent to participants a week after initial exposure that again measured perceptions of GMOs, free recall, cued recall, and information recognition. The questionnaire participants received was dependent on their original condition. Participants were not exposed to stimuli again during this post-test, nor was a distractor video necessary.

Stimuli

The infographic selected to be a stimulus in this study was chosen because it contained a balanced amount of visuals and text and encompassed enough information to test information recall and recognition. The infographic was also chosen because it contained basic information about GMOs that did not require further explanation by the researchers. The infographic did contain information from a medical study that was later retracted. Despite this, the panel of experts decided to choose this specific infographic because it was one of the top results from Internet searches for GMO infographics; therefore, it is likely a source sought out by individuals looking for information about GMOs. To correct for this error in the infographic, participants were debriefed about the erroneous statement after completing the study.

Measures

Perceptions of GMOs. To measure pre-existing perceptions toward GMOs, as well as perceptions immediately after viewing stimuli and a week later in the delayed questionnaire, a GMO perception scale was adapted from previous research (Linnhoff et al., 2017). Participants were asked to indicate their response to each scale item using a 7-point Likert scale with 1 = *strongly disagree* and 7 = *strongly agree.* Sample statements from the measure were: *I believe GM foods are fundamentally against nature* and *GM food production is a good idea.*

Free recall. After viewing the distraction video, participants were given a blank text box and asked to freely recall any information they could remember from the infographic or narrative they viewed. They were not prompted with any cues that trigger the cognitive memory searching process (Aue et al., 2016). The free recall statement was: *List any information you can recall from the infographic you viewed.*

Cued recall. To test cued recall of information, participants were given five questions that asked facts from the infographic/narrative. Participants are given a cue and must retrieve the correct memory based on that cue (Aue et al., 2016). Participants were given a blank text box and prompted to give one correct answer to each question. Sample cued recall questions were: *What crops grown in the U.S. are primarily GM?* and *Cross-species - or transgenic - genetic manipulation has combined the DNA of what two organisms?*

Information recognition. In the questions measuring information recognition, participants were given 10 true or false questions. Five of these questions were from the stimulus material; the other five were false and did not actually appear on infographic/narrative. Malmberg et al. (2012) stated past studies have found the more items participants are tested on, the less accurate their answers are. Therefore, participants were only tested on five facts from the infographic/narrative. Sample information recognition questions were: *The crops in the U.S. that are primarily GM are soybeans, cotton, and corn. True or False?* and *Only 10 kinds of GMOs exist on grocery store shelves. True or False?*

Data Analysis

The data were collected in Qualtrics then exported to IBM SPSS v. 25. The use of descriptive statistics allowed for an overview of the data, including participant demographic information and the mean and standard deviation values for the perception scale used and the questions within the study instrument. Post-hoc reliability for the GMO perception scale was Cronbach's $\alpha = .90$. Inferential statistics were employed to provide answers to the research questions. This included independent samples t-tests and paired samples t-tests. The Shapiro-Wilk test was used to assess normality of data distributions, which was met. Levene's Test for Equality of Variances was used to assess homogeneity of variance, which was met unless otherwise described. Cohen's *d* coefficient was used for analysis of effect size, where *d* is greater than or equal to .2 is small, .5 is medium and .8 is large effect size (Cohen, 1988). Statistical significance was set *a priori* at <.05 (Field, 2017).

The free recall question that appeared immediately after participant exposure to stimuli, as well as a week after exposure, required the collection of qualitative data provided in response to an open-ended question. Following the technique Agostinho (2005) and Steede et al. (2016) implemented, key message statements from participants' responses were identified. After identifying these statements, the researcher determined how many of those statements were present in each response in order to provide comparison between the two stimuli. The responses for cued recall and information recognition were scored as either correct or incorrect and the resulting percentage correct was used to determine how much participants could recall correctly from the stimulus shown. The potential scores ranged from 0 to 100%.

Results

Participant perceptions toward GMOs were measured prior to stimuli exposure, immediately after stimuli exposure, and a week after stimuli exposure. The grand mean for the pre-test was 4.09 (SD = 1.34). The grand mean immediately after they were exposed to stimuli was 4.32 (SD = 1.42), and the grand mean for the delayed-test was 3.90 (SD = 1.45). Therefore, there were overall neutral attitudes toward GMOs throughout the study's timeframe as results closer to "1" indicate positive perception of GMOs and closer to "7" indicate negative perception of GMOs.

RQ1: What influence does the message stimuli have on participants' perceptions of GMOs?

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between the infographic viewers' preexisting perceptions of GMOs before exposure to the stimulus and their perceptions a week after exposure to the stimulus. No significant difference was found in pre-existing perceptions of GMOs of infographic viewers (M = 3.56, SD = 1.20) and delayed perceptions of infographic viewers (M = 3.68, SD = 1.43); $t(21)$ = .69, p = 0.500, d = .15). Despite this, average perceptions increased by 0.12 from pre-perceptions to delayed perceptions, indicating infographic viewers felt slightly more negative about GMOs a week after stimuli exposure.

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between the narrative viewers' preexisting perceptions of GMOs before exposure to the stimulus and their perceptions a week after exposure to the stimulus. No significant difference was found in pre-existing perceptions of GMOs of narrative viewers (M = 4.15, SD = 1.49) and delayed perceptions of narrative viewers (M = 4.04, SD = 1.47); $t(33)$ = 0.72, p = 0.476, d = .12. Contrary to the perceptions of infographic viewers, narrative viewers felt slightly more positive about GMOs a week after they were exposed to stimuli, as average perceptions decreased by 0.11.

RQ2: Do participants freely recall more information when exposed to an infographic or textual narrative?

One question was used to test free recall in this study on both the post-test and delayed post-test questionnaires. Participants were asked to list any information they could remember from the stimulus they viewed. The opportunity for multiple text answers required this question to be treated as qualitative data.

Those who viewed the infographic provided comments about graphic design elements, which were statements the narrative group could not make. Such graphic design statements included recall of how the infographic was arranged such as one participant stating, "There was a corn graphic in the center". Many participants belonging to both groups were able to recall exact percentages included with the information about the CBS study conducted to gauge acceptance of GMO labeling. For example, one participant of many listed "83% of American citizens are for labeling GMO's, 56% of American citizens are against GMO's in general". Participants from both groups were also readily able to recall "30,000 GMOs exist on the shelves in stores".

In the delayed free recall, participants were asked to write what they could remember about the stimulus they viewed a week earlier. Eight of the narrative viewers said they could not recall any information they viewed a week earlier or simply did not provide an answer at all. One infographic viewer also provided no response to this item. It can be observed there were fewer statements mentioned in the delayed free recall analysis than in the first free recall analysis. Delayed free recall responses tended to be more general. While participants in both groups recalled such information as "30,000 products have GMO in grocery stores", participants tended toward broad recollection of the facts revealed by such statements as, "I can recall that most food in grocery stores is made from GMOs".

RQ3: Is there a significant difference in participants' cued information recall when exposed to an infographic or textual narrative?

An independent samples t-test was conducted to determine if there were differences in cued recall scores between infographic viewers and narrative viewers. No significant difference was found between cued recall question scores for infographic viewers (M = 64.52, SD = 24.67) and narrative viewers (M = 62.86, SD = 24.59); $t(123) = .38$, $p = .707$, $d = .07$. However, infographic viewers scored slightly higher on average than narrative viewers.

An independent samples t-test was conducted to determine if there were differences in delayed cued recall scores between infographic viewers and narrative viewers. No significant difference was found between delayed cued recall question scores for infographic viewers (M = 67.27, SD = 25.12) and narrative viewers (M = 58.82, SD = 26.94); $t(54) = 1.18$, $p = .244$, $d = .32$. Infographic viewers scored higher on average than narrative viewers. Figure 1 provides a comparison of the mean scores.

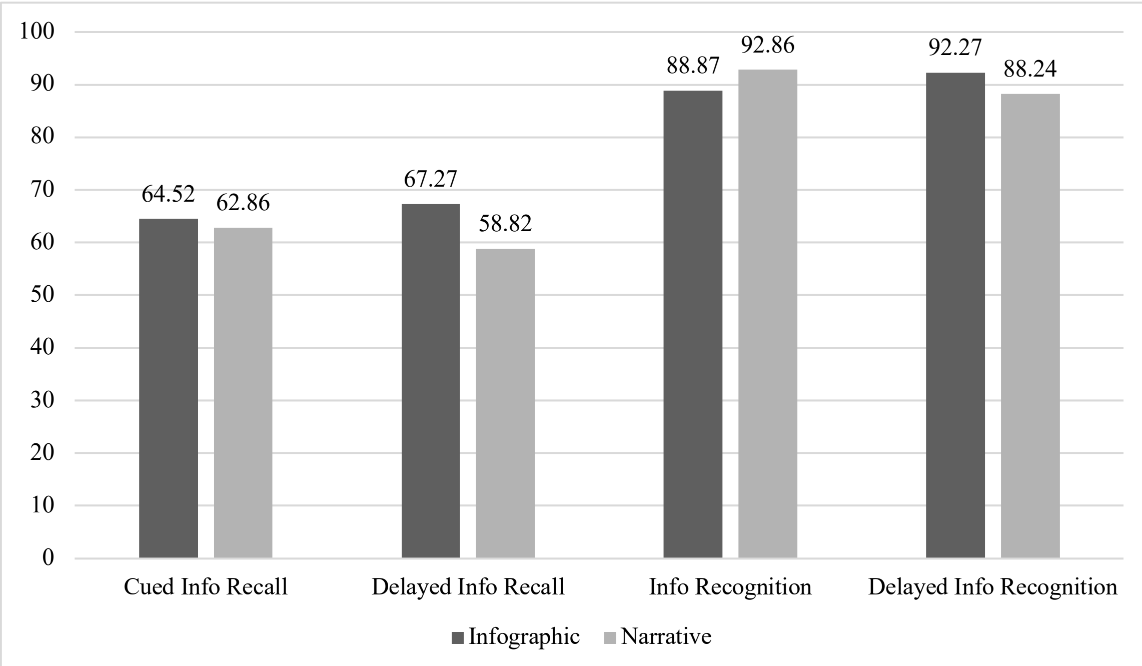
RQ4: Is there a significant difference in participants' information recognition when exposed to an infographic or textual narrative?

A Welch t-test was conducted to determine if there were differences in recognition scores between infographic viewers and narrative viewers as the assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p = .034$). No significant difference was found between recognition question scores for infographic viewers (M = 88.87, SD = 14.27) and narrative viewers (M = 92.86, SD = 11.28); $t(115.94) = 1.73$, $p = .086$, $d = .31$. Narrative viewers had a higher average recognition score than infographic viewers.

An independent samples t-test was conducted to determine if there were differences in delayed recognition scores between infographic viewers and narrative viewers. No significant difference was found between delayed recognition scores for infographic viewers (M = 92.27, SD = 11.93) and narrative viewers (M = 88.24, SD = 14.87); $t(54) = 1.07$, $p = .290$, $d = .29$. Unlike the recognition scores, the infographic viewers had a higher average delayed recognition score than narrative viewers. Figure 3 provides a comparison of the mean scores.

Figure 3

Comparing Infographic and Narrative Participants' Cued Information Recall and Information Recognition



Conclusions, Discussion and Recommendations

The results of this study did not find one form of information presentation was more effective than the other at altering perceptions about the given topic. Changing attitudes about agricultural production practices is a difficult task because the public has little understanding of agriculture (Settle et al., 2017) and the complexities involved within the industry. Therefore, it is difficult to influence or altogether change perceptions, and that process will most likely not occur with the viewing of a simple infographic. In response, agricultural literacy campaigns must stay consistent in their efforts to allow audiences to retain information, with the ultimate goal being the gain of general agricultural knowledge (Spielmaker & Leising, 2013).

The free recall, cued recall, and information recognition measures used in this study gauged the ability of the two stimuli to create information retention and recall in viewers. There were no statistically significant differences found in free recall, cued recall, and information recognition rates when information was presented in either the form of an infographic or a narrative. These findings are similar to those of Lyra et al. (2016). The difference in the allocation of resources between the two stimuli could help explain the non-significance observed between the groups. While the two groups were presented with the same information, infographic viewers were required to view graphical representations that narrative viewers did not see. The narrative viewers were responsible for creating mental representations for information on their own, whereas the infographic viewers did not have to put as much effort into this cognitive step. So while informational presentation could have played a role in resource allocation, participants were still intaking the same information and experiencing the introduction of novel information that took more effort to process than information that did not have an impact on viewers or was information they already knew.

The current study's conclusion that infographics are not superior to textual information is not consistent with what Yildirim (2016) or Comello et al. (2016) found. Both of these studies found infographics outperformed purely textual information when participants were tested on information retention. However, Yildirim (2016) had participants self-report their opinion of how much more effective infographics were than text rather than testing the true information retention of participants with recall and recognition questions. Additionally, Comello et al. (2016) tested multiple health literacy modules, and only one of these modules indicated infographics were more effective than purely textual information.

While this study did not find infographics are more effective at creating information retention and recall, it did affirm infographics are just as effective at communicating information about GMOs as narrative text. This implies these visualizations can be used to reach educational goals when communicating complex topics and infographics can compete with more traditional forms of educational materials. This conclusion is similar to what Ozdamla et al. (2016) found when incorporating infographics in an anatomy course, and Meppelink et al. (2015) also discovered in their study that used infographics to communicate health literacy topics. These findings, including those of the current study, support the CLT and LC4MP by demonstrating cognitive load can be reduced by using visuals and minimizing the amount of information presented to viewers. The subprocesses of encoding, storage, and retrieval can occur without interruption, and even more quickly, as visualizations are provided to viewers, thus eliminating the need for viewers to create a new mental visualization for incoming information.

In this study, participants recalled multiple facts from the infographic in the free recall, cued recall, and information recognition questions. They were also able to recall those same facts in the delayed questionnaire. These facts often included specific numbers or visual elements of the infographic. The LC4MP model can be used to explain why participants remembered these types of facts. Because there was not much text to go along with these facts on the infographic, the visuals used as informational representations were easy to comprehend and store in memory and later recall when prompted by the questions within the study instrument. These statements in the narrative did not contain visual representations but did present viewers with novel information that triggered an orienting response (Lang, 2009) and led to allocation of resources to absorb this information because it presented new or unexpected information.

This study should be repeated with more than two conditions with the possibility of adding a control group. The delayed post-test technique should be kept in order to efficiently measure the long-term memory, and ultimately, knowledge gain, of participants. It is also recommended this study be replicated with more participants to obtain generalizable results.

One limitation of the study was the low response rate for the delayed post-test questionnaire. Participants in this particular study were not motivated to partake in the delayed questionnaire because it was not worth as much extra credit as the first questionnaire because they were not required to come to the media lab to take the delayed questionnaire. It is recommended an incentive for delayed questionnaires surveys be made equal or higher than the first survey. An additional limitation is the agricultural involvement of the participants was not measured to control for its effect on opinions, knowledge, and recall of GMOs. As such, future studies should include this measure in the questionnaire.

A similar study could be conducted on this topic with the stimuli embedded in a magazine or informational pamphlet, or other communication material. This would help determine if infographics are effective at communicating information in the midst of other elements competing for viewers' attention and cognitive resources. The design aspects of infographics are also a subsequent area of research. Factors such as color, layout, font choices, and images should all be examined to gauge viewer preference and visual appeal, as well as cognitive preference.

Agricultural literacy campaigns can benefit from the use of the LC4MP model to better understand which forms of communications are most effective at teaching agriculture concepts. By understanding how audiences encode, store, and recall information, and recognizing that overly complex information causes these subprocesses to halt, designers of agricultural literacy curriculum can create materials that do not overload cognitive resources while simultaneously supporting learning the information.

An additional aspect based on the LC4MP that was not considered in the current study was secondary task reaction time (STRT). STRT can be helpful in determining the attention allocated to a medium (Bracken et al., 2014). By introducing distractions or increasing level of difficulty while participants are viewing media, the amount of resources being allotted in efforts to pay attention or understand the information can be measured, as well as the amount of cognitive strain participants are experiencing. Information like this could be helpful for future research in this area that focuses on cognitive overload, resource allocation, and knowledge gain.

Agricultural companies should produce infographics to ensure factual information is available to consumers. Convenience is important to many people, as well as brevity of information. In this regard, infographics are an ideal way to inform adult audiences about agricultural topics. By using all available communication tools, the agriculture industry can continue to combat misinformation and increase literacy levels.

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