USING ANIMATIONS – PART 2

Introduction

As discussed in the first paper within this series(1), animations used in tools like PowerPoint® can be a ‘two-edged sword’ (Lowe & Boucheix, 2011, p. 650). When used correctly, they can improve comprehension, impressions and attention. On the other hand, when they are used incorrectly, they can be a distraction that reduces the effectiveness of the communication.

To understand the most appropriate utilisation of animations it was first important to define the objectives for using these techniques. According to Berk (2012, p. 6) the objectives for applying animations can be categorised as ‘grab or maintain attention’, ‘create an emotional connection’, and ‘improve learning’. Part 1 in this series discussed the first two objectives. This part of the series explains a useful framework for understanding when to use animations in presentations to improve learning outcomes. It is noteworthy that there is a slight variation to this approach when creating videos, but this aspect will be discussed separately in a later article.

Background for the Learning Objective

Animations can be very useful in supporting learning, because they can be used to ‘convey procedural knowledge…demonstrate the dynamics of a subject matter, and allow exploratory learning through manipulating a displayed object’ (Schnotz & Rasch, 2005, p. 47). In other words, animations may be used to emphasise, clarify, integrate and explain information that aids learning (de Koning, Tabbers, Rikers, & Paas, 2009).

However, there have been mixed results in various experiments used to test animation used to enhance learning outcomes (de Koning et al., 2009), and there is some debate as to whether static material is more effective than animated presentations (Betancourt, 2005). For instance:

• Mayer, Hegarty, Mayer, and Campbell (2005) conducted experiments, which showed that a series of static pictures may be more effective tools to aid learning than an animated sequence;

• Nouri and Shahid (2005) identified that the animations used in their experiments may have positively affected student attitudes about the topic, but did not appear to deliver better learning outcomes than overhead projector slides showing static material;

• when used to teach mathematical algorithms, the presence of animations significantly improved learning outcomes (Tudoreanu & Kraemer, 2008); and

• student understanding, learning and retention of astronomy related information was significantly enhanced by utilising animation (Miller & James, 2011).

As illustrated in the preceding examples, there are substantial differences in the learning outcomes achieved through the use of animation. It was therefore likely that the results may have been influenced by the way in which the animations were applied to achieve specific teaching objectives. Consequently, it became apparent that a model was needed to separate learning related animation objectives, so the efficacy of differing approaches could be assessed rationally.

A starting point in the development of this model was drawn from Clark and Lyons (2011). They identified that the fundamental issue in understanding the success of animation for learning relates to its ability to help the viewer develop mental models. To apply this concept, Figure 1 provides an overview of the internal and external factors that drive cognition, and the key steps utilised by people to build mental models(2).

![Figure 1: Factors and stages in developing dynamic mental models](image)

As explained in Tudoreanu and Kraemer (2008), the external factors shown on the left of Figure 1 can directly affect the viewer’s cognitive processing of information(3). The right hand side refines Tudoreanu and Kraemer’s (2008) internal cognitive factors, by applying the framework detailed in Hegarty et al. (1999). This framework is based on common stages used in the development of dynamic mental models from static information. These stages are:

1) **Decomposition and parsing.** This relates to the generation and aggregation of entry level units into arrays(4). In other words, this early type of cognitive processing takes basic visual elements and mentally determines how they fit together.


3. External cognitive factors are related to the visual attributes explained within Section 10 in the file at <http://www.seahorses-consulting.com/DownloadableFiles/ShapingAttentionHandout.pdf>.

4. See <http://www.seahorses-consulting.com/DownloadableFiles/ArrayHandout-Part1.pdf> for more information on the mental processes used to manage these activities.
(2) **Constructing static mental models.** This stage is achieved by taking into account spatial and discernible differences (e.g. changes in different pictures within a sequence), and relationships between visual elements, to make representational associations.

(3) **Making referential connections.** Where information is provided through more than one modality (e.g. text/graphics, narration/graphics, etc.), people typically attempt to link information sources to create cognitive connections. For example, cognitively linking this text to the model shown in Figure 1 (above) is a referential connection.

(4) **Determining the causal chain of events.** In this stage the viewer consciously or subconsciously identifies a chain of events and/or a hypothesis of predicted behaviour, by generating understanding from the preceding stages.

(5) **Constructing a dynamic mental model.** A dynamic mental simulation is created in the person’s mind, by applying inferences and rules developed through the preceding stages.

It is important to note that not all five stages are required for all situations. For instance, when explaining simple material about a concept, the designer may only need to help the audience reach Stages 2 or 3 of mental model development. Additionally, at each stage of this process new information provided through the external factors (e.g. changes in the visualisation supported by animation), and the viewer’s existing knowledge (e.g. linking the new concepts to what they already know) influences the mental model that is developed.

The model at Figure 1 was then used as a foundation to help develop an understanding of why static media may sometimes be more effective than animated content. This concept is illustrated in Figure 2.

![Figure 2: Separating static and dynamic visualisations across the stages](http://www.seahorses-consulting.com/DownloadableFiles/ArrayHandout-Part2.pdf)

---

5. See [http://www.seahorses-consulting.com/DownloadableFiles/ArrayHandout-Part2.pdf](http://www.seahorses-consulting.com/DownloadableFiles/ArrayHandout-Part2.pdf) for more information on factors that influence the grouping of information to create static mental models.

6. The term modality refers to the processing pathways used in the brain (Schnotz & Kurschner, 2007). For instance, when reading an illustrated book, although the information is being received through the eyes (a single channel), the text and graphics will be processed in different parts of the brain. Because the text and graphics are taking different pathways through the brain, they are considered as different modalities.

7. This model was developed by the author from information provided in Hegarty et al. (1999), Hegarty et al. (2002), Narayanan and Hegarty (2002) and Höfler and Leutner (2007).
As shown in this second view of the developed model, the cognitive stages progress through the development of understanding from relatively static compositions (Stages 1 to 4), to the creation of dynamic mental models (Stages 4 and 5). Although all five cognitive stages can be supported by static content (Hegarty, et al., 2002), the provision of expository animations can deliver significant benefits in facilitating causal chain (Stage 4) and dynamic mental model (Stage 5) development (Höffler and Leutner, 2007).

**Using the Model**

This model can be applied to help you determine which types of animation are most applicable to aid learning in each case. As a designer, you should therefore begin by determining which stage of the mental model development process is being targeted for each particular element of the presentation (Hegarty, Kriz, & Cate, 2003; Hegarty et al., 2002). For example, is the goal to allow the viewer to construct a static or dynamic mental model?

As illustrated in Figure 3, different objectives need to be achieved to support each cognitive stage of mental model development.

![Diagram](image)

*Figure 3: The types of information required for each stage of mental model development*

In essence, these objectives outline the types of information that are needed to help people through the processing. For instance, if your objective is just to assist your audience to make referential connections, then the visualisation can simply provide appropriate static text and graphics, and the layout and/or animation must also use appropriate techniques to help the viewer integrate the material (e.g. using proximity of text and graphics, or animating in content at the same time). Alternately, if the intent is to help individuals construct a dynamic mental

---

8. Expository animations present clear and purposeful demonstrations of visual material to provide explicit explanations (Ploetzner & Lowe, 2012). For example, showing the movement of engine parts, such as the one at [http://en.wikipedia.org/wiki/Four-stroke_engine](http://en.wikipedia.org/wiki/Four-stroke_engine), can be considered an expository animation.

9. The information provided toward the right hand side of Figure 3 was developed by the author based on insights and concepts covered in Hegarty et al. (1999), Hegarty et al. (2002), Clark and Mayer (2008), Ploetzner and Lowe (2012), Lowe and Schnitz (2008), de Koning, Tabbers, Rikers, and Paas (2007) and Boucheix and Guignard (2005). As this paper is focussed on visual elements, multi-modal and dual-channel audio related concepts have only been explicitly included in this diagram for Stage 1 and 2. Later papers will explain dual-channel issues for the remaining stages in more detail (e.g. graphics and narration issues, or video development).
model, then it is important to provide visualisations that meet all of the objectives (e.g. showing how bits of a machine or concept fit together through animation).

Cue and expository animations can therefore be applied to support the five stages, but different techniques are required for different stages. To help understand this linkage of animation to different stages of mental model development, let’s begin with an overview of the two categories of animation shown in Figure 3, which can be defined as:

- **Cue animation.** This category reflects the application of animations that are designed to draw attention to specific content (Boucheix & Guignard, 2005). In other words, these refer to the types of animation techniques that capture or maintain visual attention (as discussed in Part 1 of this series). Cue animations are therefore specifically designed to get the viewer to focus on the important visual information, so they can more effectively process what they need for each stage of their mental model development (Boucheix & Guignard, 2005; Boucheix & Lowe, 2010; de Koning, Tabbers, Rikers, & Paas, 2010). It is important to note that these types of animation typically do not aim to provide an explanation of the content (de Koning et al., 2007). This objective can normally be left to the material itself (e.g. text and graphics, and/or the associated narration), when supporting Stages 1 and 2. However, as alluded to earlier, cue animations can be used to support Stage 3 by helping people create referential links. As an example, simultaneously animating-in text and graphics that need to be interrelated, will help the viewer to create the required referential connections. Alternately, as explained in more detail in the paper on the amount of text that should be allocated per slide[^10], animation of each visualised point should be synchronised with the narration in a presentation, to avoid creating cognitive overload. Just as importantly, this approach helps people create explicit referential connections (e.g. because they can see from the appearance of the objects at the same time that the material is linked).

- **Expository animation.** Ploetzner and Lowe (2012, p. 782) apply the term expository animation to reflect situations in which ‘the animated representation is intended to provide an explicit explanation of the entities, structures, and processes involved in the subject matter to be learned.’ This category of animations is therefore utilised to show how things work, or demonstrate the specific relationships between visual entities (Ploetzner & Lowe, 2012). Expository animations are therefore mostly used to support the development of causal chains (Stage 4) and dynamic mental models (Stage 5) (Hegarty et al., 2003)^[^11].

As illustrated by the alignment of the two types of animation in Figure 3 (above), the following guidance can be defined from this model:

- **Supporting static mental models.** If the intent is only to present information to support static mental model development, then the presentation should typically just apply cue animation, or no animation at all (Boucheix, Lowe, Putri, & Groff, 2013; Clark & Lyons, 2011; Narayanan & Hegarty, 2002).

- **Supporting causal chain and dynamic mental models.** Alternatively, expository animation is typically best applied to facilitate the development of understanding for


[^11]: Hegarty et al. (2003) do not use the term *expository animation*, but this appears to be the intent within their text.
complex causal chains and dynamic mental models (Ploetzner & Lowe, 2012) (e.g. supporting Stage 4 or 5).

- **The two types can be used together.** The application of cue and expository animations are not mutually exclusive, and may often be used together (de Koning et al., 2010) to support the five stages of cognitive model development. As an example, a designer wishing to assist a viewer to develop a dynamic mental model, may find it appropriate to first apply cueing animations to attract the viewer’s attention (e.g. facilitating Stages 1 to 3), before implementing the expository animation sequence (Ploetzner & Lowe, 2012) (e.g. to assist the viewer to achieve Stages 4 and 5).

Consequently, animation to support learning is not just focussed on one objective, but needs to find a balance between effectively supporting the viewers to achieve the required stage of their mental model development. To demonstrate the importance of this insight, a detailed analysis of the different experiments discussed earlier in this paper was conducted. As you will recall, these showed that different learning outcomes were achieved through animation.

Interestingly, the analysis of the first two sets of experimental examples showed that where animations were included, but the content only required the viewer to develop Stage 1, 2 or 3 mental models, there was no significant comprehension benefit achieved. It is likely in these cases that this is because the text and graphics on their own were appropriate, and were probably not complex enough to have necessitated drawing attention to key points through cue animations. However, although the cue animations that they used did not improve comprehension, their presence in Nouri and Shahid’s (2005) experiments positively influenced student impressions. Consequently, cue animations can be useful in shaping viewer impressions as discussed in Part 1 of this series, even if the intent is just to support Stage 1, 2 or 3 level mental models.

Alternately, Tudoreanu and Kraemer’s (2008) experiment (the third one in the list of examples) used cue animations to introduce information in a sequence that helped the learners to manage cognitive load more effectively. They referred to this as generating ‘cognitive economy’, and it was achieved by animating-in/out parts of complex formulae and models in a sequence that helped the students to focus on the important elements. Additionally, this approach allowed the participants to use the visual content as a form of external working memory\(^{12}\), that helped them to put the information together most effectively. In other words, utilising focussed cue animations to manage visual complexity helped the students learn complex information.

The final experimental example refers to the research implemented by Miller and James (2011). Their presentations were designed to help participants develop dynamic mental models\(^{13}\), so they were intent on helping their students reach Stage 5 of the mental process. In this case they found that the expository animations were highly successful in improving understanding and retention of dynamic information (Miller & James, 2011).

---


13. For example, ‘when possible, the figures were animated to indicate motion across the image, such as photons being scattered by a dust cloud, or a star swelling into a red giant while its core shrinks’ (Miller & James, 2011, p. 3).
Summary

These examples therefore demonstrate why animations assist learning and communication in some cases and not in others. Lessons from these experiments and the processing model therefore led to the creation of the following key rules for optimising the use of animation:

• **Rule 1.** If the visualised text and graphics are readily understandable in their own right, and the intent is just to help the audience achieve no more than a Stage 3 mental model, then the design can typically gain the same learning outcomes with or without animation. In these cases, the only difference is that the provision of focussed cue animations may generate more positive impressions about the visual material, when they are used appropriately.

• **Rule 2.** If the visual elements or the content are complex, or there is a need to integrate different channels (e.g. the speaker in synchronisation with the visual material), or modalities (e.g. showing text and graphics that require Stage 3 processing), then it is typically better to utilise cue animations. These animations should be carefully applied to draw attention without imposing significant additional cognitive load (e.g. keep the cue animations simple, as explained in the following two parts of this series).

• **Rule 3.** If there is a need to assist people to achieve Stage 4 or 5 in the cognitive processes, then the provision of expository animations can be very useful in improving learning outcomes and the communication of the information.

Looking Ahead

The following parts in this series flesh out the frameworks explained in the first two instalments as follows:

• **Part 3: Strategies and Techniques.** Part 3 explains which animation strategies and specific techniques will work best to allow presenters to achieve the objectives listed in the first two parts. This paper is specifically designed to be very practical, and it will give you a set of simple rules that are universally applicable. Part 3 is at: [http://www.seahorses-consulting.com/DownloadableFiles/UsingAnimations_Pt3.pdf](http://www.seahorses-consulting.com/DownloadableFiles/UsingAnimations_Pt3.pdf).

• **Part 4: Text Animation.** The final part in this series looks at a special case for using animation. This relates to the use of animated text. Although animated text is widely used in presentations, the research shows that many common techniques are actually counter-productive. Consequently, this last paper in the series is designed to explain how you can get the best results from showing text in presentations. The final part is at: [http://www.seahorses-consulting.com/DownloadableFiles/UsingAnimations_Pt4.pdf](http://www.seahorses-consulting.com/DownloadableFiles/UsingAnimations_Pt4.pdf).

A General Note

This is one in a series of quarterly newsletters. Should you or another person wish to receive future newsletters, and you are not already a member of the group, please email the following information to info@seahorses-consulting.com:

- your full name; and
- the email address to which you want the information forwarded.

These newsletters are provided at no cost, so getting added to the group is free and it will give you access to leading insights.
REFERENCES


