

Learners Interpreting Instructional Images: Meaning-Making and Decision-Making Strategies

Elizabeth Boling
Indiana University
Bloomington, IN, USA

Colin M. Gray
Iowa State University
Ames, IA, USA

Micah Gideon Modell
Abdullah Altuwaijri
Jiyoon Jung
Indiana University
Bloomington, IN, USA

Abstract

Instructional images are used widely in textbooks and other learning materials, but the role of learner interpretation has not been adequately explored. While previous research has demonstrated the diversity of interpretation derived from images by learners, this research has not consistently taken place in the context of authentic learning tasks. In this study, we examine the interpretations made by in a university environment in an authentic learning context—specifically foreign language learners. Participants included English speakers learning Arabic and Arabic speakers learning English, and their use of a set of designed illustrations. Meaning-making and decision-making strategies were identified, demonstrating the non-deterministic role of images in the learning activity.

Keywords: instructional illustrations; EFL learning; interpretation; cognitive load theory; semiotics

Introduction

Instructional illustrations are commonly used in instructional materials. Decades of research on visuals in learning, spanning from the 1950s to the 1980s, has been focused on understanding the forms (i.e., visual elements like size, color and texture (Wong, 1993) of such images and the development and use of message design principles (Fleming & Levie, 1993), with comparatively little attention to how learners make meaning from images. This research extends a 2004 study into the learner's process of interpreting and making meaning from instructional images (Boling, Eccarius, Smith, & Frick), with the goal of understanding more about the active role of learners in their use of simple images while completing an authentic learning activity in order to consider implications for designers of instructional images.

Review of Literature

Several distinct perspectives are discernable in the study of visuals for learning across six decades, which are instructive in guiding the framing of contemporary research in this area. To contextualize this study, we will address research on images and their use in instructional settings, first in a chronological overview of the literature, then through a topical overview of perspectives commonly used in this area of research—cognitive load theory, semiotics, aesthetics, and the role of the designer.

An Historical Overview

The 1950s and 1960s were characterized by the concerns of designers for the form of images themselves and studies revealing which forms attracted attention, or were preferred by children (Spaulding, 1955); how artistic treatment of textbooks might enhance memory for printed texts (Smith, 1960); and how the perception of images and preference for images changes by age (Travers, 1969). During this period there was certainly a recognition that the viewers of images must interpret them—"In order to be an effective communication medium, an illustration must not only interest the viewer but must be interpreted by him accurately. Research thus far has only given us hints as to the factors which assure correct and complete understanding of a pictorial illustration" (Spaulding, 1955, p. 44)—but the presumption was also that correct and complete understanding of instructional images could be assured. We characterize this presumption as deterministic, meaning that an image will cause understanding or that a certain form of graphic will always produce the same response in all learners for whom they are intended.

The 1970s through the 1990s were dominated by the application of the

scientific method and psychological principles to images, still from the deterministic stance that anticipates invariant—although contextualized—responses on the part of viewers to the content of images and to their formal properties (Holliday, 1973). This includes the publications familiar to instructional designers in the area of message design (Fleming, 1987; Knowlton, 1966; Winn, 1993). Message design (Fleming & Levie, 1993) retained a strong base in craft knowledge (e.g., application of concepts like warm and cool colors or static and dynamic composition) passed from one generation of craftsman to another and deeply tied to the forms of objects/images (Rissati, 2007), while incorporating implications from experiments of the time into the workings of the visual perceptual and cognitive systems, a classic example of which is adaption of the work of Paivio (1971). A well-known example of this merging of craft and scientific knowledge is the extended, carefully conducted series of studies carried out by Dwyer in which different treatments of images are compared for their effect in different types of learning with students of differing characteristics (e.g., Spotts & Dwyer, 1996). The ties to Shannon and Weaver's (1949) simple transmitter-receiver diagram at the introduction of their complex mathematical theory of communication are evident in this era, as made clear recently by Richey, Klein & Tracey (2010) in their survey of fundamental knowledge in the field of instructional design; the underlying idea seeming to be that if channels of communication can be made sufficiently clean (or free of noise) and the symbols sent through those channels sufficiently well established in advance (through direct learning, experience, or unspecified other means), the received meaning will inevitably be consistent with the intended meaning. As a representative of the message design era, Pettersson (1982) likewise tried to draw lines between craft-based practice and scientific reasoning, positing that preferences for color diverge based on geography and the resulting influence on the human visual system (bright sun versus subdued light in northern hemispheres) and by technological capabilities for producing images. Similarly, preferences for framed or unframed imagery have to do with historical and architectural surroundings with which learners are familiar.

Certainly acknowledgment that interpretation plays a role in using images for learning does exist in the literature across decades. Levie (1978), strongly associated with message design, acknowledged that symbolic versus perceptual behavior is the major concern for designers of instructional pictures; that is, the important questions have to do with the mental processes of learners using images. Salomon (1979) discussed the functional role of images, and posited a translation between pictorial cues (elements of pictures) and mental representations ("basic mental entries of particular ideas")

(p. 117)). This functional view focuses on the designers' intentions for the roles that images are supposed to play; a shift away from the forms of images, although not entirely divorced from determinism—an underlying assumption that certain qualities in an image will produce a certain effect in the learner, in the framing of behaviorist stimulus-response. Likewise, Duchastel summed up a meta-analysis of literature published in 1980 by saying, "what a picture looks like is of secondary concern; primary concern needs to focus on what a picture does in its particular context. I strongly believe that the functional approach needs to replace the morphological one in research on illustrations" (p. 286).

At least one voice emerges during the 1990s from science education, with the view that images and layouts to support learning could be improved by the collaboration, or at least participation in a form of usability testing, of learners in their development (Benson, 1997). There are suggestions here of the active role that learners play in relation to instructional images as they are using them, although the dominant view during this period of the role of instructional graphics is deterministic or quasi-deterministic as evidenced by a comparative dearth of curiosity on the part of scholars regarding what is happening inside learners' heads as they confront the images intended to help them learn, even as it is acknowledged that interpretation goes on.

The 2000s so far have been mixed in the approach to studying and understanding visuals for learning. Scholars studying images and images as part of multimodal texts emphasize interpretation on the part of readers as a central feature of how images are used (Kress, 2004; van Leeuwen, 2001; von Engelhardt, 2002). Within the field of instructional design, the learners' role in interpreting graphics takes central focus in some research. Watkins, Miller and Brubaker (2004), for example, studied 60 elementary students using images in the context of science learning and observed that these students "demonstrated a propensity for constructing their own interpretations to describe visual representations" and that "only two ... chose to read any part of the accompanying text" which was intended to clarify the meaning of the image (p. 23). Their conclusion was that research should "concentrate on investigating learner understanding and interpretation" (p. 23). Although focused on web materials and symbols rather than instructional materials per se, Knight, Guwarnadena and Aydin (2009) distributed a questionnaire to 232 adults in four countries eliciting their interpretations of "icons and images drawn from 26 US academic websites" (p. 22), finding that those interpretations were culturally influenced consistently within the constraints of Hofstede's model of cultural dimensions (p. 28). At the same time, however, new titles offering guidance to designers of images to support learning include both statements

like “[viewers] make inference(s) about the visual and construct an interpretation from it” (Malamed, 2011, p. 34) and designers “work with tools and actions to *manipulate how the learner will ‘see’ or perceive instructional information*” (Lohr, 2007, introduction; emphasis added).

Cognitive Load Theory (CLT)

Cognitive load theory related to multimedia (Mayer, 2005, 2009) may be seen as an extension of the application of psychology to the study of images in instruction, in this case with psychology foregrounded. Few images are presented in these publications, and little verbal discussion of the forms of the images that were used is provided. Instead the focus is on the functioning of the brain as evidenced in psychological research, and speculation about how that functioning interacts with images, primarily in terms of the purposes for which the images are intended. This is again a deterministic view: images provided to learners for certain purposes are expected to result in the same kinds of responses across learners consistently, according to the cognitive load hypothesized to be imposed by those images, contained both in their content and their form(s). Research seeks to identify these responses in terms of the cognitive processing that images require of the learner. Recently, questions are being asked about the disconnection between this research and the forms of images, with the implication that the individual learners do play a role in the differential effectiveness of images to support learning (Morrison, Anglin, & Morrison, 2012).

Semiotics

The semiotic perspective applied to images in learning has run parallel to deterministic views, albeit not always within the domain of instructional design. The semiotic perspective influencing this study is formalized by Sless (1986) who questioned in detail an early view of semiotics in which researchers tended to conflate their own interpretations of images with those of other viewers. Sless (1986) points out that creators of texts—including images as texts—have to imagine the readers of those texts who, in turn, must imagine the creators of the texts as part of the process of interpretation. This perspective can be seen in action when Schriver (1997) carried out an empirical study showing that users of information graphics consider the creation of those graphics as they interpret their meaning, demonstrating that viewers draw on multiple sources of input, internal and external to the images themselves—including speculation regarding the designers—in order to interpret them. More recently in another study, learners were asked directly what might have been the designer’s intention regarding the instructional purpose of visuals

within an e-learning lesson; learners were able to articulate their speculations and those speculations were consistent with the designers' stated intentions only about half the time (Jin & Boling, 2010). Several other researchers address in detail the full interplay of text and images as they are interpreted by viewers (Kress, 2004; van Leeuwen, 2001; von Engelhardt, 2002), not always directly addressing instruction and learning but foregrounding the semiotic interaction between images and viewers.

Aesthetics and Experience

In parallel with developments from a semiotic perspective, aesthetic and experiential approaches to instruction, including the interaction between the learner and instructional materials, have risen in prominence in the past decade. This perspective draws on Dewey's concept of *aesthetic experience* (1938/2005), described by Parrish (2005) as being "heightened, immersive, and particularly meaningful" (referencing Dewey 1934/1989). In an instructional context, this concept includes the potential to draw together both a holistic view of the instructional experience (Parrish, 2005) and the transactions inherent in this experience between the materials and the learner (Parrish, Wilson, & Dunlap, 2010). In this way, the aesthetic or experiential perspective maps similar relationships between artifact, viewer, and interpretation as in the semiotic perspective, while moving the locus of evaluation or attention away from formal properties or learning objectives to a holistic view of how learners plot their experiences over time. This framing has been used extensively by Parrish, including suggestions on how to incorporate this way of thinking into the design of instructional materials (2009). This perspective has the potential to move a reckoning of cognitive load away from solely looking at individual components of the design, toward the experience at large, as Miller (2011) demonstrates with the use of emotional design and aesthetic attention in an assessment context.

The Role of the Designer

Given the complexities of the semiotic and aesthetic perspectives, designers of images intended to support learning are not sufficiently well informed by traditional guidelines. These guidelines have been drawn historically from message design, which merges craft and psychology (Fleming & Levie, 1993), from empirical comparisons focused on the images themselves (Dwyer, 2007), or from theory-driven experimentation focused on the properties of images (Mayer, 2005). All of these guidelines can be helpful, but the manner in which they address viewers of images—in this case, learners—is to address their universal or invariant, perceptual and cognitive responses

to images. Such studies imply strongly that a move on the part of the designer will directly, and inevitably, determine a response on the part of a viewer. While this appears to be true and comparatively self-evident when those moves are obviously disruptive to universal perceptual and cognitive processes, such studies ignore the meaning-making of active learners (Carroll, 1998) and leave designers with guidelines that, in a representative example, exhort them to avoid such disruptions, even as they strive to maintain a learner's interest through the use of variety (Keller & Burkman, 1993). It is unclear why the field might be willing to accept this as the state of our knowledge regarding how viewers use images to support their learning, or why study in this area is pushed to "the future" (Schnotz, 2009, p. 66).

In the semiotic and aesthetic/experiential perspective from which this study is conducted, viewers play an active role in interpreting pictures (Gunther & van Leeuwen, 1996) and those learners do not necessarily interpret graphics—even very simple ones—as their designers may have intended (Boling et al., 2004). Although some general expectations might hold, particularly for widely disseminated symbols (Boling et al., 2004), the designers of such images simply do not know what the viewers' interpretations may be. This raises difficult questions for the creators of instructional graphics and those who commission, choose, or use such graphics. Without the certainty that the images themselves will stimulate the interpretations we want them to, we are either reduced to testing each image in each context where it may appear—or we need to understand more completely the ways in which learners will approach and use images. What strategies do they use to make these interpretations?

Purpose of the Study

An earlier study in which the interpretation of simple images by multiple audiences ($n=600$) was compared to the meanings intended by their designers found a gap of as much as 60% between interpretation and intention (Boling, et al., 2004). While the images used in that study were representative of those in authentic contexts (Eccarius, 2004), the study was conducted outside the context of any learning task, with the resulting limitation that the researchers could not be sure whether interpretations would have been different within such a context. The study design, a paper survey, did not allow the researchers to ask participants why they chose the interpretations they did.

The current study is an extension of this original study, exploring the use of an authentic learning task, and constitutes an initial effort to identify learners' strategies for interpreting images *while they are engaged in learning activities*.

Method

The researchers collected and analyzed observation and interview data using qualitative methods. We used thematic analysis to understand the strategies employed by learners who completed an authentic learning activity designed to expose these strategies. Our choice of a language learning activity was based on convenience because we had materials and students available to us through academic contacts, and because members of our research team had experience in teaching and learning foreign languages. Four members of the research team have experience as language educators and one member of the team is a native Arabic speaker. These language practice books and resultant learning contexts represent a naturally occurring, complex learning situation. While cultural translation and interpretation comprise part of the complexity, this study does not focus specifically on cultural difference. These materials yielded picture-based learning activities we knew to be common in language learning and appropriate for the study.

The Context

The study was conducted at a large university in the Midwestern United States which conducts a popular intensive English program as well as offering courses in Arabic. The original materials we used were intended for Arabic speakers learning English; as we were able to identify English speakers learning Arabic as well, we decided to use members of both groups to broaden the population, even though the study remained relatively small in scope. Participants were recruited during their language classes; sessions took place in nearby classrooms immediately following the formal instruction.

Participants

This study enrolled 16 participants, organized into eight dyads. All dyads were formed opportunistically by students who were studying Arabic or English in the same course; that is, the students agreed on exiting the classroom that they would participate and do so as one of a pair. The participants were drawn equally from the two different populations: eight native speakers of English who were studying Arabic and eight native speakers of Arabic who were studying English. In both populations, 6 participants were male and 2 female, but among the native English speakers, this yielded two mixed-gender groups while all the Arabic-speaking groups were homogenous in gender. Both groups attended classes at the university, and were in upper beginner level language courses. Dyads were chosen as a data collection strategy to enrich the think-aloud protocol. We required that the participants agree on their answers and after the activity asked them to explain the rationale for

those choices, thus externalizing decisions that would otherwise have been tacit and unavailable to the researchers.

Materials

The stimulus materials used for the study were adapted from a practice workbooks in use overseas for English language instruction to undergraduate Arabic speakers, and consisted of a matching exercise in which learners are presented with images and asked to match these images with text descriptions (Figure 1). The first author, who was responsible for the creation of the images, worked professionally as an illustrator for instructional materials prior to pursuing a research agenda focused on the design of instruction and the use of images within instruction. The exercise included eight images to be matched with eight descriptions, and an additional "warm-up" activity that included two images and two descriptions (Figure 3). The instructions for each exercise were identical, with those for the students of Arabic translated into Arabic (Figure 2).

Activity: Look at the pictures and answer the questions.



Which picture shows:

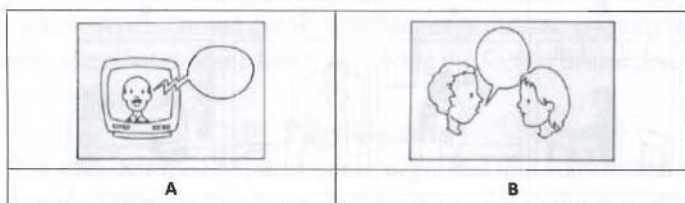
1. someone giving blood? _____
2. a girl who is sitting on a floor? _____
3. a girl who is sitting in a garden? _____
4. a pupil in a classroom? _____
5. Which picture shows a look of concern? _____
6. someone listening to something? _____
7. a library? _____
8. someone who is missing someone? _____

Figure 1. English study instrument.

- اي الصور تظهر التالي:
- ١ - شخص يتبرع بالدم؟ _____
 - ٢ - طفله جالسه على الارض؟ _____
 - ٣ - طفله جالسه في الحديقة؟ _____
 - ٤ - طالبة في الفصل الدراسي؟ _____
 - ٥ - أي الصور تظهر نظرة قلق؟ _____
 - ٦ - شخص يستمع لشي ما؟ _____
 - ٧ - مكتبه؟ _____
 - ٨ - شخص يفتقد شخصا ما؟ _____

Figure 2. Text from Arabic study instrument.

Warm-up Activity: Look at the pictures and answer the questions.



Which picture shows:

Someone telling a story? _____

Someone reporting the news? _____

Figure 3. Warm-up activity (English version).

To begin the process of creating the images used in the study, we selected images from a set of English language study materials in use at a university in an Arabic speaking country. To determine the final selection of source images

to be developed further, a set of seven practice workbooks from the English language study curriculum were reviewed and exercises were selected based upon a common theme of a single person in a distinct setting. Several overlapping themes were identified in the images, and were explicitly used by the illustrator to create overlap in gender, sitting position, or environment (see Figure 4). To reduce extraneous cognitive load (Mayer, 2009), the images used were a professionally drawn, "stylistically consistent set of images emphasizing the elements required to support their interpretation in the context of this activity" (Jung, et al., 2011, p. 1). We used principles learned within the traditions of our field and the collective professional experience of the group in the process of revising the images, on the premise that these represented the best available guidance for image creation, and we wanted to test images in this study that conformed to best known practice. As part of the revision process, content of the selected images was researched for appropriateness and potential analogues to the Arab target culture, and suggestions for improvement or changes were made to the professional illustrator for implementation in a revised image. For example, western garb was replaced with the *thobe*, which is more common form of clothing in the Middle East. The illustrator incorporated this information when rendering versions of the images for the study, working through multiple drafts to resolve any issues identified by the native Arabic speaker. These adjusted images were used with both the native Arabic speakers and the native English speakers.



Figure 4. Content themes present in the images selected for the activity.

Data Collection

The researchers conducted eight sessions: one with each dyad. These sessions were videotaped and observed by one or two researchers as permitted by availability. Each dyad completed a practice exercise (Figure 3) with only two images and text elements required to be matched. Immediately thereafter, they completed the main exercise, including eight images and text elements (Figures 1 and 2).

Participants were instructed to work together and decide on their responses by consensus, thereby encouraging them to think aloud and discuss their thought processes with their partners as they worked. On conclusion of the warm-up, the researcher asked the students to verbalize their thought processes and explain any actions that were unclear to observers. During the primary exercise, the researchers occasionally prompted the participants for more information while the activity was being completed.

Upon completion of the main activity, one researcher interviewed the participants, asking questions aimed at understanding how they made their decisions. These direct questions (e.g., "How did you decide that this image meant...?") were initially focused on asking for explanations of specific exchanges between the two students, as observed by the researchers. After clarifying the overall decision-making process, the researchers followed up with a walk-through of each image and how decisions were made in the context of that specific image.

Analysis

The researchers reviewed the video of each session as a group to become familiar with all the sessions. Researchers transcribed each session, with translations into English made where necessary. The videos in which participants spoke Arabic were also subtitled to simplify viewing and further analysis by non-Arabic speaking members of the research team. The researchers then conducted an interpretive thematic analysis of the session transcripts. Transcripts were closely read by the entire team, by individual researchers, and by pairs of researchers, for signs of strategies being employed by the participants. Qualitative analysis software was used to code the occurrences of these strategies across all sessions. As analysis was carried out, researchers attended to any potential differences between the strategies being used by the two groups of participants. We did not see any such differences, and felt this was likely due to the fact that we were examining the strategies for interpreting images and not to the specific interpretations they were making.

Through group analysis of the coded transcripts, emergent strategies were named and collapsed into distinct codes whenever overlap was detect-

ed. Numerous strategies were used for the verification of codes, including: close reading of the text, checking of interpretations with other researchers, and checking of all instances of each code to ensure consistency of application. The final codes were agreed upon by a group of researchers. The final coding scheme included 11 distinct codes falling into two categories: meaning making strategies and decision making strategies. Once these final codes were determined, and definitions for each code were agreed upon by all researchers, each transcript was reviewed a final time by a pair of researchers, with a follow-up group meeting for inter-rater agreement.

Findings

A total of 233 excerpts were coded across the eight data collection sessions (see Table 1 for a summary of coding). Each excerpt was coded non-exclusively, with an average of 1.8 codes (min=1; max=4) per excerpt. Excerpts averaged 50.24 words in length, with a median of 39 words (min=5; max=209). 84 excerpts were coded from Arabic participants who were learning English, while 149 excerpts were coded from English participants learning Arabic. Each excerpt represented a complete thought or exchange around a single idea.

Table 1. Code Application by Participant Group.

Code	English Students Learning Arabic	Arabic Students Learning English	Total
lived experience	42	38	80
extended narrative	17	9	26
image-text switching to generate possibilities	29	12	41
negotiating meaning	10	5	15
internal context	79	42	121
envisioning the designer	8	3	11
narrowing the field	23	17	40
language mechanics	24	2	26
image-text switching to check interpretation	12	7	19
partner-checking	7	7	14
extrapolation from minimal cues	24	4	28

The final set of codes were grouped into two categories: meaning-making strategies and decision-making strategies (see Table 2). Meaning-making strategies include references to a student's lived experience, creation of an extended narrative, a switch between image and text in order to generate possible answers, the negotiation of meaning with their partner to develop consensus, the identification of features within the internal context of an image, and the envisioning of a designer that has produced the learning materials. Decision-making strategies include the elimination of items to narrow the field, using knowledge of grammar or syntax to select or eliminate an answer, a switching between image and text to check a possible interpretation, confirmation of a decision with a partner, and the extrapolation of cues from an image or word without explicitly making meaning.

Table 2. Meaning-making and Decision-making Strategies Used in the Coding Process.

Meaning-Making Strategies	
lived experience	Combines elements of the image to activate culturally, personally-situated schema, and/or applies existing schema to an image.
extended narrative	Makes up a story related to, but not literally depicted in, one or several available images.
image-text switching to generate possibilities	Changes the focus of attention from image to text and back to generate possible directions for interpreting meaning.
negotiating meaning	Discusses individual expectations to reach consensus on the meaning they will accept for an image.
internal context	Identifies salient features of an image based on its being part of a set.
envisioning the designer	Addresses, directly or indirectly, the possible intentions of a designer/writer who has produced the text.
Decision-Making Strategies	
narrowing the field	Eliminates items separately from content of images or text (as in eliminating items already decided upon).
language mechanics	Determines an answer by relying on knowledge of grammar and syntax.
image-text switching to check interpretation	Changes the focus of attention from image to text and back to check or raise confidence in a candidate decision.
partner-checking	Asks about and/or confirms a candidate decision.
extrapolation from minimal cues	Selects an image element or a word that allows her to act without explicitly making meaning.

Meaning-Making Strategies

These were the strategies the researchers intended to observe. The strategies are focused on interpretation of the images within the context of the

learning activity, rather than on simple identification of objects depicted in those images.

Lived experience: Study participants often invoked lived or vicarious experience in their construction of meaning.

Facilitator (F): Then why not E the one with tables?

Participant Left (PL): Because it is an atmosphere of a library

F: No impression of a classroom?

Participant Right (PR): Right, when we see the image then we could see that it must be a library as the classroom does not contain as many books as the library in addition to the big tables.

1st language Arabic dyad—4663-5150

Extended narrative: As participants became involved in the construction of meaning in the provided images, they created narratives to engage with the depicted concepts, importing meaning that was not explicitly defined in the original image.

PL: It looks like she is thinking over friend or something. I just look at that would be her mother.

PR: No just her friend.

PL: Yeah. Like reading a lot of [inaudible] from her friend.

1st language English dyad—12808-12983

Image-text switching to generate possibilities: Participants switched their focus between the provided image and question/answer text in order to generate explanations or possibilities for interpreting meaning. This search was bi-directional, and included the searching of question/answer text for potential vocabulary derived from the image (e.g., play, blood, Arabic word for library), and the discovery of known vocabulary words in the question/answer text that was then read back into the images (sometimes resulting in extended narrative or lived experience, which were coded simultaneously with this code).

PR: What is H? What is she doing?

PL: It is giving blood. [identifying image]

PR: Do we know what blood is? [scanning the text looking for a candidate word that matches the image interpretation they decided on]

PL: No.

1st language English dyad—5770-5868

Negotiating meaning: Negotiation of meaning primarily occurred in the partners' divergent interpretation of image features, and how that affected the meaning of the image at large (and if that meaning matched with the chosen

answer text). In most cases, this negotiation was carried out with a discussion of foregrounded elements in the image or question/answer text.

PR: Concern is looking at herself? I don't know

PL: 5 I feel the picture shows a look of

PR: I feel it's important

PL: I feel also b as if she has lost someone carrying the doll, I don't know

Facilitator: Please you'll have to agree here

PL: This one is remembering and the other one is carrying the doll as if she is remembering somebody

PR: This one shows missing but this one is only a little girl carrying a doll

1st language Arabic—2463-2880

Internal context: In the process of carrying out meaning-making in the context of an image, participants evaluated characteristics of an image based on their relationship to other features in that images, or to other images in a set. Almost half of the excerpts (28/69) coded with this strategy co-occurred with the "extrapolation from minimal cues" code, implying that the salient features that were identified as a set were often created by the user, but not necessarily intended by the designer.

PR: They are both sitting sitting, one of them is on the garden and the other is I mean the sentence is one, the different is in the floor and garden.

F: Ok.

PL: For me, I compared between the two using one thing, I didn't consider it from the beginning, I thought of other things . for example, when we said picture D, here she is truly sitting, ok.

F: Aha

PL: Here he is sitting, and here he is sitting. The problem is that for this one there is indications for things other than sitting, there is thinking happening.

F: Aha

PL: You got me, so there is not similarities in here. That's why I did not choose immediately and kept these information to not confuse the two pictures. So I took the rest of the information from the rest of the pictures, ok, and come back and start branching on the issue. For example, in the two similar pictures, where they are sitting. That's why understood it this way. So sorry but everyone has their own style.

1st language Arabic—5807-6773

Envisioning the designer: Although not appearing in the course of the

activity, debriefing questions posed to the participants after the activity elicited clear evidence that they could and did consider the designer of the images. The strategic design of the images as a set was the most common concern, including the need for consistent cues for the learner to interpret the image correctly. In the exchange below, the participants do not name a designer explicitly. However, close reading reveals that the speaker is addressing the actions of an unseen designer.

PR: Yeah, to see the two that were kind of similar

PL: Yeah, and people always look for continuity [across multiple images]

PR: Yeah—

PL: So if you use like similar, like the same objects or like similar objects throughout your images, it's like—keep people like [inaudible] I guess. Or like say if this was a movie or something, they would—

1st language English—19246-19562

Decision-Making Strategies

While we were not initially looking for decision-making strategies in the context of this study, we found that they were often intertwined with meaning making. The strategies are focused on how the partners decided to confirm their decisions apart from explicit interpretation or meaning making.

Narrowing the field: Learners attempted to reduce the number of available choices, either by deciding to come back to an answer in the future, deciding between two equivalent choices (where the amount of information—or lack thereof—seems to be equivalent), or making a guess once all other available choices have been used. This strategy also included crossing out answers that had already been used (in an attempt to see what answers still remain) or starting with the vocabulary that was most well known by the participants.

PL: Yeah, just like isolate the ones that you do know and then like figure out when—what choices you can eliminate from there.

1st language English—14785-15044

PL: Concern what is meant by concern; I don't know this word, let's leave it to the end...

1st language Arabic—1712-1833

Language mechanics: Language mechanics were used to by learners to make decisions based both on surface characteristics of the questions and answers, and on the specific gender of words or conjugations of verb.

F: And um lets go to the 3rd one. How did you decide on number C?

PL: Um, he is giving blood or having some sort complicated medi-

cal procedure done

PR: Yeah hehe

PL: And [khamsa=five] was the most complicated sentence left.

PR: And we did not know what it means, so..

PL: Had no clue what, I don't think I know any of these words.

1st language English—6854-7187

PR: The word 'concern' is a little strange and when I answered this last one, 'someone is missing someone' listening to, I started to remember that 'concern' 'look'. The verb look is seeing.

F: Ok.

PR: So I figured out that concern is a mirror. [the strategy used resulted in the correct image, but the wrong vocabulary word]

1st language Arabic—7043-7291

Image-text switching to check interpretation: Learners switched their focus between the provided image and question/answer text in order to finalize their decisions. Most of the instances of this code involved the learners searching for a specific feature in the image based on a vocabulary word they knew, confirming their answer. This strategy allowed the learners to disregard certain characteristics of the image in deference to a specific action or element.

PL: The answer is there is nothing but it, then we connect it to mmmm...someone ...someone listening to something, so maybe if he is listening to something then it could be this one [referencing an image of a person listening to music with headphones].

1st language Arabic—5705-5889

Partner-checking: Prior to finalizing a question, learners occasionally confirmed the answer they had decided on with each other. Although sometimes this was merely confirmatory of previous discussion, at times this process also caused the learners to rethink or negotiate their position.

PR: I think [shakhasa = a person] so probably she is thinking about someone, a person [referencing an image with a thought bubble which representing a woman thinking about someone].

PL: Yeah ok

PR: So probably this is D.

1st language English—4680-4806

PR: I think this one. Ok E. Are there any other classroom here, this is library, right.

PL: Yes, this is library.

1st language Arabic—3162-3285

Extrapolation from minimal cues: These strategies included selecting an

image based on an extrapolation from the text, such as translating or intuiting a specific word from the question and answer, and using that word alone to guide the image selection process (often resulting in narrative, which is a meaning-making strategy). There were also instances of learners picking an answer text based on instinct, or how the text “made them feel.” The comparison of images and text also expanded to a definition of larger categories across the image set, including extrapolation based on assumptions of gender and age.

PL: But it is possible. Yeah. Because she looks, they look grown like more. So.

1st language English—9529-9610

F: So like say in C, what made you pick the blood instead of something else that was going on in the image?

PL: Well, for some reason, this last word reminded me of blood

F: OK

PL: I don’t know why—I—I had no idea why, it just did. So I just went with it [laughs] And uh, I mean they always say go with your first instinct, right?

1st language English—12491-12995

Discussion

Meaning-making and decision-making were observed to be dynamic processes, linked to each other without differentiation on the part of the participants. The learners’ focus was on completing the activity, a familiar one for them in the context of language learning. They made the assumption, presumably based on their experiences in this context, that there would be one and only one image matching each of the text items and used this assumption to influence their decision-making and their interpretations of images. They were aware of the human hand behind the design of the activity and the appearance of the images. While their strategies were purposeful, they were also fluid, without systematicity. Meaning-making and decision-making operated together, with meaning-making occurring about half again as often as decision-making (294:127). In an activity chosen to emphasize the need for meaning-making it may not be surprising that meaning-making dominated, and this may not be typical for all activities involving images. It is highly suggestive, however, that meaning-making predominated in this activity using simple images—interpretation of the images was not automatic for these learners, despite the simplicity of these images.

While we judged the images to be consistent with general principles for instructional graphics, as much as we could make them so, we were sur-

prised by some of the impact our design decisions appeared to have made in the active meaning-making process. We revised the images to be stylistically consistent in order to reduce the need for decisions about which details mattered or did not. However, one dyad interpreted the images as something like a cartoon or storyboard, meant to be seen as part of an integrated story. This was not a deterministic outcome; not every dyad responded in this way, and these learners downplayed or ignored the idea eventually when they could not make sense of the story. In other instances, learners picked up details of images that had been stripped down to what we considered essentials, and interpreted them as communicating more than we realized.

Reviewing the numbers of strategies in both categories used by these learners, the rapidity with which they switch from one to another or discard a strategy that is not working for them, we are struck by their cognitive flexibility and the limited extent to which any determinism appears to be involved in their response to the images that embodied our design decisions. In this study, for which simple images were used and for which those images had been created in accordance with the guidelines offered by our field, we see that: multiple strategies are required to use the images effectively; understanding is not determined solely by the properties of these images; and the question of the cognitive load they may impose is not simple. With regard to this last point, we might be able to label the forms of cognitive load—intrinsic, salient and extraneous (Mayer, 2005)—that each aspect of these images might represent in this activity from the perspective of their creators. However, it was apparent that the learners themselves added complexity to even simple images that were devoid of decoration and were stripped to what experienced designers considered to be the most salient elements. In addition, those images clearly functioned within a web of meaning-making that involved the learners' awareness of their context (i.e., a language lesson), their strategies for completing an activity which they knew to be governed by tacit rules (i.e., there will be only one answer per question), their content knowledge as it intersected with the use of the images, and their broader knowledge of the world outside the learning activity (e.g., libraries, classrooms, portable music players, blood donation). As we viewed the strategies these students were using, the images did not stand apart; their contribution to cognitive load was not a singular and universal "weight" added to an otherwise separate and known quantity—the instructional activity.

Limitations and Opportunities for Future Research

This study used a small number of participants, the number our small team could handle given the open-ended verbal data we collected. We took

advantage of the language programs at the study site to include two groups of language learners in this number to mitigate this limitation. We also considered the study to be exploratory, in terms of whether or not we would be able to discern the learners' strategies using our study design. While we did include two distinct cultural groups in the study, we used culture as a typical framing for learning (i.e., an authentic type of complexity found in instructional materials) and did not focus specifically on cultural differences in interpretation. As discussed previously, this was in part because we were examining strategies for interpretation rather than the interpretations themselves. The use of dyads to externalize learners' thinking during the think-aloud protocol masks some aspects of individual strategies for participants who are somewhat passive in the dyad. On balance, however, we saw the method as a positive extension to standard think-aloud protocol in that it did elicit a range of statements about strategies through exchanges between participants.

The structure and scope of this study indicates a variety of future research opportunities in this area, including: verification and expansion of the meaning- and decision-making strategies we identify in this study in broader instructional contexts; the role of age, culture, or other environmental factors in shaping particular strategies; and how best to account for these strategies in the creation of instructional visuals, through processes such as user research or usability testing of materials.

Conclusion

Learners do, indeed, use a fluid, active, and inter-related mix of strategies to decide what an image is supposed to mean to them in the context of a learning activity. We have to let go of the idea that specific visual forms ensure outcomes when used to support learning, or that simple images *are* simple in the context of a learning activity. In place of this view, we see a rich interplay of meaning-making and decision-making on the part of learners who can be ascribed interpretive agency, and these learners use distinct types of strategies that are discernible and worthy of more exploration. A larger study could establish these types more definitely and allow us to understand which, if any, display consistently the co-occurrence we observed in this study. With that knowledge, more and less effective use of strategies might be identified in various contexts and made amenable to improvement so that learners can take maximum advantage of graphics supplied for their support.

A potential implication for researchers is that attention could productively be paid to exploring how learners' strategies can be focused and made

more effective as an adjunct to successful learning. This knowledge, combined with positive practices already in place among designers regarding the forms of graphics that, while not deterministic, are supportive of learners' interpretations, could represent a leap forward in the use of visuals for learning.

References

- Benson, P. (1997). Problems in picturing text: A study of visual/verbal problem solving. *Technical Communication Quarterly*, 6(2), 141-160.
- Boling, E., Eccarius, M., Smith, K., & Frick, T. (2004). Instructional illustrations: Intended meanings and learner interpretations. *Journal of Visual Literacy*, 24(2), 185-204.
- Carroll, J. (1998). *Minimalism beyond the Nurnberg Funnel*. Boston, MA: MIT Press.
- Dwyer, F. M. (2007). The program of systematic evaluation (PSE): Evaluating the effects of multimedia instruction 1965-2007. *Educational Technology*, 67(5), 41-45.
- Duchastel, P. (1980). Research on illustrations in text: Issues and perspectives. *Educational Communication and Technology*, 28(4), 283-287.
- Eccarius, M. A. (2004). *Using graphic elements in cartoon sequences to improve written narratives of hard of hearing students*. Dissertation. Retrieved from <http://digitalcommons.unl.edu/dissertations/AAI3126948>
- Fleming, M. L. (1987). *Designing pictorial/verbal instruction: Some speculative extensions from research to practice*. In H. A. Houghton & D. M. Willows (Eds.), *The psychology of illustration*. (pp. 136- 57). New York, NY: Springer.
- Fleming, M. & Levie, H. (1993). *Instructional message design: Principles from the behavioral and cognitive sciences*. Englewood Cliffs, NJ: Educational Technology Publishers.
- Gunther, K & van Leeuwen, T. (1996). *Reading images: The grammar of visual design*. London, UK: Routledge.
- Holliday, W. (1973). Critical analysis of pictorial research related to educational science. *Journal of Research Science Teaching*, 12(1), 77-87.
- Jin, S. H., & Boling, E. (2010). Instructional designer's intentions and learners' perceptions of the instructional functions of visuals in an e-learning context. *Journal of Visual Literacy*, 29(2), 143-166.
- Jung, J., Gray, C., Howard, C., Kwon, S., Modell, M., & Boling, E. (November 2011). Preparation of visual materials to study how EFL learners use images in the learning process. Roundtable Discussion at AECT International Convention 2011, Jacksonville, FL.

- Keller, J., & Burkman, E. (1993). Motivation principles. In M. L. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2nd ed., pp. 3-54). Englewood Cliffs, NJ: Educational Technology Publications.
- Knight, E., Gunawardena, C., & Aydin, C. H. (2009). Cultural interpretations of the visual meaning of icons and images used in North American web design. *Educational Media International*, 46(1), 17-35. doi:10.1080/0952398090278127
- Kress, G. (2004). Reading images: Multimodality, representation and new media. *Information Design Journal*, 12(2), 110-119.
- Knowlton, J. (1966). On the definition of a "picture." *AV Communication Review*, 14(2), 157-183.
- Levie, W. H. (1978). A prospectus for instructional research on visual literacy. *Educational Communication and Technology*, 26(1), 25-36.
- Lohr, L. (2007). *Creating graphics for learning and performance: Lessons in visual literacy*. Upper Saddle River, NJ: Prentice Hall.
- Malamed, C. (2011). *Visual language for designers: Principles for creating graphics that people understand*. Beverly, MA: Rockport Publishers.
- Mayer, R. E. (2005). *The Cambridge book of multimedia learning*. New York, NY: Cambridge University Press.
- Mayer, R. E. (2009). *Multimedia learning*. New York, NY: Cambridge University Press.
- Miller, C. (2011). Aesthetics and e-assessment: The interplay of emotional design and learner performance. *Distance Education*, 32(3), 307-337. doi:10.1080/01587919.2011.61029
- Morrison, G., Anglin, G., & Morrison, J. (2012). Redundancy with text and pictures: A contradiction. Paper presented at the annual meeting of the AECT International Convention, Louisville, KY.
- Paivio, A. (1971). *Imagery and verbal processes*. New York, NY: Holt, Rinehart and Wilson.
- Parrish, P. E. (2005). Embracing the aesthetics of instructional design. *Educational Technology*, 45(2), 16-25.
- Parrish, P. E. (2009). Aesthetic principles for instructional design. *Educational Technology Research and Development*, 57(4), 511-528. doi:10.1007/s11423-007-9060-7
- Parrish, P., Wilson, B. G., & Dunlap, J. C. (2011). Learning experience as transaction: A framework for instructional design. *Educational Technology*, 51(2), 15-22.
- Pettersson, R. (1982). Cultural differences in the perception of image and color in pictures. *Educational Communication and Technology*, 30(1), 41-53.

- Richey, R. C., Klein, J. D., & Tracey, M. W. (2010). *The instructional design knowledge base: Theory, research, and practice*. New York, NY: Routledge.
- Risatti, H. (2007). *A theory of craft: Function and aesthetic expression*. Chapel Hill, NC: The University of North Carolina Press.
- Salomon, G. (1979). *Interaction of media, cognition and learning: An exploration of how symbolic forms cultivate mental skills and affect knowledge acquisition*. San Francisco, CA: Jossey-Bass.
- Schnotz, W. (2005). An integrated model of text and picture comprehension. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 49-69). New York, NY: Cambridge Univ Press.
- Schrivver, K. (1997). *Dynamics in document design: Creating texts for readers*. New York, NY: John Wiley.
- Shannon, C., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, IL: University of Illinois Press.
- Sless, D. (1986). *In search of semiotics*. Totowa, NJ: Barnes & Noble Books.
- Smith, K. U. (1960). The scientific principles of textbook design and illustrations. *Audiovisual Communication Review*, 8(1), 27-49.
- Spotts, J., & Dwyer, F. M. (1996). The effect of computer-generated animation on student achievement of different types of educational objectives. *International Journal of Instructional Media*, 23(4), 365-75.
- Spaulding, S. (1955). Research on pictorial illustrations. *Audiovisual Communication Review*, 3(1), 35-45.
- Travers, R. (1969). A study of the advantages and disadvantages of using simplified visual presentations in instructional materials. Final Report on grant, United States of America, Department of Health, Education and Welfare.
- van Leeuwen, T. (2001). Semiotics and iconography. In T. van Leeuwen & C. Jewitt (Eds.), *Handbook of Visual Analysis* (pp. 92-118). London, UK: Sage Publications.
- von Engelhardt, J. (2002). *The language of graphics: A framework for the analysis of syntax and meaning in maps, charts and diagrams*. Amsterdam, Netherlands: Institute for Logic, Language and Computation, Universiteit van Amsterdam.
- Watkins, J. K., Miller, E., & Brubaker, D. (2004). The role of the visual image: What are students really learning from pictorial representations. *Journal of Visual Literacy*, 24(1), 23-40.
- Winn, W. (1993). Perception principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2nd ed., pp. 55-126). Englewood Cliffs, NJ: Educational

Technology Publications.

Wong, W. (1993). *Principles of form and design*. New York, NY: John Wiley & Sons.