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An Analysis of Visual Images in Examples of ‘Encountered’ Science Communication

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Abstract

Visual images are often used in science communication activities and events for different purposes and in different contexts. However, there is limited research on this area and the decision made for choosing a visual image often relies on common sense or the personal judgement of a science communicator. Previous studies have highlighted potential effects with respect to a specific visual image property. This research aims to expand on existing research by examining visual images and their accompanying written texts utilised in 'encountered' science communication events.

A case study approach was adopted to examine selected examples occurring within the years 2014-2018. The analysis is based on discourse analysis of the visual image and accompanying written texts which scrutinises the construction of an intended concept or ideology. The analyses of exemplified cases demonstrate several relationships between a visual image and accompanying elements to express an ideology. As such, there are four distinct, though occasionally overlapping, ways accompanying elements contribute to a visual image namely identification, expansion, implication, and reinforcement. The case studies then serve as the basis for synthesising the research findings in a science communication context.

The findings indicate that a visual image or series of visual images can increase the opportunity for initial engagement through large physical size or occupied space, colour and brightness, recognisable elements, and the coherence with other collaborative visual images. It may also prolong the initial attention by being part of a series or continuation, displaying aspects of relevance or applicability, resonating with emotions, and being intriguing or challenging with respect to the interpretation. With regards to achieving learning outcomes, textual/verbal information is often required for the audience to process scientific knowledge relevant to the images. The interdependent combination of visual and textual/verbal information may enable the promotion of an attitude/value or ideological standpoint. Meanwhile, the use of a visual image can provide enjoyment or inspiration, as well as support the improvement of visual skills by default. These findings are summarised as a guide for science communication practitioners to use in the selection of visual images. In addition, there is a suggestion that the use of a visual image analysis framework could be a useful tool for a science communicator in selecting visual images for use in science communication.

Lay summary

Visual images are often used in science communication activities and events for different purposes and in different contexts. However, there is limited research on this area and the decision made for choosing a visual image often relies on common sense or the personal judgement of a science communicator. Some previous studies have shown potential effects with respect to a specific visual image property. This research aims to expand on existing research by examining visual images and their accompanying written texts utilised in 'found' science communication events.

A multiple-case study approach was adopted to examine selected cases occurring in the UK, USA, and Thailand within the years 2014-2018. Several methods were used to gather relevant information of each case either from primary sources like interview or field notes, or secondary ones. The preliminary analysis is based on a framework for analysing the construction of messages through a visual image and accompanying written texts which may associate a particular concept or ideology. The case studies then serve as the basis for synthesising the research findings in a science communication context.

The findings indicate that the visual images' properties allow a science communication event to get and maintain attention, and certain components between visual images and accompanying written/verbal information tend to be the primary enabler of each potential learning outcome. A visual image can increase the chance of the event to be found in a daily life context through physical size or occupied space, colour and brightness, recognisable elements, and the coherence with other collaborative visual images. It may also prolong the initial attention by being part of a series or continuation, displaying aspects of relevance or applicability, resonating with emotions, and being intriguing or challenging the interpretation. In regard to achieving learning outcomes, textual/verbal information is mainly required for the audience understanding of information. Both visual images and textual/verbal information are supposed to be present to enable the promotion of an attitude/value, and behaviour. Meanwhile, the use of a visual image can provide enjoyment or inspiration, as well as support the improvement of visual skills by default. The implication of the findings is proposed as a practical guideline for the process of utilising visual images in science communication.

Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgement, the work presented is entirely my own.

Kaewnapha Phothi

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Chapter 1
Introduction

This research explores the use of visual images in science communication. It examines multiple cases of casually encountered science communication exhibitions and displays which involve a range of science communication purposes. For the purpose of this research, casually encountered science communication is defined as science communication which audiences have not necessarily planned to attend, instead, encountered it within their day to day activity. Besides this introductory chapter, the thesis comprises the following eight chapters which are arranged in three primary sections. The first section, including this introductory chapter, introduces some background for the research i.e. the review of relevant literature in Chapter 2 and the research design and methods for conducting the research in Chapter 3. The following section includes four chapters (Chapters 4 to 7) which provide the accounts of case studies regarding the analyses of eight exemplified visual images or exhibitions in relation to their characteristics, associated messages, and science communication contexts based on a framework for discourse analysis. Finally, the last section entails the research results and findings in Chapter 8 and the conclusions in Chapter 9. The findings are drawn from the cross-case synthesis which is an approach of data analysis to compare results emerged in different cases respecting the focused aspects relevant to the research questions. Chapter 8 explains what and how certain characteristics of visual images and their collaboration with accompanying modes of communication enable different functionalities in science communication. The final chapter describes the summary of the research, the implications for science communication practice, limitations of the work as well as recommendations for future research.

1.1 Visual communication

There has been some recent interest in studying the use of visual images in science communication as seen in the special issue of a science communication journal featuring articles focusing on various relevant dimensions (Nucci, 2015). Previous studies contribute to the understanding of certain visual image characteristics and potential effects. However, given the prevalence of visual images in a science communication context, the dynamic use of visual images in combination with their accompanying element(s) is a subject demanding further study.

Communication within contemporary societies operates through the convergence of mass media, technology, and culture that affects the way people experience the world around them (Hassan, 2008; McQuail, 1994; Open Textbook Library, 2016). A range of messages can be disseminated and received, not only in the form of direct interpersonal communication but also through different channels of mass media transmission of

information. The advancement of media technology enables better media production or reproduction, as well as makes available more extensive forms of media comprising both traditional and innovative ones such as magazines, radio, television, and the Internet. As such, someone may receive the same information through different means of communication with several enabling devices or can use merely a single digital device such as a mobile phone or computer to access different forms of digital media simultaneously. Such synergetic movement of media and technology also leads to the expansion of a message itself that is no longer exclusive or pertinent only to a particular society but can be disseminated on the global scale across geographically distant cultures.

Besides the distinction of information types corresponding to the encoding schemes of data transmission regarding analogue or digital information, information can be characterised by its respective sensory modalities. In other words, information might be contained and perceived in several modes such as auditory or verbal, textual, visual, or kinesthetic (Fleming, 2012). Most communication events are less likely to deploy only a single mode of sensory modality but usually involve a contribution of several modalities instead. A multimodal message often brings cognitive and affective effects into communication. Namely, a multimodal message potentially promotes the efficiency of information processing, and a greater tendency of stimulating emotional responses, as well as being attractive and accessible to audience members with different modality preferences (Fleming, 2012; Pincus, 2011; Rigutto, 2017). Moreover, the visual mode is one modality often featured in the majority of multimodal representation of information. This might be due to the efficiency of the human visual system allowing one to experience and respond to a visual stimulus spontaneously or cognitively, in addition to the sophisticated technology making visual media production and dissemination more convenient (Bruce, Green, & Georgeson, 2003; Mirzoeff, 2009).

The ubiquity of visual communication might also be evident in the interest shown by social scholars leading to the notion of visual culture (Mirzoeff, 2009; Rampley, 2005). It involves the consideration of the characteristics of and the social interaction related to visual forms and events, as well as individual visual artefacts themselves such as visual images, time-based media, architecture, or performances (Mirzoeff, 2009; Walker, 1997). The evolution of visual culture after the postmodern period associates broader aspects and visual expression approaches that are not exclusive to a cultural elite. Namely, visual culture no longer focuses only on artworks defined by art history but also covers other kinds of visual artefacts such as cinema or television, advertising, graphic design, comic books or photography (Rampley, 2005). In addition, with current reproduction technology, the visual experience becomes more accessible beyond traditional viewing settings, such as in the gallery or cinema. This, in turn, highlights the visual modes of representation available in everyday life (Rampley, 2005). The visual culture that influences how people in society experience the surrounding

world may challenge, particularly in Western culture, the perception of verbal text as being the primary form of communication. Although visual elements might not be able to entirely replace the linguistic mode regarding being the medium of information, one benefit of the visual mode is that it may have an undeniable emotional impact on audiences that written texts may be less capable of portraying (Gombrich, 1995; Mirzoeff, 2009).

Among several kinds of visual materials, visual images or pictures are often deployed to communicate messages associated with many aspects of contemporary society. Publics encounter various forms of visual images in their everyday life including the visualisation of objects which cannot be seen by the naked eye (Mirzoeff, 2009) as a result of the growing competency in and convenience of visual image production. Likewise, the increase in the capacity of mobile devices and the Internet allows one to create and/or rapidly disseminate a visual image to a large audience. As a communication tool, a visual image has the potential to diminish linguistic boundaries in communication, and it may become a tool for accessibility especially in a cross-cultural communication event (Lester, 2010; Schroer, 2014). Visual images are utilised for a variety of purposes such as to stimulate an emotional response or to persuade the approval of a proposition in advertisements or political campaigns (Hill & Helmers, 2004; Kozol, 1994; Messaris, 1997; Seo, Dillard, & Shen, 2013). Similarly, visual images are also a crucial format exploited in many other disciplines including science communication (Bowater & Yeoman, 2012; Burns, O'Connor, & Stocklmayer, 2003)

1.2 Science communication and the definition of relevant terms

The terms 'science communication', 'science communication event', or 'science communication practice' in this context are used interchangeably. They are defined as the process of communicating messages relevant to science for public audiences rather than the dissemination of scientific information within the scientific community (Bultitude, 2011; Burns et al., 2003). The terms 'public', 'public audiences' or 'members of the public' mentioned in this research involve the audiences or participants of a science communication event who are non-experts or have no or less background knowledge about the scientific subject featured in the event (Berlo, 1960; Bowater & Yeoman, 2012; Wood, 2009). They might be differentiated by a range of criteria such as by their age, levels of expertise or interest in science (Aikenhead, 2001; MacLaren, 2015).

Although science is part of people's everyday life and plays an essential role in the cultural contribution to society, there is still a lack of public engagement with or interest in science (Bennett & Jennings, 2011; Bultitude, 2011; Bickerton, 2018). As a result, scientists and scientific institutions have been encouraged to engage with the public in order to share scientific knowledge, as well as to establish a mutual understanding and relationship between science and society. The practice of science communication may be initiated or facilitated by a person or institute referred to as a 'science communicator'. A science

communicator might be either a science researcher or a mediator who often but not necessarily has a background in science (Bowater & Yeoman, 2012; British Science Association, 2016; Russell, 2009).

Public audiences may take part in science communication activities through a direct or face-to-face mode or indirectly through modes such as broadcasting, mass media, or online interaction (Haste, Whitmarsh, Kean, Russell, & Peacock, 2005; McCallie et al., 2009). The majority of science communication events occur in particular settings in which accessibility and participation are likely to be intentional and pre-planned by the participant. An audience may plan to visit or may need to obtain tickets or pre-book to gain access to such science communication events. As a result, the event may be exclusively limited to some members of the public who have an interest in science or might be personally affected by the event's associated scientific topic. Meanwhile, a science communication event or activity happening in a public space or in a context occurring in everyday life may be able to reach out to a broader audience which can include those not usually interested in science who unexpectedly have a chance to encounter certain aspects of science (Bultitude, 2011; Haste et al., 2005; Russell, 2009).

However, to bring science communication into a daily life context is often challenging. One aspect of difficulty may be the competitive environment in everyday life which consists of different communication strategies of different sectors attempting to get attention from people who might be already overwhelmed by all kinds of available information. This social phenomenon potentially affects the practice of science communication and inevitably leads to the appropriation of a variety of approaches, both traditional and innovative to ensure the engagement of science with the public (Bultitude, 2011; Burns et al., 2003). As such, visual images may be used in a science communication event primarily as a visual stimulus to secure attention. Although a visual image may be striking enough to make people aware of an event, if there is potential to utilise visual images in the science communication activity itself, it does not seem to be very economical to utilise a visual image merely for an auxiliary purpose when other functions such as to construct aspects of meanings or to affect emotional responses remain neglected (Cristina, Estrada, & Davis, 2015; Rigutto, 2017).

1.3 The prior understanding of visual images used in science communication

Similar to other kinds of media, visual images have their own particular dynamics of conveying a message and stimulating particular experience and perception of meanings (McLuhan, 2013). It is notable that the interpretation of a visual image is not always straightforward since it may contain a series of visual signs that can only be understood by cultural learning of their meanings. Also, the perception of a visual image tends to be influenced by subjective factors such as personal experience, or cultural belief or values possessed by the viewer, possibly leading to different interpretations and receptions of the

message (Anglin et al., 2004; Gregory, 1980; O'Sullivan, 2003). Moreover, the polysemic nature of a visual image may also be the result of its intertextuality in which the possible meanings can be differently constructed depending on its context (Kress & Leeuwen, 2001; Rigutto, 2017). Therefore, the understanding of visual image characteristics and their respective potential functionality may allow one to use this device to its full potential.

To deploy a visual image purposefully and meaningfully is arguably part of the development of science communication practice. It involves an overarching consideration of several factors such as target audience, relevant setting or context, or the appropriate approach and tools for communication (Bowater & Yeoman, 2012; Bultitude, 2011; Russell, 2009). Although science communication may involve practices appropriated from various disciplines, one way of improving science communication practice is by evaluating and reflecting on previous practice. Without explicit dissemination in the wider science communication community, this learning probably becomes tacit knowledge for particular practitioners who might then make decisions for an event based on their previous experiences and reflections. As such, the utilisation of visual images might hugely rely on the personal judgement of an experienced science communicator, such as in terms of the perception of the aesthetic appeal of the visual image, or its potential functionality. Nevertheless, from the notion of multiple intelligences and different skills and abilities among people (Gardner, 2006), one could assume that not every science communicator can perform the task of using visual images skillfully. For some science communicators, it may become a challenge that is overlayed by the presumption that the use of visual images can be handled with common sense or availability of the image.

With the growing body of literature in the discipline of science communication and the developing expertise in the practitioner community, a number of studies and implications relevant to the subject have been shared among scholars and science communicators. They may contribute to different dimensions of science communication such as the intent to define a standard definition or understanding of the subject, or some practical frameworks for better practice (Bultitude, 2011; Burns et al., 2003; Davis, 2010). Regarding the appropriation of communicative devices, several studies investigated and provided applicable implications for some major science communication approaches such as writing, television or radio, or hands-on activities (Aikenhead, 2001; Bowater & Yeoman, 2012; Brake & Weitkamp, 2010; Russell, 2009). However, studies mainly focusing on visual images seem to be under-researched although visual images are used extensively in science communication (Priest, 2015; Trumbo, 1999).

Different types of visual images are utilised in science communication for different purposes. They can serve as a versatile communication tool applicable to all kinds of events regardless of the event’s underpinning science communication concepts or objectives. For instance, a

visual image might be presented in combination with other modes of communication to give information in a one-way manner, or it can be deployed in another event to engage audiences and encourage two-way dialogues. In addition to visual images specifically created to be used in scientific research and teaching, they could be categorised with respect to their original purposes of production such as visual images created specifically for a science communication event, created as the product of an event participation, or existing visual images which may be created for other purposes but can be used in a science communication context (Bloomfield & Doolin, 2012; Bucchi, 2006; Manghani, 2013; Smith & Joffe, 2013; Stevenson, 2013). To contribute to this area of science communication practice, some studies endorsed the significance of visual images in science communication and raised attention to the requirement of visual literacy entailing visual thinking, visual learning, and visual communication (Anglin et al., 2004; Cook, 2006; Gardner, 1982; Gregory, 1974; Pauwels, 2006; Trumbo, 1999). From such major visual skills, the majority of previous studies mainly investigated the dimension of visual science communication which may involve the examination of a portrayed message, visual image production, the nature of visual images, and audience perception.

For studies investigating the potential effects of visual images in science communication, examples were presented to postulate that visual images have a potential to endorse the salience of the associated scientific topic, as well as to promote audience engagement with science (Bloomfield & Doolin, 2012; O'Neill & Nicholson-Cole, 2009). Besides, the collaboration between a visual image and textual information can bring the superiority of delivering an intended message over either of any single modality alone which may also support better comprehension and retention of the message (Grootens-Wiegers, De Vries, Vossen, & Van den Broek, 2015; Lazard & Atkinson, 2014; Tatalovic, 2009). Likewise, a visual image is argued to be an appropriate device for communicating the uncertainty of scientific information since it can be manipulated to represent a futuristic scenario or a perceivable extent of quantity despite the absence of the exact amount (Severtson, 2015). Although these studies considerably contribute to visual science communication primarily affirming the benefits of using visual images, they barely examined the site or properties of a visual image itself (Rose, 2016) which may provide a more extensive explanation to understand what and how visual image characteristics allow their functionalities in different science communication contexts.

Being inspired by such a call, some studies suggested general criteria for an appropriate visual image such as it is supposed to be aesthetic or beautiful and scientifically accurate (Jarman, McClune, Pyle, & Braband, 2012), or to be underpinned by the principles of user-centred and graphic design (Cristina et al., 2015). Meanwhile, a few studies specifically investigated the nature of a visual image in relation to a science communication event's intended message and objectives. For instance, one study examined some catastrophic

visual images regarding their effects on the audience perception of, or engagement with the climate change-related issues (O'Neill & Nicholson-Cole, 2009). Another study concerned a science communication event displaying astronomy images that provided some implication for the characteristics of such kind of visual images and their accompanying written texts that would be appropriate for promoting comprehension and engagement (Smith et al., 2014). Furthermore, an examination suggested the effects of provocative or symbolic visual representations in the communication of issues relevant to GM (Genetic Modification) (Bloomfield & Doolin, 2012).

From these previous studies, it can be seen that they focused on either a certain property/ kind of visual images or an associated subject matter of a science communication event. Although they contribute to the understanding of visual image utilisation in specific contexts, the finding may not always be generalisable. A broader or more holistic explanation or a practical guideline for the effective practice of visual images in science communication is still required by researchers (Gigante, 2012; Trumbo, 2000). Therefore, to investigate visual images utilised in a variety of contexts may further contribute to the understanding of the topic and potentially provide sufficient evidence to base some suggestions on the use of visual images in science communication.

1.4 The purpose of the research

The purpose of this research is to examine the nature of visual images and their accompanying information used in casually encountered science communication events occurring approximately around the course of this research (2015-2018). The study is conducted to answer how to use visual images in science communication which particularly involves four associated research questions:

RQ1: How is the message constructed by a visual image and accompanying information in a science communication context?

RQ2: How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)?

RQ3: How can visual images perform their function regarding the capturing and maintaining of audience attention?

RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements corresponding to the fulfilment of Generic Learning Outcomes (GLOs)?

To answer the research questions, a multiple case study approach was adopted to extensively investigate each exemplified science communication event regarding the intertextuality between its adopted visual image(s), other modes of communication, and their relevant contexts in order to construct an intended message. The findings, drawn from the

analyses of several cases, serve as the basis for some recommendations for using visual images in a science communication event with respect to its context and purposes. The research may contribute to the enhancement of science communication practice specifically for events offered in a daily context accessible to people who are not necessarily interested in science-related topics. The implications of the research findings may also be applicable to other science communication events using visual images despite some variation of relevant factors.

1.5 Summary of the other chapters

Chapter 2: It reviews some relevant literature to set the general background and context of the research associating two major domains: science communication and visual communication. It describes some science communication concepts, its development throughout history. It provides some examples of science communication approaches which also suggests a variety of purposes. It also explains some learning theories and styles, and the Generic Learning Outcomes framework (GLOs) since they are the aspects of event objectives being considered in this research. Then, the chapter explains several aspects of visual communication such as the ubiquitous appropriation of visual images including in the domain of science communication, as well as the interpretation and perception of visual images. Some previous studies focusing on visual images used in science communication are also reviewed. As a result, it suggests that there are still a variety of aspects to be investigated in this topic and leads this research to further explore the nature of visual images used in science communication.

Chapter 3: It introduces the research questions relevant to the factors being focused on in this research. This research mainly considers the nature of visual images being used in science communication in relation to event functionalities such as to get and maintain attention, to convey a message, as well as to achieve the expected learning outcomes. Then, the chapter explains the concept of a multi-case study research design as the approach adopted in this research. As such, it provides the criteria for selecting the eight exemplified cases followed by the methods for gathering data both from primary and secondary resources. Subsequently, it explains how the data would be managed, organised, and analysed. The analysis of data can be considered in two stages: preliminary analysis based on a discourse analysis framework, and cross-case synthesis. The accounts of the preliminary analysis/discourse analysis are described in Chapters 4-7. Meanwhile, the results of cross-case synthesis or the comparison of all individual cases to answer the research questions are discussed in Chapter 8.

Chapters 4-7: These four chapters are the analyses of individual cases. They provide descriptive information relevant to each case based on the adopted discourse analysis framework. The framework considers several significant aspects of a case including the content, size and space, the contexts of production, distribution, and reception, as well as the construction of meanings that may be underpinned by a certain concept or ideology. Namely, the framework not only provides the consistent basis for transforming visual data into textual data for the subsequent cross-case synthesis, but it also serves as the coding scheme for the research data. Each chapter features two exemplified cases which are coupled based on their primary expected learning outcomes.

Chapter 4 explains two cases potentially aimed at promoting positive attitudes toward science and scientific community. Both cases (cases 4.1 and 4.2) are exhibitions containing photographs of scientists. Chapter 5 analyses two murals appropriated mainly for entertaining or inspiring an audience. The two murals are associated with environmental conservation although in different contexts and techniques to promote the subject matter. Chapter 6 investigates two cases in relation to the expected learning outcome as understanding or gaining knowledge. There are two pictures sampled from the same photographic exhibition: 'Light Works' exhibition. Besides the main case definition and boundary, the cases (cases 6.2 and 6.3) are also selected based on some particular criteria assigned to narrow down the choices of applicable visual images. Then, Chapter 7 features two cases (case 7.1 and 7.2) involving public health campaigns aimed at promoting the compliance to suggested behaviours. The analyses of the individual cases included in these chapters may partially provide some answers to the RQ1 and RQ2.

Chapter 8: This chapter recapitulates the individual case analyses described in Chapters 4-7 in relation to the research questions RQ1 and RQ2. Then, it discusses the findings drawn from the cross-case synthesis of all cases. As such, it explains the emerged answers for research questions RQ3 and RQ4. Namely, it suggests some characteristics of visual image and event that may promote the presence and invitation of science communication. Several properties can be adopted to get attention especially in the case of encountered science communication. Subsequently, some observable aspects of visual images are explained as the desirable characteristics for maintaining audience attention. The final dimension of findings affirms that visual image-based events can be exhibited to cater all audiences

regardless of their learning styles. Also, it describes how learning may occur in the investigated cases and suggests the main enabler of each expected learning outcomes either in terms of a visual image, accompanying written texts or verbal communication, or the interdependence between modalities.

Chapter 9: This chapter summarises the whole thesis and concludes that visual images can be appropriated with other modes of communication meaningfully and purposefully. A visual image-based science communication event has the potential to convey different facets of science and fulfil the expected learning outcomes. The study suggests that the visual analysis frameworks can also be beneficial to a science communicator for considering potential visual images to be used in an event. The discourse analysis framework adopted in this research in conjunction with another visual image analysis serves as the basis for proposing a practical guideline for selecting visual images. The findings of the research also provide some exemplified characteristics responding to the suggested guideline. As such, this research may contribute to the practice of science communication especially for events using visual images as a tool.

Chapter 2
Literature Review

Science communication plays a crucial role in engaging members of the public with science through a variety of approaches. Visual images are one tool frequently used in events which focus on communicating science. They provide potential as a modality with which people are familiar in their everyday lives. This research seeks to gain an understanding of visual image utilisation in science communication. This chapter aims to provide the background and context for the study focusing on four main areas: science communication, learning theories and styles, visual images and existing work in the field.

The first section on science communication defines the term and its development. It introduces some communication practices related to science communication and identifies some practical approaches and purposes of different types of science communication events. The second part of this review considers learning styles, especially those which utilise a visual modality. The literature review highlights cognitive theories which discuss how visual images may support learning. The third aspect of the literature review then defines visual images as they are to be considered in this research and introduces some existing image typologies adopted in science communication. This final section reviews some theoretical and empirical research related to the utilisation of visual images particularly in a science communication context in order to describe what is currently known about the subject, as well as outline a research opportunity to support the practice of science communication using visual images.

2.1 Science communication

2.1.1 Definition

Science communication can be defined as the process of communicating science to public audiences. The content relates to science; and the participants primarily involve publics or non-experts (Berlo, 1960; Bowater & Yeoman, 2012; Wood, 2009). Such a definition can be underpinned by a model of general communication which is explained as the process happening under social systems shared by participants who send or receive, or simultaneously send and receive messages through various methods such as speaking, listening or gestures (Wood, 2009) in addition to text and images.

As such, the content or message delivered in science communication may encompass communicating different facets of science including the body of knowledge regarding the natural and physical worlds together with communicating other fields such as mathematics, engineering, statistics, technology, and medicine; the scientific method and practice; the profession of science i.e. scientists and science institutions which are usually referred to as the scientific community; as well as science-based worldviews, social and policy issues

raised by science (Bennett & Jennings, 2011; Brake & Weitkamp, 2010; Burns, O'Connor, & Stocklmayer, 2003; Gregory, 2015; Hohenberg, 2017; The Office of Science and Technology and the Wellcome Trust, 2000).

In terms of participants, science communication may occur between the scientific community and the public or between intermediaries and the public (Bowater & Yeoman, 2012; Burns et al., 2003; Davis, 2010; Gregory, 2015; Stocklmayer & Bryant, 2001). Regarding intermediaries, they may encompass various institutions such as the media, science museum/centre, science communicators within various organisations including universities and research institutes, policymakers, or private industries relevant to science (The Office of Science and Technology and the Wellcome Trust, 2000). Science communicators can either communicate the science themselves or be the intermediary between scientists and the public.

2.1.2 The development of science communication

Science and society are interlinked and their relationship can be complex. Scientific knowledge is involved in technological and medical developments often for the betterment of society. Meanwhile, scientific research often relies on resources provided by society such as in terms of funding, laws and regulation, or cultural values (Brake & Weitkamp, 2010; Jucan & Jucan, 2014; Rogers, 2005). For example, a contentious issue may arise from a scientific study because of its subject matter which challenges a cultural moral or value held by a society such as seen in the case of animal testing or stem-cell research (Adam, 2004; Ferdowsian & Beck, 2011; Gruen, Grabel, & Singer, 2007; Kalb, 2005; Mintrom, 2013). For the progress of both science and society, their interdependent relationship needs to be sustained by establishing a common understanding or resolving potential conflicts appropriately. As a result, science communication in forms of multiple strategies and approaches has been evolving since ancient times to work towards achieving such ultimate goals (Hannam, 2011; Jucan & Jucan, 2014; Nelkin, 1987).

Some forms of science communication can be traced back to the ancient Greek era as early as the emerging of interest in the natural world (Hannam, 2011; Rihll, 2002). In this early period, knowledge about the natural world was communicated mainly to elites or wealthy people through some forms of writing such as handbooks, encyclopedia, commentaries, or stories (Berggren, 2002; Hannam, 2011; Murphy, 2004). Such exclusive dissemination was arguably initiated by the need for science to receive the financial support from the state's authorities, and may also reflect the social status and power of individuals who could access it. Later, around the 18th century, science was popularised widely through pamphlets, journals, and books especially during the Enlightenment period or the age of reason (1685-1815) (Hannam, 2011; Knight, 2009). As a result, the opportunities for learning about science were available to a wide audience. Moreover, the establishment of science

education in European countries brought systematic teaching and researching which subsequently led to the eminence of science and the scientific community within society (Gregory, 2015; McClellan & Dorn, 2006). Nevertheless, its contribution was still restricted to philosophical implications without apparent materialisation until the late 18th century (Gregory, 2015; Hannam, 2011; McClellan & Dorn, 2006).

The number of scientific applications utilised in technology continued increasing extensively in the 19th century which is highlighted as the industrial revolution era in Western Europe (Brake, 2010; Gregory, 2015). Science played a crucial role in the development of industrialisation, and its potential was recognised by governments and industries (McClellan & Dorn, 2006). Likewise, the public paid greater attention to science due to its influence over their daily life (Hannam, 2011). Around this same period, the growth of science also engendered various relevant institutions and science communication activities either among the scientific community or with public members such as the establishment of the Royal Institution and the science-related forum for public audiences in 1799, or the BAAS (British Association for the Advancement of Science) Cambridge meeting in 1834. These events were arguably aimed to regulate science and its community systematically as well as to sustain support from society (Gregory, 2015).

However, the reaction towards the progress of science and the scientific community was not always positive. Some sceptical responses and opposition can also be generated against science. This can be exemplified in the cases of the application of scientific knowledge challenging social values such as the research and invention of the atomic bomb, or the threatening power of science like the imaginative idea about destructive potentials of technology portrayed in the novel 'The War of the Worlds' (Brake, 2010; Knight, 2009). The challenges of science communication emerge from the scepticism about scientific claims or theories but also from the proliferation of scientific jargon which makes science-related messages less accessible to a non-expert. As a result, the distinction between science communication within the scientific community and that for nonscientists began emerging. While the former one was conducted mainly in the context of formal education, academic conferences, and journal publications, science for the public was popularised through various informal approaches and accessible language (Gregory, 2015; Knight, 2009).

Science communication with public audiences gradually evolved with the advancement of science and the social and cultural dimensions of globalisation during the 20th century. For example, the newspaper industry provided a new form of media for disseminating science to a broader public (Gregory, 2015; Hannam, 2011; Russell, 2009). Within the UK, science communication with the public was significantly promoted through the initiatives recommended by the Bodmer Report in 1985 explained further in the following section (The Royal Society, 1985). Science-related institutes and their scientists were encouraged to

communicate their research and its contribution to society (Bowater & Yeoman, 2012). Starting with different levels of communication skills, some scientists undertake public science communication themselves while others collaborate with media and journalists for example on radio, television, or with the institution's press office to disseminate their science in an accessible way (Gregory, 2015; Hannam, 2011). In addition, there are more opportunities for professional science communicators who may come from disciplines other than science and are able to harness different skills for engaging members of the public with science (Bennett & Jennings, 2011; Gregory, 2015).

Based on such a significant endorsement of science communication in the UK, other countries adopted many aspects of its initiatives and institutional programmes (Lock, 2011). Since this research also features some science communication events that happened in the USA and Thailand, it might be worthwhile considering the contexts of science communication in such countries.

In terms of Thailand, it had its first 'Thai National Science Day' in 1982 from which Thailand's National Science Fair was developed. From the national science day, the event developed into a two-week annual fair. Science communication in Thailand continued developing, to a greater extent, as the foundation of the national science museum enterprise (NSM) in 1995. NSM not only displays science-related artefacts but also takes the leading role in undertaking science communication in the country (Chen, 2013). For example, in the year 2018, the NSM had more than 1.1 million museum visitors and arranged around 40 science outreach activities such as public exhibitions, science camps, hands-on workshops, walk rallies, and science caravan (TRIS Cooperation, 2018).

The evolution of science communication in Thailand is also characterised by its variety of approaches. There are many activities which are similar to those conducted in the UK such as science competitions for students, communicating science through mass media or online channels, exhibitions, hands-on activities, technology transfer workshops, science talks or seminars, as well as science policy-making such as the launch of the government policies for supporting innovative small-medium enterprises (SMEs) and farming or improving water management systems (Chen, 2013; Durongkaveroj, 2015). Currently, there is also the start-up Thailand platform endorsing transactional communication between scientific institutions and public sectors to collaboratively develop a technology suitable for Thailand's social context (Startup Thailand, n.d.). The discipline of science communication itself is also promoted through the government funding of relevant research, or the adoption of the British-initiated 'Famelab' competition encouraging creative science communication among science communicators (British Council Thailand, 2018; Chen, 2013).

For science communication in the USA, it is conducted with a similar ultimate goal as in the UK, that is to serve as an important mechanism for maintaining and increasing public

support for science and technology (American Academy of Arts and Sciences, 2018). Also, science communication movements in the UK and the USA arguably evolve in the same direction, namely from knowledge deficit model of communication to public engagement with science (PES), further explained in the following section. One rationale to explain such conclusion can be observed from the modification of indicators present in the longitudinal survey conducted by the US National Science Foundation (NSF) since 1970s. Those indicators are presumed to be the significant factors underlining public attitude toward science and technology. The indicators mainly exclusive to science literacy considered in the early years of the survey have been expanded to other cultural factors such as the degree of trust in the leaders of numerous institutions including scientific community, or the understanding of potential benefits and harmful results of scientific research (Bauer, Allum, & Miller, 2011). This transformation is congruent with the acknowledgement of social research findings that suggested a small correlation between scientific literacy and favourable attitude toward science and repudiated the concept promoted in the deficit model.

To communicate science in an engaging way as suggested by the concept of public understanding of science (PUS), as explained in the next section, in the USA is by no means without difficulty. A study suggested some challenges observable in the USA, which may also apply to science communication in other countries, including the lack of interest in science or readiness to acquire new scientific information, the increasingly complex and fast-moving scientific developments, and the decline of science-related content offered in traditional news outlets which are argued to be the primary source of scientific information (Scheufele, 2013). As a result, there are various practical training programmes led by AAAS (American Association for the Advancement of Science), the National Science Foundation, and many universities that try to bring the best practices for interacting between the scientific community and the public. In addition, the growing body of research relevant to the discipline of science communication contributes to the development of its practice in the USA and leads to several research-informed approaches. For example, by consulting the studies suggesting that entertainment media like TV programmes play a crucial role at shaping attitudes toward science, the National Academy of Sciences (NAS) currently attempts to collaborate with entertainment industry to create film or TV programme that provide engaging narratives and storylines with accurate portrayal of science (Scheufele, 2013).

In general, it can be seen that science has evolved from being on the perimeter of society to an authoritative enterprise of world civilisation (Knight, 2009; McClellan & Dorn, 2006). The increased rate of scientific progress leads to higher demand for science communication (Bultitude, 2011). This can be seen in the growing body of science communication activity throughout the world (Gregory, 2015). Various communication strategies are utilised and validated with different types of systematic evaluations (Bowater & Yeoman, 2012; Grant, 2011). Moreover, the significance of science communication can also be discerned in the

emergence of research and its subsequent publication in academic journals which focus on the subject; as well as its position as an academic discipline and as a qualification contributing specific theoretical perspectives and practices (Bowater & Yeoman, 2012; Guenther & Joubert, 2017).

2.1.3 Models of science communication

Since many countries have followed initiatives and institutional programmes initially proposed in the UK (Lock, 2011), it may be instructive to consider science communication models from the UK. A defining moment in science communication in the UK is arguably the launching of the Royal Society report entitled 'The Public Understanding of Science' (PUS) often referred to as the 'Bodmer report', in 1985 (Lock, 2011; Miller, 2001; The Royal Society, 1985). The Bodmer report can be considered in three main sections associated with public understanding of science including its necessity, existing position, and ways to improve it. In the report, several examples were given to emphasise the importance of science understanding either at a personal or national level. The existing nature and extent of understanding of science presented in the report was mainly based on the surveys of public attitudes to science and technology in the UK in comparison to some alike studies conducted in USA, as well as evidence from relevant institutions (such as the Department of Education and Science, Association of British Science Writers, ITN Channel 4 News, or some key scholars) (The Royal Society, 1985). The gathered data showed that many members of the public were interested in science and had a desire to learn more about it although some of them were concerned about certain scientific applications. The Bodmer report then provided a range of recommendations for improving the understanding of science to several relevant sectors including a long-term development of formal education, and other suggested mechanisms for the mass media, museums and libraries, industry, and especially the scientific community.

An emerging implication was that better public understanding of science could be beneficial to the nation's prosperity, and scientists should undertake science communication with members of the public as one of their duties and learn how to do so effectively (Bodmer, 2010). Such a consideration might have been influenced by the notion of scientific literacy which was considered to be a key element which allows individuals to have better personal or public decision-making. At a broader societal scale, it may also improve a democratic society that supports science and technology (McCallie et al., 2009). Therefore, the Bodmer Report proposed a solution considered to be largely top-down i.e. informal science education which endeavoured to communicate scientific facts and processes to the public with the aim of addressing the deficit in scientific knowledge (Bultitude, 2011; McCallie et al., 2009). Subsequently, there was the rising number of institutional programs and activities which primarily focused on top-down science communication referred to as public understanding of science or PUS.

Besides suggesting that researchers embrace the practice of science communication in the UK, the Bodmer report also recommended that research institutions such as the ESRC: the Economic and Social Research Council promote further research programmes focusing on PUS measurements and the assessment of effects potentially resulting from better understanding of science (The Royal Society, 1985). The research area continued expanding to become a distinct field which is evident in the establishment of the first post-graduate course in science communication at Imperial College London in 1989, and the launching of 'Public Understanding of Science' academic journal in 1992 (Lock, 2011; Richards, 2005).

The public attitude toward science surveys conducted at the same time in the US and the UK showed coherent results demonstrating that those surveyed were interested in and receptive to science despite lacking knowledge about scientific facts and processes (Durant, Evans, & Thomas, 1989). Although the research attested to the assumption that the public was not well informed regarding scientific knowledge, it suggested that such a deficit is less relevant to their opinions toward science. Instead, social factors such as value or belief and personal experience seem to be more prominent when coming to a public judgement on scientific issues (Wynne, 1991).

The critical implications of research on PUS were followed by a transition in science communication in the UK when public trust in science was declining (House of Lords, 2000; McCallie et al., 2009). This lack of public trust in the UK might well be related to science-related incidents which had been eroding public confidence in science. For example, the BSE (Bovine Spongiform Encephalopathy) crisis and the Chernobyl accident affecting the hill sheep farmers in Cumbria are claimed to be the major affairs creating scepticism and distrust for scientific advice and democratic institutions (House of Lords, 2000; Lock, 2011; Wynne, 1996). The level of trust arguably affects the public acceptance and appreciation of science and, at worse, may result in the public dissent. To improve the relationship between science and the public, science communication is supposed to aim at mutual understanding further than giving information in a one-way manner (Lock, 2011). In such a scenario, science communication in the form of dialogues may serve as the impartial and engaging agency attending to the voices of the public, scientific community and policymakers. Subsequently, it may enable the establishing and maintaining of public confidence about decisions made for science and technology. These concerns were reviewed in the House of Lords report published in 2000 which endorsed a new concept of public science communication: two-way dialogue in place of the top-down, largely one-way model suggested in the PUS agenda.

The top-down or one-way model may be considered in relation to the 'deficit model' used among social scientists investigating public science communication (Dickson, 2005). Initially,

the term ‘deficit model’ itself did not indicate any particular approach of science communication. Instead, it is a conceptual model which coherently highlights the major assumption of PUS i.e. there was a discernable ‘deficit’ of scientific knowledge in the public (Durant et al., 1989) which could lead to scepticism or negative perceptions about science. Therefore scientists as individuals who have a fair level of scientific literacy need to address such knowledge gap by imparting scientific facts and methods to the public in order to promote a better appreciation of science (Bowater, 2012; Lock, 2011).

Meanwhile, the transactional or two-way communication model encourages interactive communication between science communication participants, namely the scientific community and the public (Trench, 2006; Wood, 2009). The model is arguably acknowledged and promoted in the sphere of science communication through the Public Engagement with Science (PES) movement (Bultitude, 2011; Haste, Whitmarsh, Kean, Russell, & Peacock, 2005; Trench, 2006). The premise of PES focuses on mutual learning as a result of engagement between the scientific community and society (McCallie et al., 2009). Dialogue type events are carried out with the assumption that both groups have valuable knowledge and experience to be attended to by one another and to foster the retention of public trust and an effective social contract (Miller, 2001; Russell, 2009).

The PES approach could address and clarify scientific issues that are of interest to or relevant to individuals, particular groups of people, or society as a whole (Lock, 2011; McCallie et al., 2009). Most often, those dialogues involve ongoing scientific research or technology development which inevitably results in areas of uncertainty and risk. These potentially controversial aspects of scientific research and its applications usually create challenges in engaging with public audiences when it might lead to conflicts or misunderstandings of science and scientists in society (Haste et al., 2005). Therefore, the House of Lords report also recommended ways to communicate uncertainty and risk with public audiences highlighting the openness of dialogue as the basis of any PES programme (House of Lords, 2000; McCallie et al., 2009). These beneficial outcomes obtained by adopting the transactional model may endorse its appropriateness to be the basis of some aspects of science communication practice.

Although the evolution of science communication conceptually from PUS to PES has been acknowledged by scientific institutions (Miller, 2001), in practical terms, science communication events undertaken by practitioners seem to have a less direct relationship to the conceptual frameworks of PUS or PES. Many science communicators realise the complexity of public science communication in which requires various modes of communication not exclusive to the simplified conceptual models of either PUS or PES (Lock, 2011; Trench, 2006). Therefore, as stated by Bucchi (2008), an important question to ask of any science communication activity is not which model will be the most appropriate

one, but how different formats of science communication can be utilised under a particular context to achieve its intended purposes.

In addition, a recent conceptual framework relevant to science communication is proposed by the *Enterprising Science* project through the partnership between King's College London and the Science Museum (Archer, Dawson, Dewitt, Seakins, & Wong, 2015). The framework is relevant to a concept called 'science capital' developed to understand the relationship people have with science.

"Science capital itself is a measure of your engagement or relationship with science, how much you value it and whether you feel it is 'for you' and connected to your life. It highlights the significance of ***what you know*** *about science,* ***how you think*** *about it,* ***what*** *(science related activities)* ***you do*** *and* ***who you know*** *in shaping attitudes and feelings about STEM."* (Science Museum Group Learning Team, 2016, para. 2).

Through experiencing different science communication events, one may accumulate several dimensions of science capital such as knowledge and understanding about science, its practice and transferability/application; science-related attitudes/values or personal view about the relevance of science in everyday life; the engagement with science in informal contexts like attending to science-related media or participating in science-featured events/activities; connection to persons either in one's family or community who have science-related skills/qualifications or roles; as well as the conversation about science with people in one's life (Archer, Dawson, Dewitt, Seakins, & Wong, 2015). The amount of science capital an individual has can affect how his/her feel about science, and the increase of science capital may promote the tendency of the individual's engagement with science throughout his/her life. Although the conceptual framework initially focuses on the development of science capital in young people and provides recommendations mainly relevant to teaching approach (UCL, n.d.), the concept of science capital can endorse the significance of science communication.

2.1.4 Practical approach

The public may encounter science communication in a variety of activities occurring in either physical or virtual spaces (Haste et al., 2005; McCallie et al., 2009). Science communication activities can take place in the form of face-to-face events, indirect channels via broadcasts, media, or through online interactions. The extensive variety of science communication approaches is argued to be necessary to serve the different interests and characteristics of public audiences (Burns et al., 2003). Science communicators embrace a variety of opportunities, media and methods for communicating science to public audiences. While continuing to use more traditional approaches for science communication such as public lectures or science museums (The Royal Society, 1985), more innovative methods, made available through communication technology or cultural movements, have developed the

range of approaches (Bultitude, 2011).

Corresponding to the advancement of media technology, starting from the printing press in the 1450s followed by the steam and electric powers in the 19th century, the number and extent of media forms were diversified such as the rise of visual media in forms of photography and film, or telecommunication like telegraphy and telephone. Media technology continued expanding to broadcasting i.e. radio and television and the Internet. It provides a variety of modern communication channels such as through mobile technologies like mobile phone, or virtual space (Watson, 2003). For instance, recent studies suggested that the Internet is one of the most used sources for seeking information including science information (Castell et al., 2014; National Science Board, 2016). The adoption of the Internet in science communication sphere can be evident in the growing number of Internet sites relevant to science such as online science journalism, blogs, wikis, podcasting, or platforms of social networking like Facebook and Twitter (Bultitude, 2011). These sites offer flexible access to science information which is disseminated on the Internet, as well as catering for engagement with science through online discussions, conferences, or information exchange between users (Hook & Brake, 2010; McCallie et al., 2009).

Besides media technology, science communicators also adopt several cultural means to engage publics with science. The significance of science in people's lives justifies itself as a cultural inheritance to be recorded and collected in museums. Besides displaying scientific collections, museums are also a place to illustrate, explain, and interpret science for all visitors. Despite preserving this philosophy, museums also employ various kinds of new media with traditional static exhibitions and displays to provide different modes of experiences that may further inspire and encourage learning. For example, there are uses of interactive or hands-on exhibits, or oversized models of scientific objects (Science Museum, n.d.).

There are also festivals and popular culture involving a range of interactive activities accessible to public audiences. Science festivals can be established as a longstanding event taking place in the same period every year (Hill, 2014). With the nature of festivals for celebration or commemoration, a science festival may generate a good atmosphere for raising interest in or awareness of science (Krauss, 2008). By adopting various types of entertainment and activity, science festivals also provide opportunities for public audiences to encounter science casually in formats with which they are familiar. This is also the case for communicating science through popular culture devices which are admired in society such as films, performances, TV or radio programmes, visual images, or literature (Hadfield, Dimmock, & Shinn, 2014; Waites, 1981).

Since Public Engagement with Science became a dominant idea in the UK after being emphasised in the House of Lord report (House of Lords, 2000), the concept of dialogue can

be utilised in science communication. Dialogues may take place on various scales and forms of two-way or multiway communication at either a physical or virtual location (McCallie et al., 2009). It is not necessarily a deliberative mechanism informing policies relating to science, but it can also exist in the form of dialogue-based events having a range of different science communication purposes. Dialogues initiated for policymaking might be deliberative or scenario-based such as a foresight event anticipating potential consequences; deliberative opinion polls after debating about relevant issues; panel discussion to explore opinions from different relevant sectors; Citizens' juries; and consensus conferences (Bowater & Yeoman, 2012; House of Lords, 2000; Russell, 2009). As a result, they may provide a chance for experts to give necessary information relevant to a particular issue and public participants to consolidate an evidence-informed set of recommendations for policymakers to take into account.

There are also other innovative ways to facilitate science-related dialogues such as the informal discussion between lay publics and expert speakers in a Café Scientifique event, book clubs focusing on books in scientific themes or genre, or film screenings (Bowater & Yeoman, 2012; Russell, 2009). Notwithstanding the limited number and scope of participants in a dialogue activity, if they are efficiently conducted, dialogues in science communication are argued to be a potential approach for sustaining favourable relationships between the public and the scientific community (Bultitude, 2011). In addition, another type of science communication which has developed is 'citizen science' in which members of the public participate in different stages of scientific research. For example, there are projects inviting public members to collect research data such as nature-related surveys: Garden Birdwatch or Big Butterfly Count; or to manage scientific data like classifying galaxies in the Galaxy Zoo project (BBC, n.d.; Simmons, n.d.; Zooniverse, n.d.).

2.1.5 Purpose of science communication

This section articulates some of the purposes associated with science communication activities. Due to the lack of frameworks particularly for classifying the purposes of science communication (Matterson & Holman, 2012), it might be appropriate to consider them from the perspectives of evaluation frameworks which have been developed. The demand for conducting the evaluation is usually based on the aim to investigate whether the communication results of an activity meet the set objectives (Fogg-Rogers, Grand, & Sardo, 2015; Gascoigne & Metcalfe, 2001; Jensen, 2014). Therefore, they tend to focus on reviews of aims, objectives and outcomes. Several reviews indicated that evaluation frameworks can also be a potential tool for refining objectives of an activity (Friedman et al., 2008; Gascoigne & Metcalfe, 2001; Research Councils UK, 2011).

The evaluation framework reviewed for use in this research is the Generic Learning Outcomes (GLOs) framework developed initially in the context of institutions facilitating

informal learning such as museums and libraries (Devon County Council, 2006; Museums, libraries and archives (MLA), 2008; RCMG, 2003; The British Museum, n.d.). GLOs encompass five distinct categories of learning outcome an audience may gain from a science communication activity. These are described in Table 2.1. The effectiveness of GLOs has been extensively studied and found that due to its clear classification, using simple terms and flexible application, the framework is adopted widely by most museums throughout the UK as well as other cultural and educational fields (Brown, 2007; Graham, 2013; Hooper-Greenhill, 2004). There might also be some limitations in adopting GLOs framework for evaluation such as being heavily reliant on observation or self-report of audience experience. Such an approach to gathering information may limit the accuracy or validity of the evaluation results (Brown, 2007; Graham, 2013; Hooper-Greenhill, 2004; Jensen, 2014). Instead, this research adopts the GLOs framework for considering the potential learning outcomes a science communication event may bring, not for evaluating the exemplified events. As a result, the framework can provide a comprehensive outline of purposes regarding learning outcomes an activity may selectively aim to achieve.

2.2 Learning theories and styles

The more recent movement in science communication was originally focused on improving scientific literacy. Although people acquire the basis for the understanding of science from science lessons in schools, they spend more time in their life in informal learning environments (Burns et al., 2003; Russell, 2009; The LIFE Center, 2007; The Royal Society, 1985). Therefore, informal science learning is one component having an impact on scientific competencies and public engagement with science (Matterson & Holman, 2012).

Effective learning in an informal context can be described as a process providing learning experiences that may lead to the construction or improvement of a person's accumulating knowledge and attitude. Some of its objectives might be different from performance orientation i.e. focusing on accomplishing and being assessed on an assigned task emphasised in curricula and the examination systems of formal science education (Friedman et al., 2008). However, it is arguable that formal science education can influence how people would participate in informal science learning in the future (Brake & Weitkamp, 2010). Both informal science learning occurring in science communication and formal science education still associate with the brain processing of experience or information, while in the context of science education such information might be predominantly present in the form of scientific knowledge or facts. Therefore, both contexts of science learning can be affected by similar factors such as environment, psychological factors like motivation or self-esteem, individual learning styles, and modes of communication.

Learning styles and modes of communication are also applicable to learning in a science communication context (Reid, 2005). The acknowledgement of different styles and

preferences people may adopt for learning allows a science communicator to devise an event/activity with a variety of components able to engage and motivate a broad audience to learn regardless of their learning style (Bowater & Yeoman, 2012; Bultitude, 2010). Also, for a target audience, the assessment of their potential learning styles may promote an event's attractiveness by elements tailored specifically for such a group. Some learning style models reviewed in this section are Kolb's learning style inventory (LSI), Honey and Mumford's learning style questionnaire (LSQ), and Fleming's VARK model of preferences.

Table 2.1: The detail of Generic Learning Outcomes (GLOs) framework

Learning outcome	Detail
Knowledge and Understanding	▪ Knowing what or about something ▪ Learning facts or information ▪ Making sense of something ▪ Deepening understanding ▪ How museums, libraries and archives operate ▪ Making links and relationships between things
Skills	▪ Knowing how to do something ▪ Being able to do new things ▪ Intellectual skills ▪ Information management skills ▪ Social skills ▪ Communication skills ▪ Physical skills
Attitudes or Values	▪ Feelings ▪ Perceptions ▪ Opinions about ourselves (e.g. self-esteem) ▪ Opinions or attitudes towards other people ▪ Increased capacity for tolerance ▪ Empathy ▪ Increased motivation ▪ Attitudes towards an organisation (e.g. a museum) ▪ Positive and negative attitudes in relation to an experience
Enjoyment, Inspiration, and Creativity	▪ Having fun, ▪ Being surprised ▪ Innovative thoughts, ▪ Creativity ▪ Exploration, experimentation and making. ▪ Being inspired
Activity, Behaviour, and Progression	▪ What people do ▪ What people intend to do ▪ What people have done ▪ Reported or observed actions ▪ A change in the way that people manage their lives

Note. Reprinted from General Learning Outcomes Checklist. Retrieved October 17, 2017, from https://www.artscouncil.org.uk/measuring-outcomes/generic-learning-outcomes#section-8. Copyright (n.d.) by Arts Council England.

Various models of learning style are developed with the recognition of individual differences regarding psychological or cognitive factors that may influence their learning approaches. The consideration of difficulties caused by the variety of learning style conceptualisations led some researchers to organise them into different themes theoretically (Coffield, Moseley, Hall, & Ecclestone, 2004; Curry, 1983; Riding, 1998). Curry (1983) proposed the organisation of learning styles resembling an onion structure. It consists of three layers including cognitive personality style, information processing style, and instructional format preference. Two learning style models reviewed in this section: Kolb's LSI and Honey & Mumford's LSQ fall into the category of information processing style. Meanwhile, Fleming's model of VARK is in the instructional preference category since it explains individuals' preferred mode(s) of communication (Fleming, 2012).

2.2.1 Kolb's experiential learning cycle

Kolb's learning cycle is the basis for the construction of both Kolb's and Honey & Mumford's learning style models. It is a theoretical model articulated from previous works of influential scholars such as Dewey, Lewin, and Piaget (Kolb, 1984). The experiential learning theory explains learning as a process in which the reconstruction of experience forms knowledge. The concept of experiential learning integrates various perspectives on learning. As a result, its implication may involve myriad factors that can influence a learner's experience such as ways of teaching or learning, forms of activity, or even the environment surrounding the learning process.

The structure of the experiential learning process, as shown in Fig. 2.1, presents a cycle of four adaptive learning modes. In an integrated learning process, the concrete experience is followed by reflective observation leading to the conceptualisation of abstract ideas which then are tested by active experimentation. However, in most cases, there is no balancing between those stages, yet acquisition of knowledge can still occur through partially accomplishing the learning cycle. These learning modes can be coupled into two distinct dimensions necessary for constructing knowledge: grasping and transforming experiences. Simply grasping an experience without the operational aspect cannot yield knowledge. Likewise, the transformation of experience cannot happen without experience.

In the model, the dimension of grasping experience is referred to as prehension, involving either mode of concrete experience (apprehension) or abstract conceptualisation (comprehension) which dialectically oppose each other for acquiring experience. It means prehension can rely on either a concrete feature or a conceptual interpretation of experience. Similarly, the transformation of experience can take place through either internal reflection (intention), or actively engaging with the external world (extension). It can be seen in Fig. 2.1 that several types of knowledge can be obtained from different transactions among the four adaptive modes guided by the selected approach. For example, in order to obtain

‘accommodative knowledge’ corresponding to the learning process proposed by Kolb (1984), one may perceive an experience from physically doing or sensing something then try what has been observed in practice.

Kolb’s model of learning process illustrates that there are different adaptive orientations individuals may use to achieve knowledge in an emerging learning situation. Individuals may have distinctive patterns of processing their learning which can be recognised as learning styles. Nevertheless, because there are complexities in human learning, learning styles cannot be regarded as the fixed stereotypes of individuals. Instead, the recognition of learning styles merely provides the tendency of orientation or combination one may predominantly adopt for learning.

2.2.2 Kolb’s learning style inventory (LSI)

The first version of Kolb’s learning style inventory created in 1969 is based on the model of the experiential learning process explained above. It comprises four distinct learning styles corresponding to the predominant transactions of adaptive modes in the learning cycle as shown in Fig. 2.2 including divergent, convergent, assimilation, and accommodation (Kolb, 1984). The characteristics of each learning style can be described in Table 2.2. The Kolb's LSI is one of the learning style models which is empirically examined in many studies focusing on its validity and reliability, though the findings are still inconclusive (Curry, 1983; Veres, Sims, & Locklear, 1991).

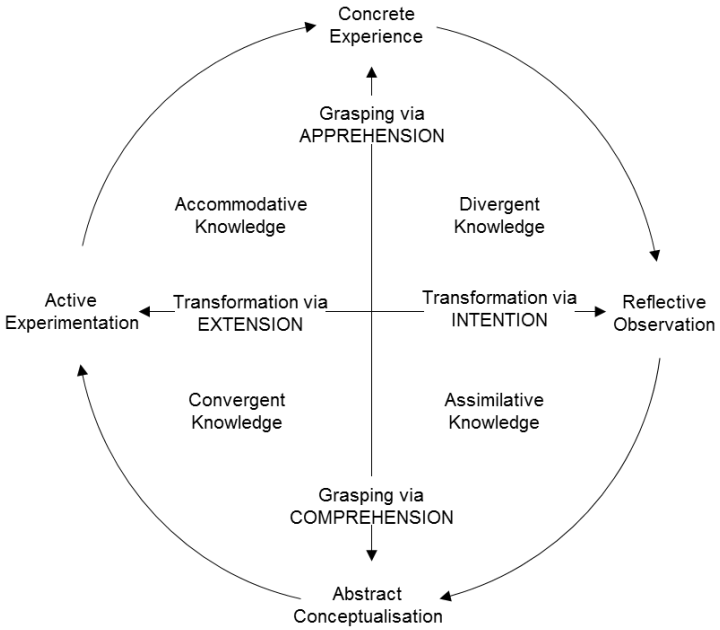


Fig. 2.1: Kolb’s structural dimensions of the experiential learning process (Reprinted from David A. Kolb, *“Experiential learning”*, 1984, p.42)

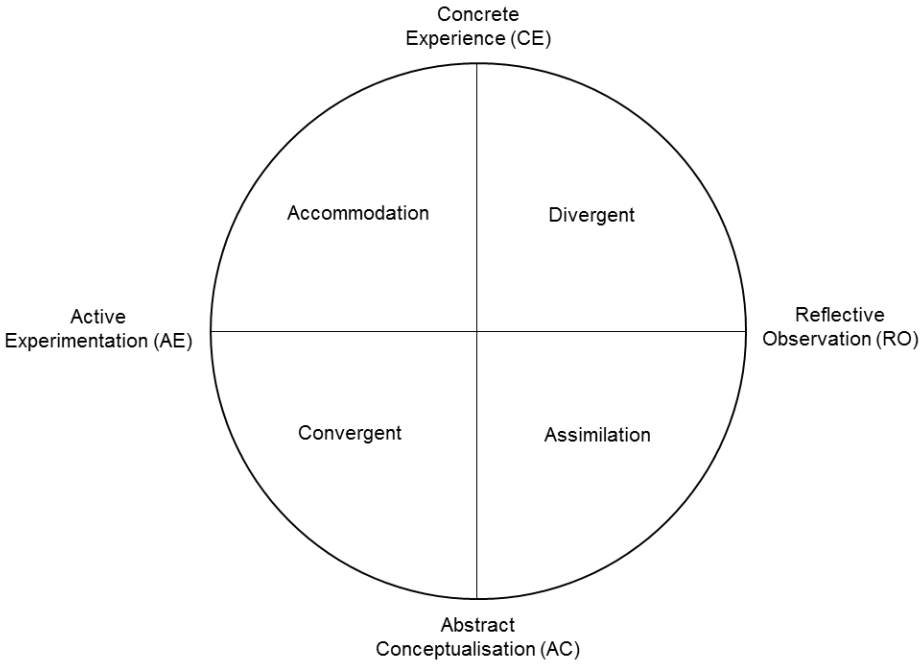


Fig. 2.2: The diagram of Kolb's learning style inventory (LSI) in relation to the experiential learning cycle (Reprinted from David A. Kolb, "Experiential learning", 1984)

Table 2.2: The characteristics of learning styles proposed in Kolb's learning style inventory

Learning style	**Learning mode**	**Main characteristic**
Divergent	CE, RO	A diverger has an imaginative ability to consider concrete situations from various perspectives for constructing meaningful concepts. They may perform well in learning situations that require the generation of ideas.
Convergent	AC, AE	A converger can generate hypotheses about specific problems or situations and rationally test them to construct knowledge or find a solution. They might be keen on solving problems, making decisions, or accomplishing a task.
Assimilation	AC, RO	An assimilator can incorporate various observations and inductively analyse them to draw an integrated explanation or theoretical models of situations. In the appraisal of an idea, an assimilator may esteem its rationality and accuracy more than its practical application.
Accommodation	CE, AE	An accommodator can accommodate changing situations where theoretical concepts are inapplicable, and practically take actions to respond to emerging problems. They might be excellent at practical skills, completing plans or tasks by following instructions, actively engaging in experiences, and willing to take risks that may be required in certain situations.

Note. Adapted from *Experiential learning: experience as the source of learning and development* (pp. 114-134), by D. A. Kolb, 2015, Upper Saddle River, New Jersey: Pearson Education, Inc. Copyright (2015) by Pearson Education, Inc.

2.2.3 Honey & Mumford's model of learning styles

The development of Honey & Mumford's model of learning styles is based on the concept of Kolb's learning cycle and learning style inventory although it is modified to be more appropriate for utilising in the context of organisational development (Coffield et al., 2004; Honey, 1986). The model denotes learning styles in terms of individuals' different requirements to approach learning which comprises activist, reflector, theorist, and pragmatist as described in Table. 2.3.

Table 2.3: The characteristics of learning styles proposed in Honey & Mumford's model of learning styles (Honey, 1986)

Learning style	Main characteristic
Activist	May learn best by actively engaging in new experiences or activities
Reflector	May learn best by being a passive observer who consolidates experiences from different perspectives in their own time to draw a conclusion or solve a problem
Theorist	May learn best by exploring rationally parts of a system or model such as in forms of books or lectures purposefully offered to them. They may need a chance to interrogate or question about situations for analysing and synthesising relationships between relevant factors
Pragmatist	May learn best when practical advantages or applications are given along with offered ideas or concepts, or when they have a chance to try and prove the validity of such ideas in practice

Note. Adapted from *The manual of learning styles*, by P. Honey, 1986, Maidenhead, Berkshire: Peter Honey Copyright (1986) by Peter Honey.

2.2.4 Fleming's model of VARK modal preferences

VARK is the acronym of different modes of communication including Visual, Aural, Read/Write, and Kinaesthetic respectively. It was initiated from the findings showing that the majority of survey participants ascribe learning difficulties to course materials and the recognition of people having different preferences regarding sensory modalities. As a result, Fleming's model considers such preferences as an attribute probably suggesting learning styles (Fleming & Mills, 1992). Some individuals might have a single dominant preferred modality or style, while more than 50% of people who were assessed have a mixture of preferences which can be categorised as the multimodal style. It is notable that the results obtained from the VARK questionnaire merely emphasise individuals' perceived modal preferences. It does not present any relationship to cognitive information processing in the brain, or individual strengths and abilities (Fleming, 2012; Willingham, Hughes, & Dobolyi, 2015).

Regarding the preferred types of materials relevant to each style, visual (V) includes drawings, diagrams, graphical or symbolic modes of representing information, as well as the uses of colours. Aural (A) denotes auditory or verbal information such as lectures,

explanation or discussion. Read/write (R) relates to textual information printed or written as words. For kinaesthetic (K), it is relatively complicated and can be multimodal because the kinaesthetic mode may be realised through various means of presenting the information. It possibly involves aspects of sensory experiences such as touching, smelling, or tasting. However, its significant characteristic is to provide an experience that can connect learners to concrete experience either in forms of actual practice or virtual experience. Some examples relevant to the kinaesthetic (K) style are hands-on activities and field trips.

2.2.5 Visual learning

Besides giving significant benefits to visual learners, visual forms of communication can also support learning in general regardless of learning styles or modality preferences. A review of scientifically based studies on the effectiveness of visual aids in learning shows that the implementation of visual learning can help learners to acquire knowledge in different disciplines including science (Guastello, Beasley, & Sinatra, 2000; IARE, 2003; Kleiss, 2016; Saunders, Wise, & Golden, 1995; Simmons, Griffin, & Kameenui, 1988). Moreover, the use of visuals to improve learning outcomes is also supported by some cognitive theories including the dual coding theory, schema theory, and cognitive load theory which are explained as follows.

Dual coding theory

Dual coding theory (Paivio, 1990) explains the properties of representational systems within the brain in terms of their structure and function. The structural property involves different forms of information including verbal or nonverbal objects and events. Meanwhile, the functional property relates to the activation of representational systems by input information, and the subsequent processes of organising, elaborating and integrating such information into the memory. The theory assumes that there are distinct representational systems which are specialised in dealing with different structural properties or modes of information classified as the language/verbal system and the nonverbal/imagery system.

Both representation systems can be activated and operate independently and simultaneously although in some cases they may function collaboratively. The operation of the systems can be distinguished in three levels namely representational, referential, and associative levels of processing. Such different ways of processing information suggest implications for learning strategies. It is argued that in order to support cognitive learning, multimodal materials consisting of both verbal and nonverbal modes of representation might be superior to those with only one either mode. Multimedia can provide a greater chance for activating both representational systems to be prompted for processing information which is beneficial for improving the retention and transfer of information for problem-solving in the future (IARE, 2003; Mayer & Sims, 1994).

Schema theory

Schema theory describes the mental structure as a form of schematic organisation that stores people's knowledge. The schemata consist of series of facts interconnected to each other in particular ways. According to Winn (2014), a schema can be explained by various aspects of its primary characteristics as described in Table 2.4 which also suggests the implication for learning strategies. Regarding visual learning, studies suggested that visual images may affect the encoding of depicted information in the schemata in two aspects: imaginal and structural encoding. The imaginal encoding assumes that a visual image is directly encoded as a mental image resulting in a schema that consists of image properties as seen by a learner. On the other hand, the structural encoding suggests that instead of being directly encoded as a mental image, a visual image provides some structural information which would be employed to approximately create a certain mental image in a viewer's mind probably different from the actual visual image. Despite being based on different assumptions, both aspects of encoding can postulate the benefit of visual images for improving learning.

In either case, a visual image can provide visual information regarding the spatial properties of an object depicted within a visual image such as its location in relation to other elements perceptible in the spatial layout. Humans are familiar with the processing of structural or spatial information in their daily experiencing of the surrounding environment. As a result, the spatial information presented in a visual image potentially allows it to get attention, and if it provides a spatial layout of visual elements isomorphic to a preexisting schema, namely a familiar or recognisable visual image, it may enhance the activation of the memory to be ready for the processing or assimilation of the encountered information (IARE, 2003; McNamara, Hardy, & Hirtle, 1989).

Cognitive load theory

In relation to learning, cognitive load theory (CLT) considers two major accounts: the learning material and the learner. In other words, they respectively involve the structure of the represented information and the person’s cognitive structure entailing the working memory and the long-term memory in the brain (Paas, Renkl, & Sweller, 2003; Sweller, 2016). In terms of the structure of subject matter/information, it is regarded as the sets of elements that interact with each other, and instead of the number of elements, the complexity of information structure depends on the level of element interactivity which results in the extent of cognitive load potentially required for processing. Meanwhile, the operation within the cognitive structure presumes that the human brain deals with ranges of information through the cooperation of the working memory and the long-term memory (Baddeley, 1986). The working memory cognitively processes information in consciousness which is very limited in its capacity. However, the information processing ability might be extended by the long-term memory that stores numbers of schemata.

A schema links many interacting elements that can be processed automatically without a conscious effort. Therefore, to handle complex information, a relevant schema in the long-term memory might be brought to the working memory as a single unit which consequently reduces the intrinsic cognitive load caused by the learning material. It can be seen that the reduction of intrinsic cognitive load of the working memory can be achieved by either reducing the complexity of the learning material or developing prerequisite schemata in the long-term memory.

In learning acquisition, there are also kinds of cognitive load in addition to the intrinsic one including extraneous and germane cognitive load (Paas et al., 2003). The extraneous cognitive load is the unnecessary load produced by instructional procedures in which may hinder learning if they are ineffective. On the other hand, the germane cognitive load is the cognitive effort required for schema acquisition which is the primary mechanism of learning new materials. When the intrinsic or extraneous cognitive loads are high, a learner cannot learn the material efficiently due to lacking mental resource for the germane cognitive load for assimilation. The majority of studies based on CLT are undertaken to provide implications for reducing the extraneous cognitive load or substituting it with germane cognitive load (Kirschner, 2002; Paas et al., 2003; Sweller, 2016).

Many studies focus on eliminating effects that may impose an unnecessary cognitive load. The effects relevant to visual materials include the effects of split-attention and presentation modality which are applied extensively to the construction of multimedia especially in the case of using visual materials with words (Adcock, 2000; IARE, 2003). The split-attention effect may occur when associated sources of information are separately presented. The dispersed elements, which cannot be understood alone, need to be mentally integrated to become meaningful content. Such element integration is accomplished at the expense of working memory resources resulting in less capacity for learning. In order to reduce the split-attention effect, studies suggest using materials that physically integrate sources of corresponding information together (Mousavi, Low, & Sweller, 1995; Sweller, 2016). For example, one may place a written text beside its relevant visual elements instead of separating them into different sections or areas (Sweller, Chandler, Tierney, & Cooper, 1990).

Regarding presentation modality, when the extraneous cognitive load cannot be reduced, a potential way to support learning is to extend the capacity of the working memory. With the principles explained by the dual coding theory (Paivio, 1990), the working memory can efficiently operate when both verbal and nonverbal/visual memory systems are activated simultaneously. Such a modality effect leads to the implication of using visual elements with auditory narration instead of written texts (Goolkasian, 2000; Mousavi et al., 1995; Sweller, 2016). For the written texts, despite directly relating to the verbal system, they are

represented in a visual form which also shares the cognitive resource of the visual memory system. Therefore, by using auditory words, such cognitive load is imposed on the verbal memory instead which can spare some mental resource for learning. In addition, in combination with the split-attention effect, the most effective presentation of materials seems to be accompanying visual elements concurrently with corresponding auditory narration (Mayer & Moreno, 1998).

Table 2.4: The characteristics of a mental schema (Winn, 2014)

Characteristic	Description
Being an organised memory structure	Schema theory is based on the assumption that human memory consists of cognitive structures accumulated from experiencing the world. Such structures subsequently influence the ways of encoding and recalling of information later when encountering with an event. It also suggests that unusual or incongruent structures of information might be either omitted or cognitively processed and reorganised to an understandable or congruent version for remembering. For example, an unusual or unfamiliar visual image may raise awareness and provoke engaging contemplation in a viewer whereas a familiar or agreeable visual image may affiliate positive acceptance of the depicted information (Halkias & Kokkinaki, 2014)
Operating at the level of abstraction	A schema tends to be an abstract representation containing typical information or general concepts of things rather than specific details. On the one hand, such understanding suggests that people, when encountering with some distinct features of things, may be able to recall further information corresponding to such given cues. On the other hand, the generality of mental representation may hinder people from correctly identifying things containing particular variables differ from typical patterns.
Being dynamic	It is argued that the knowledge of the world stored in the schemata is changeable through encounters with new experiences. When new information is perceived, people tend to match it with a stored schema in order to assimilate such experience to the prior schema, or else to deal with it if such experience cannot successfully match any schema. This concept provides an implication about proper conditions to promote learning. Learning is likely to take place when there are elements like instructions or materials that can affect a schema in memory such as in the forms of schema augmentation, alteration, or creation (Rumelhart & Norman, 1981)
Providing a context	A schema provides a context influencing the interpretation of new experiences. Studies show that prior knowledge plays a significant role in directing the comprehension of ambiguous information (Anderson, Reynolds, Schallert, & Goetz, 1977; Bransford & Johnson, 1972). This implication also leads to the concept of priming that attempts to consolidate proper mechanisms for activating a schema to prompt a context for learning.

Note. Adapted from *Cognitive Perspectives in Psychology*, by W. Winn, 2014, In M. P. Jonassen, David H. Driscoll (Ed.), *Handbook of Research for Educational Communications and Technology,* pp. 79-112. Lawrence Erlbaum: Mahwah. Copyright (2014) by Mahwah.

In summary, the recognition of different styles people adopt for learning may lead to communication strategies that encourage people to learn more efficiently. Particularly the VARK model that directly addresses modalities utilised in learning situations, it may inform ways of presenting information that can accommodate modal diversity with which all participants can associate. Various studies demonstrated the rationale of using visual images, especially when being used with accompanying texts. They are conducted in the context of educational settings and mainly focus on instructional materials to support the acquisition of knowledge. However, science communication considers also other aspects of learning outcomes besides the acquisition of knowledge or facts. Therefore, this study attempts to explore the potential of visual images in relation to those additional science communication purposes. The literature on the subject of visual images relevant to this research can be reviewed in the following section.

2.3 Visual images

2.3.1 Defining visual images in this research

The definition of the term 'image' can be multifaceted and varied. For example, according to Mitchell (1987), the different types of images can be explained as the family of images as shown in Fig. 2.3. From the diagram, in the sphere of natural science, an image may involve kinds of optical phenomena like mirrors or projections, but in psychological studies, it can be referred as a mental image or image in the mind such as dreams, memories, or ideas instead.

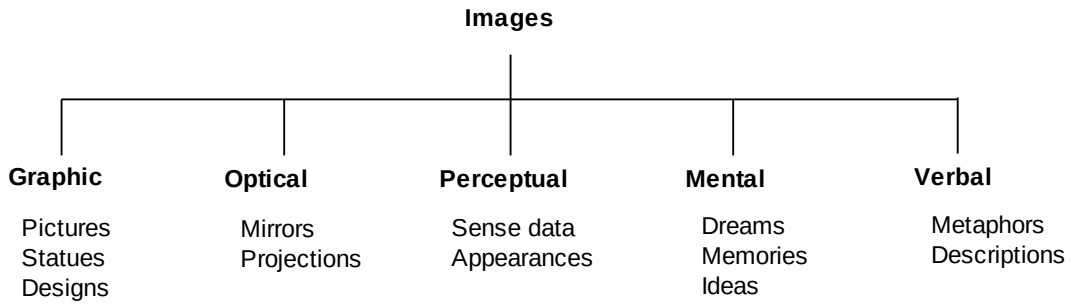


Fig. 2.3: The family of images (Reprinted from W.J.T. Mitchell, *"Iconography: Image, Text, Ideology"*, 1987, p.10)

Based on the image family above, the term visual image used in this research primarily denotes images classified to the distinct mode of graphics or pictorial representation. It mainly illustrates the likeness or resemblance of ideas or things through visible forms. There are several kinds of visual images, and from the art history perspective, there is a distinction between the classifications of fine art or visual art and visual images that are not defined as art. Visual art involves pictures made in accordance with the Western concept of art and respective stylistic movements such as classical, medieval, Renaissance, Realism, or Impressionism paintings (Art Gallery NSW, n.d.). They are fundamentally created for

representing the humanist philosophy of artistic values such as taste, judgement, and beauty (Elkins, 1999). However, it is notable that some non-art images might share some conventions of visual art or represent various expressive meanings. Despite being neglected in art history; non-art images such as informative images like graphs or charts, scientific images, printing, or graphic designs are the majority of visual images used in society for a variety of functions (Gombrich, 1999). They also gain some interest from other disciplines including visual communication. Similarly, this research considers various kinds of visual images not exclusive to visual art which are examined from the aspects of communication rather than the appreciation of visual art.

2.3.2 Visual image interpretation

In this research, visual images are regarded as a form of communication created for conveying certain information. Therefore, they might be considered in relation to the perspective of verbal or speech communication which is the primary mode of human interaction. By considering the Jakobson's linguistic model of communication as illustrated in Fig. 2.4 (Lacey, 1998, p.6), it can be seen that various factors can influence the dynamics of such a process (Chandler & Munday, 2011; Lacey, 1998). Based on such a communication model, in the context of visual communication, the contact is primarily visual materials which might be used with other modes of media such as aural or tactile. Besides the contact, other factors are also argued to be the fundamental aspects contributing to the comprehensive understanding of a communication process which can be explained as follows.

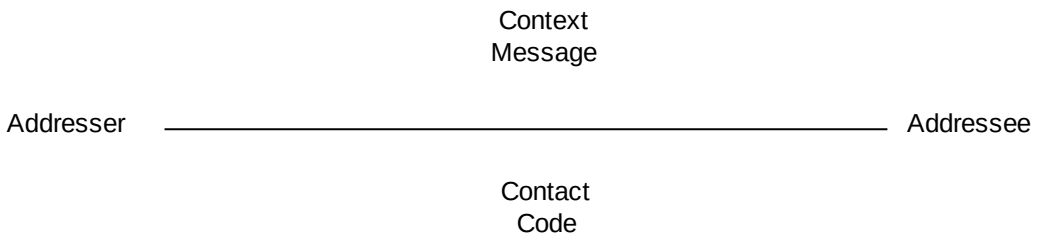


Fig. 2.4: Jakobson's model of communication (Reprinted from Nick Lacey, "*Image and representation: Key concepts in media studies",* 1998, p. 6)

The addresser and addressee may have their own ways of seeing the world. Such different worldviews are constructed from the variety of previous experiences gained by individuals in the society to which they belong. It could be argued that such variation can respectively affect the creation and perception of visual images. It is also the case for institutions performing the role of a communicator when their organisational practices or agenda might inform the ways of depicting content in visual images.

Regarding context, it is the social situation of the communication in which visual images are presented and perceived. The context provides information outside the content depicted in a

visual image and may influence the tendency of interpretation. In order to reach a common understanding of a message, it is necessary that the addressee and the addresser interact within a common communication context. Some kinds of visual images may be associated with a specific social context, although they might be actually presented in other different contexts. For example, Renaissance paintings are usually related to the institutional context of an art gallery, and potentially offers certain values or expectation for viewing even if they are being displayed in a different venue like a public park.

The message is what the addresser intends to deliver to the addressee. However, it is not always the case that the intended message is understood precisely. The decoding of a message contained in a visual image can be straightforward and explicit, or it may introduce obscurity and ambiguity. For the latter case, it requires a higher effort from the addressee to construct a possible meaning from the given codes. Codes are types of language utilised to represent the message, and a visual image can comprise a series of codes or signs associating with particular meanings. The adopted codes are usually chosen to be recognisable or accessible to target audiences to ensure the correct interpretation of meanings. Some viewers might not be able to understand a visual image if they are incapable of interpreting the depicted codes due to lacking sufficient prior knowledge, familiarity or experience of them.

To understand a visual image, a viewer may require two interrelated stages of visual interpretation including the image denotation and connotation with respect to the relevant communication context (Lacey, 1998). The denotation primarily aims to identify the codes given within a visual image which can be observed in terms of the image's form and content. The form of a visual image involves how or in which fashion it is created. However, in most cases of visual communication, details about the image production might not be available or explicitly provided to viewers. As a result, the majority of codes about the form are gathered by considering some typical visual image properties such as framing, viewing angles, distances of depicted objects or the spatial depth created between the nearest and furthest points of a visual image in relation to a viewer. Meanwhile, for the image content, it can be perceived by an audience's capability to recognise its denotative accounts regarding what is depicted in the visual image as well as the manner of such depiction. It is considered with the assumption that every visual element is purposefully depicted in the frame as a series of meaningful codes.

Therefore, the codes of the image content can be portrayed in the forms of the represented subject, lighting, and the setting within a visual image. The subject(s) of a visual image may be anything that can be visually depicted. The representation of a subject can be either congruent with reality or abstract. Without any form of description to define the subject, a viewer may require some prior knowledge to recognise and understand it. The denotation of

a subject can cover aspects beyond identifying what the subject is, but also includes how the subject is placed or composed within the frame, namely its spatial properties or location in relation to other surrounding subjects (if applicable), or to the centre and the corners of the visual image frame. Regarding the lighting, it considers how an image is illuminated relating to the kinds of light and shadow adopted in the visual image. For example, the lighting can be natural or manipulated with intended light intensity or direction that may give particular effects to the image interpretation. Meanwhile, the setting of a visual image might be considered from its background which may provide some context for the interpretation of a visual image. An example can be illustrated in Fig. 2.5 which may suggest different perceptions toward the two visual images without or with background: Figs. 2.5(a-b) respectively. By viewing Fig. 2.5(a), an audience might mainly focus on the depicted penguin regarding its appearance or physical characteristics. On the other hand, Fig. 2.5(b) contains some background elements such as the environment and other penguins which may also suggest the perception of its habitation or way of living.

Fig. 2.5(a): An exemplified visual image representing a subject with the absence of background (Adapted from Matas 2012)

Fig. 2.5(b): An exemplified visual image representing the main subject with background elements (Matas 2012)

It can be seen that the denotation process mainly defines codes either those depicted in visual images or gathered from surrounding factors. However, to perceive a visual image in some cases, a viewer may need to consider it further according to the connotative meaning. The connotation of a visual image might not be explicitly presented although it might be

drawn in a viewer's mind as the collaborative construction of visual cues, other accompanying information, and the given context (Barthes, 1977). As such, the overall perception of a visual image is more meaningful than the sum of individual elements that can only be approached through culturally learned knowledge or experience. The construction of a message based on the given cues can be explained further in the following review of some visual perception theories and in particular, semiotics.

2.3.3 Theories of visual image perception

The theories on image perception have been developed by scholars from various disciplines with the attempt to explain how people see and learn from visual images (Anglin et al., 2004; Lester, 2010). The theories reviewed in this section include Gestalt theory, constructivism, and semiotics. The first one mainly relates to the perception of visual images at the denotation level while the latter two theories primarily operate at the connotative level. These theories involve either visual sensation and perception considering how the brain detects visual cues like colour, form, and depth as well as how the mind understands them in a meaningful way.

Gestalt theory

The Gestalt approach explains visual perception in terms of brain processes. The main concept proposed by the Gestalt movement is that the whole is different from the sum of individual elements, namely the perception of a visual image arguably differs from seeing all individual parts in isolation (Gordon, 1997; Lester, 2010). There are several principles of 'grouping' which have been postulated in order to identify different ways in which elements within visual images can be categorised. They include proximity, similarity, continuation, and common fate which are explained in Table 2.5 (Gordon, 1997; Lester, 2010; Wagemans et al., 2012). They describe the conditions of the visual phenomenon where viewers are likely to perceive the inclusion of some elements as a group. On the other hand, such a phenomenon also introduces the separation of elements not belonging to the group such as the distinguishing of a visual figure or foreground from the background.

Constructivism

The concept of constructivism in the context of perceiving visual images explains that the perception is not merely the direct registration of sensations but involves the construction of meaning enacted by the combination of visual stimulation and experience. This basis led to several studies postulating various views about image perception. A contemporary theory based on constructivism is proposed by Gregory (Gregory, 1980). The Gregory theory correlates visual perception to hypotheses about things which are generated from visual data and prior knowledge of an observer. In other words, viewers may form some hypotheses regarding the potential meanings of a visual image based on available given cues which

subsequently are tested or evaluated with respect to relevant contexts to determine the most appropriate one as the visual image's interpretation.

Different variables contribute to the characteristics of visual signals or codes of communication as described in section 2.3.2: visual image interpretation. These visual variables can be recognised and interpreted with particular coding systems to understand visual phenomena. However, codes relevant to visual data might be conventional or arbitrary which may introduce complexity to the interpretation. The acquired visual data alone might be ambiguous and insufficient to draw a comprehensive meaning. As a result, visual perception also relies on the relevant contextual knowledge which might be influenced by personal experiences or direct instruction (Anglin et al., 2004).

Therefore, the perceived meanings of visual data are not necessarily the reality, but they are hypothetical possibilities cognitively selected by a viewer with the reliance on both available visual codes and individual cognition. One example that can be explained by Gregory's constructivism is the perception of an illusory or ambiguous visual image. In such a case, meanings may be constructed differently according to viewers' attitudes and expectations (Gombrich, 2002). In addition, the influence of mental processing may also introduce visual distortions in which the visual perception is different from reality or from the intended message (Gregory, 1998).

Table 2.5: The summary of main grouping principles in Gestalt theory

Grouping principle	Description
Proximity	Visual elements close to each other regarding their relative distances are usually perceived as the same group apart from distant ones. The proximity is applicable to the horizontal or vertical planes as well as the aspect of the spatial depth.
Similarity	Viewers tend to perceive similar visual elements as the same category or group. The similarity can be presented in various visual characteristics such as regarding colour, shape, size, and orientation. This principle can be applied to create an attractive visual image in which there is a distinct or different visual element among similar ones to get the viewer's attention.
Continuation	It involves the smooth movement of a line within a visual image. The line can be visibly depicted as a drawing or a series of visual elements placed sequentially to form a perceptual line. The continuation property may encourage viewers to follow the line in their minds to further complete the whole picture from visual elements partially presented in a visual image.
Common fate	It is mainly relevant to the position and velocity of visual elements. Visual elements that present the tendency of moving or pointing in the same direction are mentally grouped. It is also the case for the changing of visual features in the same fashion. On the other hand, the opposite direction between visual elements can separate them from each other and create tension among them. This principle can be applied to create a visual image containing common fate properties for directing viewers' eyes toward or away from particular visual elements within the image.

Semiotics

Semiotics or the science of signs was originally utilised to study languages in relation to the perception of the world. Nevertheless, its principles can also be applied to analyse other systems of communication including visual communication. The sign system consists of the following primary terms i.e. signifier and signified which are simultaneously perceived by a reader. According to the principle proposed by Saussure (Lacey, 1998), the signifier is the perception of the sign's physical form such as types of material, appearance, gesture, or visual image. The signified is the mental concept associated with the signifier that refers to a particular thing or idea. Such a process in which a sign is adopted for the representation of its reference is called the signification.

Besides the signification proposed by Saussure, other scholars such as C.S. Peirce and Roland Barthes also contributed to the discipline of semiotics. C.S. Peirce categorised signs into three distinct groups comprising iconic, index, and symbol (Short, 2007). An iconic sign represents a reference by resembling the qualities of the reference, for example, a photograph or a portrait image. Meanwhile, an index sign represents a thing by depicting a direct relationship or link between a signifier and its reference. Regarding a symbolic sign, it is created arbitrarily to represent its reference which can be recognised by learning from an established social consensus. For example, national flags to represent countries, or traffic lights to control the operations for people using the road.

Moreover, Roland Barthes associated semiotics with the concept of ideology, namely the dominant value system constructed within a particular society. Barthes (1993) argued that the denotation derived from signs not only leads to the connotation referring to a paradigm of things but can also suggest an ideology or myth as illustrated in Fig. 2.6 (Barthes, 2015, p.129).

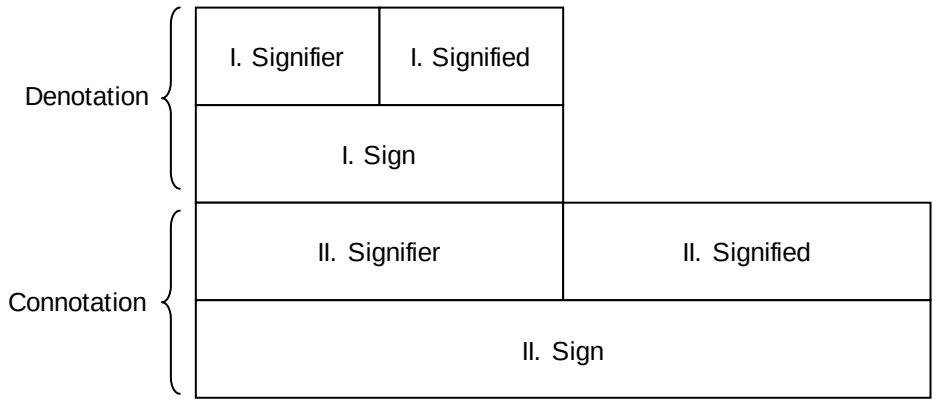


Fig. 2.6: The signifying system proposed by Roland Barthes (Reprinted from Roland Barthes, 2015, *Mythologies [ePub],* p. 129)

Although the identification of visual elements at the denotation level allows an audience to discern what is represented in a visual image, the interpretation of its intended message may require further analysis. Due to the arbitrary nature of signs, the deconstruction of the sign system might offer various meanings. Therefore, to pinpoint the actual meaning, its contextual information also needs to be appreciated. Moreover, in many cases of visual image analysis, besides the denotation of depicted elements, they might involve the connotation of some myths or ideologies to be perceived by some culturally learned knowledge.

An ideology is a worldview constructed in a particular society that can influence the members of the society regarding their ways of seeing the world. Due to potential influence on people in society, ideologies are argued to be interrelated with aspects of social power. As a result, there might be a competition of ideologies within a society, and some of them are dominant and overpower other different or opposing ideologies. A mainstream ideology usually expresses itself as a common-sense which is naturally adopted in society. In other words, ideology is a particular version of reality that is socially articulated by relevant discourse(s). An ideology usually involves sets of ideas within discourses that tend to be flexible and adaptive to changing conditions.

In visual communication, ideologies potentially underpin the structure of sign systems or discourses represented within a visual image. Therefore, the interpretation of such a visual image requires the deconstruction of the associated sign system suggesting an intended message, namely the meaning is drawn on the basis of a discourse that can match the visual representation (Lacey, 1998). Therefore, discourse in the context of visual image analysis can be described as the expressed or observable attributes of an ideological process that involves certain ways of viewing and describing the world (Kenney, 2009; Kozol, 1994). A discourse offered in a visual image can invite viewers to interpret the image from particular perspectives. It is notable that each visual element may be recognised in association with various discourses, hence it is not always the case that every viewer will adopt the same discourse and commonly utilise it for interpreting a visual image. Moreover, the ability to determine a discourse for explaining a visual phenomenon also depends on the variety of discourses at one's disposal. Those who have learned myriad discourses may have a higher potential to acknowledge the intended discourse proper for the interpretation of meaning in a given context. On the other hand, a viewer might not be able to interpret the meaning of a visual image if they cannot recognise or lack the knowledge about the presented discourse.

2.3.4 Visual images in science communication

Visual science communication can operate through many forms of visual materials such as visual images, motion pictures, displays or models and even demonstrations. However, as

mentioned above, this research focuses only on static visual images. As such, within the sphere of science communication, various types of visual images may be utilised for different functions. Through the observation of relevant literature, visual images used in science communication can be categorised, based on their initial purpose of production, into four distinct groups including scientific images, visual images created specifically for science communication, images already existing in other communication contexts, or visual images created by an event's participant (Mullen, 2010; Pauwels, 2006; Stevenson, 2013).

Scientific images are specifically created as a component contributing to developing knowledge. They are produced to explain or illustrate a particular concept or model in science since aspects of scientific knowledge cannot be communicated only in texts. The production of these images usually involves scientific knowledge, and possibly specialised imaging instruments and processes (Manghani, 2013). They have been produced to represent scientific ideas, facts, and processes since the early age of human history (Priest, 2015). When more sophisticated photographic techniques became available, the production of scientific images was enhanced accordingly resulting in better visual representation beneficial for scientific investigation, explanation and communication.

Scientific images can be found in many channels of communication within the scientific community and also in the public sphere. These images are utilised in different contexts ranging from academic journals and textbooks to being displayed in popular media and the Internet. Print media is an area where various forms of scientific images are utilised extensively. For example, tables, illustrations, or photographic evidence are utilised to support scientific argumentation and become a fundamental element in scientific articles. Moreover, the advancement of digital communication and the Internet allows people to access and share scientific images rapidly. In these contexts, the use of scientific imagery may serve a variety of functions besides visually depicting scientific phenomena or conveying scientific facts.

Nevertheless, in science communication with public audiences, there are also other kinds of visual images besides scientific images. For images produced purposefully for communicating science to lay audiences, they may represent science in a more accessible and imaginative way through different kinds of formats and production techniques. Some science communicators also use visual images with written texts in a narrative manner to communicate scientific facts or data such as in terms of infographics (Popular Science, n.d.), a science comic book like "Adventures in synthetic biology" (Endy & Deese, 2005), or drawings used in health communication (Houts, Doak, Doak, & Loscalzo, 2006). Visual images in this group might not directly relate to scientific concepts or knowledge but they are intentionally created to use in science communication. For instance, some provocative pictures of naked female flesh were deployed for protesting against GM (genetically

modified) milk production which could raise attention and also stimulate viewers' emotional responses toward the subject matter (Bloomfield & Doolin, 2012). Meanwhile, there are some found visual images which are not intentionally produced for science communication purposes although they may demonstrate particular links to an intended scientific context. Besides being presented in science communication, visual images can also be created by the event's participants. Namely, the creation of visual images can be adopted as a tool for inviting people to participate in activities. For example, the activity 'In Your Element!' featuring a large periodic table in which consists of individual visual images of elements (Stevenson, 2013). As such, to be able to create a visual image, a participant was encouraged to learn some science (information about the selected element) through the conversation with the event's facilitators or the accompanying book.

2.3.5 Previous studies on visual images in science communication

Visual images are utilised to a considerable extent in science communication in different forms and for different purposes, although the understanding of using visual images in this particular area is argued to be under-researched (Priest, 2015; Trumbo, 1999). Much research on visual images and their use in science communication seems to arise after the publishing of the article 'visual literacy and science communication' written by Trumbo (1999). It emphasised the significance of visual images in communicating science and suggested some consideration that may promote the effectiveness of creating, disseminating, or reading visual images in this sphere. As such, Trumbo (1999) postulated different facets of visual literacy which are required in this context and categorised them into three major dimensions comprising visual thinking, visual learning, and visual communication.

Visual thinking involves the preference of cognitive process and a set of visual skills possessed by individuals. The difference in the level of visual thinking can be manifested in the difference between scientists creating visual images as an aspect of their scientific investigation or communication, and audiences interpreting scientific images (Gardner, 1982; Gregory, 1974). Research which considers visual thinking contributes mainly to the understanding of scientific images or visual representation in science (Pauwels, 2006). Meanwhile, the facet of visual learning focuses on the acquisition of scientific knowledge through visual images. In this dimension, the visual representation is considered as a learning tool which is usually adopted and analysed with the combination of textual information. It is commonly studied within the realm of psychology and science education to inform visual science learning strategies (Anglin et al., 2004; Cook, 2006; Willerman & Mac Harg, 1991).

Meanwhile, visual communication involves the consideration of visual images used in science communication events. It aims at understanding how a message is delivered or

interpreted through visual representation. It comprises various perspectives as explained in Table 2.6 (Trumbo, 1999). This is also coherent with a broad range of subjects calling for investigation especially at the areas of image production, dissemination, and reception (Cristina et al., 2015; Rose, 2016).

Table 2.6: The aspects of visual communication recommended by Trumbo (1999)

Consideration	Detail
Source of the message	The addresser or communicator who communicates the message such as scientists, science institutes or organisations
Message	The information to be communicated
Visual image production process	It involves various stages including defining the problem, analysing data or the message, conceptualising potential visual images, selecting appropriate form and format, creating visual images according to the concept and form, refining visual images, and evaluating the effectiveness of visual images.
The nature of the medium	It considers different characteristics of visual images and their uses including style or format of portrayed content, purposes and potential effects, access and availability, technical and affective qualities such as sensory potential or aesthetic qualities.
Audience	Addressees or people who receive the message and how they interpret, perceive, and respond to the message.

Note. Adapted from Visual Literacy and Science Communication, by J. Trumbo, 1999, *Science Communication, 20(4), pp.* 409–425. Copywrite (1999) by SAGE Social Science Collections.

From Table 2.6, the aspect of the visual image production process is arguably insufficiently researched in the discipline and practice of science communication. This might be because science communicators often select visual images from existing galleries instead of creating them specifically for an event. Moreover, a proportion of visual image selection may rely on two general criteria i.e. the aesthetic features and the scientific accuracy of visual images (Jarman et al., 2012). The research also suggested that when visual images (even scientific ones) are used in the context of science communication, they tend to be regarded as popular media and recontextualised to serve particular functions (Trumbo, 2006). For example, an attempt to make visual images engaging to public audiences possibly leads to the adoption of visual communication techniques used in other familiar disciplines such as marketing or advertising. Moreover, the visual images produced may feature certain components or social aspects besides the scientific content which are accessible to audiences (Lester, 2010; Throop, 2013). Similarly, this concept is endorsed by Cristina et al. (2015) recommending the utilisation of user-centred design and graphic design principles as the approach to create and use visual images in science communication.

On the other hand, studies in science communication provide some evidence to support the potential effects visual images bring into various events. In the sphere of communication of environmental issues, O'Neill & Nicholson-Cole (2009) demonstrated the influence of visual images on audience perception about the salience of communicated issues as well as the sense of engagement with the issues at a personal level. This observation is expanded on by the research underpinning the effect of using visual images with written texts over either text or a single mode alone (Lazard & Atkinson, 2014). Such a study showed that an appropriate combination of the two modalities might encourage audience participation with subject matter regardless of the audience's modality preference or visual literacy level. This is also the case for science communication which seeks to enable comprehension of and adherence to an intended message (Grootens-Wiegers et al., 2015).

Moreover, due to possessing particular properties, visual images can be efficiently used to serve different purposes. For example, Tatalovic (2009) suggested that drawings such as in the form of comics are able not only to support education in science for a reader but also to promote audience engagement with the subject matter. Namely, the represented story or characters may establish a rapport with audiences. Moreover, their informal and friendly style potentially makes comics suitable for representing perspectives of nuanced ethics or sensitive issues in science which otherwise may not be readily addressed by textual statements. Likewise, Severtson (2015) demonstrated that visual images particularly created for the investigation, which rendered uncertain risk levels, could overcome the barrier of numeracy usually required to interpret this kind of information. Also, Bloomfield & Doolin (2012) showed the capacity of visual images to portray symbolic representations that can provoke emotional responses to win support or encourage actions on a controversial issue like GM (Genetic Modification).

However, the majority of visual images considered in the research studies mentioned above have never been used in an actual science communication event. Most of them were created particularly for investigation purposes. In other words, some components are manipulated or controlled as variables for examining their potential effects that might be reflected from audience perspectives gathered through surveys, interviews or focus groups (Grootens-Wiegers et al., 2015; Lazard & Atkinson, 2014; Severtson, 2015). These studies may support Trumbo's proposition (Trumbo, 1999) regarding the importance of visual images in science communication and primarily contribute to the dimensions relating to the nature of the medium as well as the audience mentioned in Table 2.6. They also raised a consideration on the appropriate use of visual images by demonstrating that the effects caused by a visual image can be different from context to context (Bloomfield & Doolin, 2012; O'Neill & Nicholson-Cole, 2009; Severtson, 2015). These studies may encourage multimodal science communication using visual images as one component.

There are few studies which investigated the nature of visual images and their portrayed messages in relation to intended purposes. O'Neill & Nicholson-Cole (2009) were interested in the style of content depicted in visual images relevant to the climate change issue and found that the world's catastrophic images inducing fear messages may be effective for raising awareness of the issue. Nevertheless, such a style of visual images may hinder the sense of personal relevancy and discourage the contemplation of the issue. Instead, such personal engagement may be better promoted through visual images associating with scenes or situations relatable to audiences' everyday lives. These findings are also congruent with the principles for images of climate change recommended by Corner, Webster, & Teriete (2015).

Focusing on the similar subject matter, Chapman et al. (2016) further investigated the audience perceptions toward some groups of climate images including images featuring the representation of human subjects, images depicting protests and demonstration about climate change, images suggesting potential solutions, and familiar or iconic climate images. The study explained the potential impacts and drawbacks of each image type which may be useful to practitioners involving in climate change communication. Also, another study examined climate imagery particularly used in digital media not exclusive to the forms of visual images such as news, social media platforms, art, video, or visualisations (Wang et al., 2017). The research emphasised that visual tools can play a significant role in engaging public members with climate change issues.

For a different scientific topic, Smith et al. (2014) focused on the aspects of the technical qualities of astronomy images and types of accompanying labels that are suitable for promoting comprehension and engagement. The results suggested some general components which potentially give a superior outcome such as visual images with vivid colours, aesthetic appeal, question-answer type of labels, or proper size and resolution for displaying great details. It is notable that both studies were conducted in a pre-evaluating fashion by prescribing potential communication contexts and gathering opinions toward some assigned visual images from sampling groups of audiences.

Meanwhile, Bloomfield & Doolin (2012) carried out their study by learning from existing examples, which is one practical approach for improving the effectiveness of science communication (Aikenhead, 2001; Bowater & Yeoman, 2012). The study investigated visual images already utilised in an actual GM protest event that caused effects either corresponding or contrary to the intended purposes. It adopted a visual analysis approach recognised in the visual communication discipline, comprising the examination of visual image meanings at the denotative and connotative levels, in order to decode the intended message associated with particular relevant discourses. The elements constructing the message were examined in connection with surrounding cultural contexts to realise

significant features that yield the respective effects. Some characteristics of visual images observed in this research include being provocative and containing content that may somehow violate a social boundary; excessively using symbolic representation; containing connotative meanings and visual rhetoric.

The research conducted by Bloomfield & Doolin (2012) not only provides implications for future science communication events with a similar context, but it also demonstrates that investigating salient features of visual images within associated contexts can be a useful way of contributing to the understanding of visual science communication. Therefore, being inspired by such study, this research aims to analyse the nature of visual images used in other contexts with different major purposes found in science communication events. The results provided by this study may serve as a practical framework for using visual images in this arena that may be applicable to a variety of relevant contexts.

In summary, this chapter reviews some relevant literature to set the general background and context of the research. The first three sections include science communication, learning theories and styles, visual communication, especially via visual images. The section of science communication introduces its history, theoretical concepts followed by practical approaches and various intended purposes. Science communicators adopt either traditional or innovative communication strategies from diverse practices as they deliver events and activities which are contemporary and efficiently engage public audiences with science. Subsequently, the learning styles section rationalises the use of multimodal materials in science communication to address the diversity of audience preferences. It primarily considers a variety of potential learning outcomes offered by visual images.

The last section defines visual images considered in the context of this research in relation to the aspects of visual communication. Some previous studies focusing on visual images used in science communication are also reviewed. It demonstrates that the subject is under-researched, and many relevant aspects could be further researched. There is some potential for the exploration of visual images themselves to better explain how or what characteristics allow them to bring particular effects into their associated contexts. A study on such a topic may provide further implications contributing to the effective use of visual images in this specific domain by analysing case study examples of science communication activity in which visual images are the main element. These case studies will be analysed using the tools of visual image analysis and setting the findings in the context of learning theory and science communication purposes.

Chapter 3
Research Design and Methods

The previous chapter suggests possibilities for approaches to researching the use of visual images in science communication. Previous studies explored various capabilities of visual images to function in this dimension although the studies were mainly conducted within a controlled or prescribed setting rather than an actual science communication context. In addition, most of the studies did not focus on the characteristics of visual images in relation to their effects. Yet these two factors seem to have a significant relationship as suggested by Bloomfield & Doolin (2012) and O'Neill & Nicholson-Cole (2009). As such, the studies by Bloomfield & Doolin and by O'Neill & Nicholson-Cole not only demonstrated the potential of visual images to portray certain messages that can influence the perception of scientific content but also investigated the nature of visual images with respect to their science communication context and potential outcomes.

Stemming from such previous studies, this research attempts to further understand visual images used in science communication events especially those spontaneously encountered by public members. Since a visual image is rarely used in isolation but usually accompanied with other components to convey a message (Lazard & Atkinson, 2014; Kenney, 2009), both characteristics of visual images and their relationship or collaboration between the different modes of communication are the focus of this study. Besides their potential reception effects, the investigation of visual images and accompanying elements is also conducted in relation to their relevant science communication contexts especially their intended messages and goals.

This may imply that an efficient judgement for utilising visual images regarding their characteristics may allow a science communication event to better achieve its objectives. However, science communication can involve a variety of contexts and purposes, hence what did work well in one event may not be the case for the others. Facing such potential nuance without strategic guidelines, some science communicators may find the task of using visual images challenging and undertake it with less confidence. Therefore, this research aims to examine various examples to diversify the scope of science communication contexts and broaden the understanding of the nature of visual images from particular implications contributed by previous studies. The research may contribute to good practice in science communication, namely to suggest what and how some characteristic(s) of visual images can be important to a certain context and purpose. This chapter describes the procedures of the research. It introduces the research questions. Subsequently, it explains the research design and methods adopted to gather and analyse the research data, as well as some consideration about the issues of the research validity and reliability.

3.1 Research questions

As explained previously, the research is conducted to explore how visual images are used in science communication contexts and for different purposes. It focuses on the nature of visual images in relation to some functionalities of science communication including to get and maintain attention, to convey an intended messages, as well as to achieve expected learning outcomes. It should be noted that the outcomes considered in the context of this research are based on the Generic Learning Outcomes framework (GLOs). Therefore, this research aims to answer four relevant research questions:

RQ1: How is the message constructed by a visual image and accompanying information in a science communication context?

RQ2: How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)?

RQ3: How can visual images perform their function regarding the capturing and maintaining of audience attention?

RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements corresponding to the fulfilment of Generic Learning Outcomes (GLOs)?

3.2 Research design

The planning of the research is based on a framework corresponding to comparative research design which is undertaken through a multiple-case study approach (Bryman, 2012). The multiple-case study approach is influenced by the stance of critical realism recognising the reality of a social event which might not be conclusively examined or observable under a manipulated or controlled condition. Instead, it attempts to identify hypothetical entities called generative mechanisms that, in interaction with a relevant context, produce an observable social phenomenon (Bryman, 2012). For this research, the multiple-case study approach extensively investigates individual examples of science communication events associated with different contexts. Then, a comparison between the exemplified cases is undertaken to establish their common or differentiating factors. Namely, the emerging commonality or distinction of visual image characteristics drawn from cross-case synthesis serves as a basis for theoretical reflections about the research findings which subsequently provides practical suggestions for the use of visual images in science communication practice. The rationale for adopting the multiple-case study approach is explained as follows.

The development of a science communication event considers several factors that may affect the effectiveness of the event. As a result, science communication usually occurs in a variety of settings that do not necessarily rely on any universal strategy or set of factors

(Bowater & Yeoman, 2012). By focusing extensively on the particularity of each individual case, the research allows the researcher to investigate such aspects specific to each science communication context. The results obtained from comparing multiple cases may contribute to a broader understanding of visual materials that also acknowledge the agency of the context differentiation underpinning some distinct characteristics of events.

An experimental method may be deployed to examine the relationship between certain visual image characteristics and their respective effects on audiences (Grootens-Wiegers et al., 2015; Lazard & Atkinson, 2014; Severtson, 2015). However, it might not be the most appropriate method for this research focusing on existing events in which the researcher has less control over the nature of visual materials to be examined. Moreover, the study also considers the agency of the event's contexts which involve some specificity such as in terms of the event's actual venue, duration, or physical size. As such, to devise different controlled scenarios following those actual conditions, and to recruit participants for an experiment might be improbable for gathering research data. Meanwhile, a survey primarily providing quantitative data may not be able to answer the research questions especially ones proposed to extensively examine the visual image nature used in particular social phenomena. In addition, the study comprises the interpretation of visual images which inevitably relates to the nuance of social aspects and several disciplines such as visual representation, multimodal communication, or art and visual design. Due to the flexibility of multiple-case study research design, it admits the appropriation of several methods to gather data as well as a variety of theoretical perspectives for data analysis (Yin, 2014). Therefore, the multiple-case study approach seems to be more advantageous than other acknowledged research designs (Bryman, 2012).

It is arguable that the findings drawn from multiple-case study approach may not be statistically generalizable as plausible in a cross-sectional design or survey, and the exemplified cases are by no means a representative sample to explain all population or events using visual images (Bryman, 2012). Instead, the findings of this study may serve as a range of choices or possibilities of visual image characteristics and ways of using them in combination with other modes of communication. As such, a reader of the research may apply the proposed implication of findings intuitively to their uses of visual images. Namely, the theoretical or analytic generalisation of findings may happen when a reader can associate the aspects suggested in this study with the context of science communication event being considered. Therefore, this study may offer practical knowledge, especially to readers undertaking science communication as well as those intending to develop a visual image-based event.

3.3 Research methods

The study adopts a qualitative method to gather evidence for the analysis of individual cases. In this research, visual images and written texts (or spoken material) are considered as the primary semiotic resources appropriated in each case for constructing meanings. They are examined through the perspectives of multimodal discourse analysis (MDA). MDA is extended from discourse analysis originally focusing on the use of language in relation to different contexts (O'Halloran, 2011). The emerging of MDA may be the result of the expansion of the discourse analysis discipline that seeks to provide comprehensive theoretical frameworks applicable to all kinds of semiotic resources not exclusive the linguistic modality (O'Halloran, 2011).

Studies in the field of MDA are based on the metafunctions of language proposed by Halliday (1978). A language can create a representation, interaction, and several types of recognisable communicative events via the combination of individual semiotic attributes. They contributed to the theory and practice of MDA which can be categorised into three focused themes (O'Halloran, 2011) listed as follows:

- Modelling the systems of semiotic resources which may be different from languages
- Modelling and analysing the relationships between semiotic resources that construct meanings
- Modelling and analysing the semiotic reconstruction of particular multimodal phenomena across different situations

This research incorporates the first two dimensions, focusing especially on visual and textual (or spoken) materials. The discourse considered in this research involves the utilisation of visual attributes and the mechanisms between modes of communication (visual images and accompanying elements) that are designed to work in combination to convey a message or perform a particular function. A framework of multimodal discourse analysis is employed to examine how such construction could be achieved (Kenney, 2009).

In addition, the explanation of the findings is also based on other theoretical frameworks relevant to the study of visual materials such as visual representation, perception, or attention (Arnheim, 2004; Bloomer, 1976; Kennedy, 1985; Lacey, 1998; Lester, 2010; Watzl, 2017). Meanwhile, the exemplified cases are selected from actual science communication events which people may encounter casually in generic venues.

3.4 Case selection

This section describes the selection of cases based on the purposive approach and availability that may provide a variety of examples as evidence to address the research questions. According to Yin (2014), the selection of a case involves two steps including to define the case definition and its boundaries. In this research, a case can be defined as a

science communication event or activity utilising a static visual image(s) as the primary tool which may also be accompanied by other elements/modes of communication. Also, the case is likely to convey a message involving social positions besides being informative or objective.

In regard to the case boundaries, they can be explained in relation to the model of communication as shown in Fig. 2.4 entailing participants, context, message, contact, and code. The last three factors are attributes of the case unit to be examined in this research. Meanwhile, the participants can be any group of science communicators and public audiences. Therefore, the case boundary adopted for the comparative purpose respecting the multiple-case study approach can be defined in terms of the contexts of science communication which can be different from case to case. However, to narrow down the scope of the case boundary (science communication contexts), there are some common criteria deployed for cases to be recruited for this research. Namely, science communication events investigated in this research need to be actual events happening at a particular time around the duration of the study (2015-2018) in generic venues where audiences may encounter them unexpectedly.

With such definitions of a case and its boundary, there are eight cases to be examined in this research as listed in Table 3.1. Each couple of cases serve as two examples of science communication events associating with each aspect of Generic Learning Outcomes (GLOs) framework as listed in Table 3.1. By considering each case in relation to a particular dimension of purposes does not mean that there is the absence of other purposes in such case. Instead, the arrangement of cases assigned in Table 3.1 is based on each case's most predominant objective. For example, case 7: the poster for campaigning about antibiotics resistance partially involves fact/scientific knowledge as well as elements of attitude/value. It is also delivered through an enjoyable or pleasurable approach like visual representation. Despite involving several dimensions of purpose, this research mainly analyses such case in relation to its goal that is to promote behavioural change or encourage compliance with the prescribed behaviour.

While the individual case analysis may provide some answer to RQ1 and RQ2, and the cross-case synthesis to RQ3 in general, the investigation of the exemplified cases in the association with GLOs may contribute to the understanding of how visual images are used in combination with other modes of communication to achieve the event's expected learning outcomes that is to respectively answer RQ4. From the five dimensions of GLOs (Arts Council England, n.d.), only four aspects of outcomes, except the aim to improve skills, are adopted to sample exemplified cases since all cases can provide a chance to practice the skills relevant to visual image viewing (further explained in Chapter 8).

Table 3.1: The multiple cases to be studied in the research

Potential main learning outcome	Exemplified cases
Attitudes or Values	4.1 ‘Let The World Keep Turning' exhibition 4.2 ‘Enjoy Science Careers’ exhibition
Enjoyment, Inspiration and Creativity	5.1 ‘Seeing red’ mural 5.2 ‘We are the same blood’ mural
Knowledge and Understanding	6.2 ‘Light Works’ exhibition: X-ray Kiss 6.3 ‘Light Works’ exhibition: Chocolate shells
Activity, Behaviour, and Progression	7.1 Antibiotics resistance poster 7.2 Alcohol abstinence billboard

It should be noted that most couples of cases entail examples from different countries (i.e. UK, USA, or Thailand) and the individual analyses of cases also take into account their associated cultural contexts. However, the characteristics of visual images drawn from the cross-case synthesis are generally considered in relation to science communication purposes rather than the particular cultures of those countries. In addition, for the expected learning outcome regarding knowledge and understanding, both cases of interest are drawn from the same exhibition (‘Light Works’ exhibition). This is because, in such an exhibition, there are several kinds of visual images and contexts of using visual images that may provide sufficient information to contribute to such an aspect of the investigation.

To sample cases 6.2 and 6.3 for the enquiry, the content analysis of all visual images in the exhibition is conducted to classify them prior to selecting two different visual images that are also congruent with the case definition and boundary mentioned above. Since there are several visual images applicable to such case criteria, to narrow down the variety of cases some particular details are set for selecting cases from the exhibition. As such, the two sampled examples are supposed to be existing visual images initially created and used for other purposes outside the contexts of scientific practice and science communication. One visual image is with, and the other is without human being representation. This may also shed some light on the adoption of existing visual images into the context of science communication. The brief overview of the content analysis and its results are described in the respective chapter (Chapter 6).

3.5 Research data

Since the research primarily investigates visual materials, it relies on evidence that can provide information involving their relevant contexts (Kenney, 2009; Rose, 2016). Also, to provide an in-depth description of the cases (Rapley, 2007; Yin, 2014), this research utilised multiple data sources both primary and secondary ones. The forms of evidence are also heterogeneous comprising either audio, visual, or textual based materials. For the primary

data generated by the researcher, it includes transcripts of interviews as exemplified in Appendix C, field notes in forms of written notes, voice recording, or photographs of events. Meanwhile, the secondary data that already existed can be various sorts of materials directly provided by events' facilitators or documents found in public domains such as event evaluation reports, published articles or news about the events.

Due to the different levels of accessibility, the number and type of relevant evidence might vary from case to case as appropriate. Moreover, the variety of data sources in each case not only gives comprehensive information but may also increase the data validity. The inventory of data gathered for each case can be shown in Table 3.2

Table 3.2: Data inventory for each exemplified case

Case	Sources of evidence			
	Case artefacts	Secondary documents	Interview transcripts	Fieldnotes
1. 'Light Works' exhibition: 'X-ray Kiss' image	✓	✓	✓	✓
2. 'Light Works' exhibition: 'Chocolate shells' image	✓	✓	✓	✓
3. 'Let The World Keep Turning' exhibition: portraits of scientists	✓	✓	✓	✓
4. 'Enjoy Science Careers' exhibition: portraits of scientists	✓	✓	✓	✓
5. 'Seeing red' mural	✓	✓	✓	n/a
6. 'We are the same blood' mural	✓	✓	n/a	✓
7. Antibiotics resistance campaigning poster	✓	✓	n/a	✓
8. Alcohol abstinence billboard	✓	✓	n/a	✓

3.6 Data collection

In this research, the gathering of data was different from case to case and conducted in an iterative manner rather than in a progressive one. However, in order to explain how such a process was undertaken, this section overviews the general procedures applicable to all cases in relation to sources of data including documentation, interviews, and field notes. In addition, prior collecting data, the research has reviewed and obtained the ethical approval from the Social Research Ethics Group (SREG) in Edinburgh Medical School: Biomedical Sciences, The University of Edinburgh. Within the University of Edinburgh, the process of getting the ethical approval is mainly conducted through an online system associated with the research's relevant school. Since this research has no reasonably foreseeable ethical risks (level 1) as concluded in the research ethics application form (See Appendix A), the

process is rather short and straightforward. It does not require any further review either within the university or to be reviewed by an external UK committee. The application form is filled by the researcher and submitted electronically to the online system which then forwardeds it to the research supervisor. Once the supervisor has reviewed and signed off the application, the SREG then issues an exemption letter, namely, the application is approved and the research can proceed.

3.6.1 Documentation

The secondary documents in this research were primarily retrieved from the Internet. The documentation for each case was undertaken through some major steps including searching, reviewing, and organising materials. The searching of documents is conducted through search engines such as Google search with some relevant keywords like an event's name as mentioned in Table 3.1, the names of artists, or scientific projects associated with the event. Then, the search results which might be articles, news, interviews, formal report, video, or photographs were reviewed roughly regarding their relevance to the case of interest. Applicable documents were collected in a computer folder with the record of their URL and reference details. Moreover, some web pages may also provide links leading to other relevant data sources. The searching of documents was halted when several found documents seemed to provide the same information. From this stage, the accumulated documents were deliberately reviewed again to examine their content and purpose. The pertinent documents provided by reliable sources or authors were kept and organised according to their topics or how they are relevant to a case. These steps could be repeated even during the data analysis until there seemed to be no other relevant data sources or the retrieved document could provide sufficient information about the case.

Besides retrieving information available in public domains, the researcher also asked some case's facilitators to provide existing documents relating to the event (if applicable). This group of documents could be archival records such as internal event reports, survey data, or evaluations.

3.6.2 Interviews

Interviews were conducted by the researcher with event facilitators or image creators who agreed to take part in the research. The interviews started by informally contacting the prospective interviewees via e-mail or telephone to ascertain whether they were interested in taking part in the research. Then, the informed consent form as shown in Appendix B was sent for reviewing and making an appointment for the interview. Subsequently, the interviews took place at a convenient time either in person, via telephone, or video call application. Most interviews were conducted in such conversational fashion and recorded by voice recorders. Nevertheless, some of them were undertaken through several exchanges

between text-based questions and answers due to the constraints of time, distance, or the quality of the Internet connection.

The interviews aimed to collect factual information and interviewees' opinions about the associated cases. They were semi-structured eliciting required information while also allowing participants to develop topics or raise issues specific to each case (Bryman, 2012). Therefore, the interviews were guided only in the following ways:

- Greeting the interviewee and giving an overview of the research project.
- Reviewing the consent form considering confidentiality, interview recording approach, and the use of data in the research. Then, asking for a formal agreement to take part in the interview.
- Starting to ask the interviewee to provide an overview of the science communication event regarding its context, purposes, and the initial stage of event planning.
- Asking the interviewee to talk about how the visual images and accompanying texts were created/selected and used in the event.
- Prompting the interviewee to share the experience and opinion about what took place in the actual event.
- Asking the interviewee if there is any recommendation for a similar future event.
- During or later in the interview, if interesting issues were raised, the interviewer would ask the interviewee to give more information about such topics.
- After the completion of the interview, ensuring the confidentiality whereby the data would be anonymised and asking whether the interviewee required to review the interview transcripts before they could be used in the research.

In addition, because the researcher is a non-native speaker and lacking experience conducting an interview, some scripts and interview questions were prepared beforehand which were used in practising interviews with native speakers. Such pilot interviews gave the researcher some experience for conducting an interview and dealing with unexpected circumstances that may arise during the interview. They also helped the researcher to be familiar with the interview guide as well as to refine it to be more efficient for eliciting the required information.

3.6.3 Field notes

In this research, field notes are contributed from visiting the venues of science communication events. The visit may happen during events or after they were over. Since the considered events took place in public spaces, the researcher could access the locations

without asking any specific permission. Fieldnotes primarily gather information in terms of the environment and context of viewing visual images featured in each event. Also, they compile the researcher's personal reflection about the events and venues. The majority of field notes were written notes, although they were also recorded in other forms such as drawings of an event's arrangement and potential viewing paths, or photographs of events and their surroundings.

3.7 Managing and preparing data for analysis

The data collected as the evidence for each case and the copy of associated visual images were recorded and sorted into the same folder in the database. To prepare the primary data for analysis, all forms of materials including visual images were transformed into primary textual information.

The audio recordings of the interviews were transcribed to dialogues by the researcher. According to Flick (2009), the decision making for transcription could depend on the research question whether it requires transcription of a whole conversation including every single word and verbatim account, for example, "ums", pause or digression. Since this research considered the details of interview information rather than how they were constructed by the conversation between participants, the transcription omitted such parts of unnecessary verbatim data but preserved the data accuracy and anonymity. The transcription of data also contain all related details, such as the details of participants who were anonymised, or the place and time the data was taken. By transcribing all interviews data alone without any helper or transcription tool/software, the researcher found that this task could be tedious and time-consuming.

Nevertheless, it could be an efficient way allowing the researcher to explore and become familiar with the interview data (Ritchie, Spencer, & O'Connor, 2003). During transcribing the interview records into a word processor software (Microsoft Word), some notes, highlighting of interesting parts of the data, or potential relationships were also made on the copy of transcription, including the record of the descriptive précis of the data, and reflection that came across into the research journal. By doing this, the researcher found that it provided a sense of physical engagement with the data that could increase the level of data familiarisation and understanding.

Meanwhile, the transformation of visual images into texts was not straightforward like literally transcribing the interview data. It requires an extent of analysis which is part of the preliminary analysis explained in the following section.

3.8 Data analysis

To answer the research questions, the data analysis for this research was guided by some analytic strategies outlined by Yin (2014). The analysis relied primarily on the researcher's

empirical thinking postulated with the presentation of evidence that could be underpinned by related theoretical concepts. The analysis process involved three main steps: preliminary analysis, explanation building, and cross-case synthesis in which the first two steps involve the translation of visual images into textual data and the analysis of multimodal discourse.

3.8.1 Preliminary analysis and explanation building

The first step of data analysis is to develop a case description by digesting the data into meaningful chunks. Information from different data sources was coded according to the framework for discourse analysis suggested by Kenney (2009). Namely, the framework not only serves as the tool for transforming visual images into textual data, but it also provides the data coding scheme. The framework as described in Table 3.3 provides the guidelines for analysing visual images and accompanying written texts with the consideration of particular historical, social and cultural contexts. Meanwhile, the interpretation of visual images that is associated with the aspect of reception context is primarily based on the principles of social semiotics or the potential meanings of adopted sign series.

The framework was developed in the field of mass media study to decode ideological positions underpinning the realisation of discourses through components depicted in a visual image and accompanying written texts. It usually relates to the social relation of power which potentially influences the worldview and behaviour of people in a particular society (Kenney, 2009). However, the analysis of this study adopts such a framework to analyse potential meanings and concepts conveyed in visual images which may not necessarily involve any social interest or ideology considered in sociological domains. It helped the researcher to demonstrate how a message could be constructed in particular contexts through visual images and accompanying written texts. The descriptive accounts of the exemplified case and interpretation may be able to answer the research question RQ1.

Moreover, as seen in Table 3.3, the aspect of construction seeks to build an explanation about how each case may be associated with a certain concept or ideology. Therefore, it may be able to answer the research question RQ2. Such results were extracted from the data observation using written memos to identify and record themes of relationships found in each case (Ritchie et al., 2003). Then, the observation made by the researcher was incorporated with pertinent theoretical concepts to explain the individual case. Because this research features various cases involving different settings, purposes and subject matters, the analysis in this stage may feature various theoretical aspects respecting to their potential communicative functions and associated ideologies or concepts. Although some theories may be more relevant to a certain case than the others, the contribution of all cases may serve as the general basis for drawing the overall research findings through the subsequent cross-case synthesis.

Table 3.3: The framework for discourse analysis of visual images and accompanying written texts (Kenney, 2009)

Aspects of analysis	Details
Content	To provide a description of visual images and accompanying written texts regarding the following aspects: • *Subject:* the individual elements depicted in visual images as well as their priority (if applicable) • *Composition:* the use of space within visual images, the position of individual elements in relation to the others and the image background • *Visual perspective:* the sense of depth and physical relation to a viewer that is engendered by a visual image • *Tonality and colour:* the brightness and any distinct tonality rendered in a visual image as well as the choice of colours • *Look and gesture:* in the case that features people or kinds of characters, this aspect explains what gesture expressed in the image and to where the subject's sight point • *Size relationship:* the size and proportion of individual elements in relation to each other within a visual image • *Written texts:* to describe the written texts accompanying a visual image and their relationships to the visual representation as well as the expression of typography
Size and space	To provide descriptive information about the physical size of a visual image and the space it occupies
Production context	To analyse why, for whom, and for what purpose a visual image and its accompanying written texts were produced
Distribution context	To analyse in which medium or approach a visual image and its accompanying written texts reached their audiences
Reception context	To analyse the environment in which a visual image and its accompanying written texts were received and understood by an audience, what potential impact they could have on an audience, and how they were likely to be interpreted in such particular context.
Construction	To explain how messages or social realities were constructed by a visual image and its accompanying written texts

3.8.2 Cross-case synthesis

The cases investigated in this research are specific in their contexts and not comparable with each other in terms of subject matter. Nevertheless, one common boundary as mentioned in the case selection is that they are featured in a science communication event taking place in a generic venue and likely to be encountered unexpectedly. Therefore, it may be worth

considering the difference and similarity among the multiple cases through the cross-case synthesis. This final step of analysis may not only increase the robustness of the previous single case analysis but also provide the general implications of the research findings (Yin, 2014).

The process of cross-case synthesis started from creating a matrix to display the findings drawn from different cases according to the uniform aspects considered in the research questions RQ3 and RQ4. As a result, it primarily considers various characteristics of visual images that may be significant for getting and maintaining attention in those exemplified cases. It also explores the enablers of the event's potential learning outcomes either in terms of visual images, accompanying written texts or verbal conversation. By doing that, it may illustrate some pertinent characteristics of visual images used in this type of unexpected public events from the converged similarities. Meanwhile, it may also demonstrate the differences between the cases that underpin some specific features associated with particular science communication contexts and objectives.

3.9 Validity and reliability

The quality of research can be considered from two primary criteria comprising reliability and validity. However, the concept of such terms for qualitative research might be different from the assessment for quantitative research but involves the rigorous research conduct (Bryman, 2012; Kenney, 2009; Yin, 2014). Regarding the case study, reliability and validity can be established throughout the research processes, and this study ensures such requirements with several strategies described as follows:

Triangulation

The study relies on multiple sources of evidence as explained in section 3.5 to construct validity (Bryman, 2012; Yin, 2014). In the data collection process, it gathered information from different sources either primary and secondary ones that addressed the same focused issues. The data triangulation not only allowed the researcher to investigate each case from a broader range of perspectives but also demonstrated the convergence of different data sources. This could affirm the accuracy of evidence, research findings and subsequent conclusions. In addition, the validity of the research findings can be endorsed by cross-checking the accounts observed by the researcher with existing theoretical perspectives.

Transparency of research procedures

The research provides a clear definition of relevant terms and systematic processes and strategies for selecting cases, gathering and managing data, and analysing the data. The analyses of visual images are conducted consistently across the exemplified cases with the same discourse analysis framework. The clear and systematic analysis suggested in this study may endorse the robustness of the case explanation, and allow a reader to make a

plausible transferability to adopt the discourse analysis framework to examine visual images appropriated in other different contexts (Bryman, 2012; Kenney, 2009).

Chapter 4
Visual images of scientists

This chapter provides the descriptive explanation of two exemplified cases aimed at attitude toward science. Cases 4.1: 'Let The World Keep Turning' and 4.2: 'Enjoy Science Careers' were casually encountered exhibitions arranged in the UK and Thailand, respectively. They consist of a number of retractable banners featuring the representation of scientists in combination with written texts and verbal conversation with event's facilitators. The analysis is based on the discourse analysis framework as explained in Chapter 3 (Kenney, 2009) which may generally contribute to the answer of RQ1: How is the message constructed by a visual image and accompanying information in a science communication context? and RQ2: How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)? It also contributes to the answer of RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements corresponding to the fulfilment of Generic Learning Outcomes (GLOs)? Namely, it suggests the attributes that play a significant role at achieving learning outcomes, especially in the aspect of developing positive attitude and value toward science.

4.1 The visual images used in the exhibition 'Let The World Keep Turning'

This section examines the exhibition "Let The World Keep Turning": a pop-up exhibition featuring the portraits of four representative scientists who collaborate on a multidisciplinary healthcare-related scientific project named 'Proteus'. The project is funded by the Engineering and Physical Sciences Research Council (EPSRC) and based at the University of Edinburgh (Proteus, n.d.). The portraits were taken by Ron O'Donnell, a contemporary art photographer, and printed with accompanying written texts on individual retractable banners. The exhibition was organised by Proteus' science communicator in line with its responsibility to engage with public audiences. The exhibition was part of the Gather festival which annually celebrates multiculturalism at the University of Edinburgh (Gather, n.d.). During the festival in 2014, the exhibition was displayed at several places in Edinburgh, UK including the Royal Infirmary of Edinburgh, the Cameron Toll Shopping Centre, and the Informatics Forum at the University of Edinburgh. Although the exhibition was also shown abroad at a university in China, its distribution context considered in this section mainly focuses on those venues within the UK. The digital version of the portraits and the event's information can be accessed through the Proteus's archive (Proteus, 2014).

4.1.1 Content

Subjects

There are four visual images in the exhibit in which individual scientists are displayed together with some aspects of their cultural identities. These include native language,

associated scientific disciplines and attitudes. The copies of these visual images are shown in Figs. 4.1(a-d) (Proteus, 2014), and the variation of the image content is displayed in Table 4.1. Each photograph consists of a scientist; face and upper body, wearing a long-sleeve white T-shirt and holding, with both hands, a piece of A3 white paper close to and in front of his/her body. The paper displays 2-4 lines of black hand-written texts in the scientist's native language. Behind the scientist, there is the cropped area of a blackboard displaying hand-written/hand-drawing scientific content comprising terms, abbreviations, formulae, diagrams, or charts which are written/drawn with white chalk. At the bottom of the image, there is also a black rectangular shape displaying 1-2 lines of white hand-written texts in English which is the translation of the texts written on the above white paper.

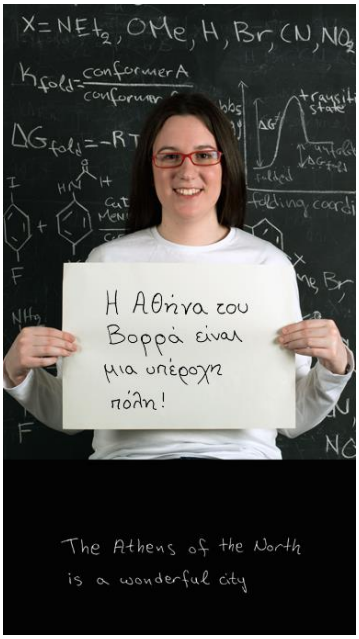


Fig. 4.1(a): The photograph of a chemist featured in the exhibition 'Let The World Keep Turning' (O'Donnell 2014)

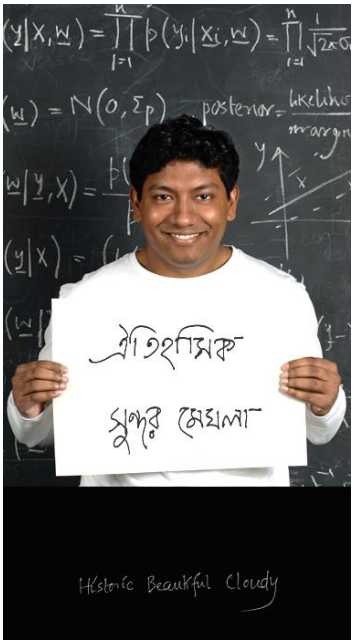


Fig. 4.1(b): The photograph of a machine learner featured in the exhibition 'Let The World Keep Turning' (O'Donnell 2014)

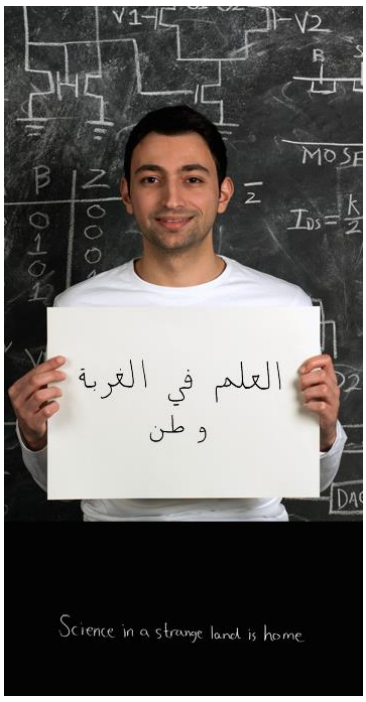


Fig. 4.1(c): The photograph of an engineer featured in the exhibition ‘Let The World Keep Turning’ (O’Donnell 2014)

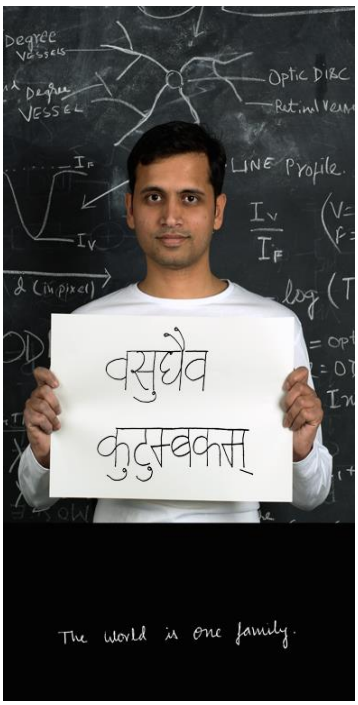


Fig. 4.1(d): The photograph of a biologist featured in the exhibition ‘Let The World Keep Turning’ (O’Donnell 2014)

Table 4.1: The content inventory of photographs featured in the exhibit ‘Let The World Keep Turning’

Fig.	Nationality	Language	Gender	Discipline	Translation of attitudes
4.1(a)	Greek	Greek	Female	Chemistry	‘The Athens of the North is a wonderful city'
4.1(b)	Indian	Bengali	Male	Computer science	‘Historic Beautiful Cloudy’
4.1(c)	Syrian	Arabic	Male	Electronic Engineering	‘Science in a strange land is home’
4.1(d)	Indian	Sanskrit	Male	Biology	‘The world is one family’

Composition

Each visual image can be considered as the combination of two distinct parts: the upper part displaying a photograph of a scientist and the lower part containing the translation which respectively covers around the 2/3 and 1/3 of the vertical line. The photograph section portrays a scientist holding a white piece of paper at the centre of the horizontal line in front of the blackboard background. Meanwhile, the lower part is a black space displaying written texts in English around the centre of the horizontal line. The considerable contrast of colour and brightness between the two areas of the visual image may emphasise their distinction or separation. Although it may be inconclusive, it is arguable that such bottom area may not be

part of or captured at the same time with the photograph of a scientist featured at the upper area but the two parts are probably combined together in the editing process to create the final visual image.

Visual perspective

The visual image shows that each photograph was taken by a camera set directly in front of and at a 'social distance' from a scientist (Kress & Leeuwen, 2006). The camera's position and frontal angle allow it to capture the scientist's face and other elements within the scene clearly. The spatial depth of the photograph can be perceived from the different proximities of elements from the camera which may serve as a viewer's eyes. Those elements from the one closest to the surface are the written texts on the white paper, the scientist in the middle, and the scientific language as the background. However, the spatial depths between elements are close to each other which may suggest their equal significance for interpretation. Due to the vertical shape and composition of the visual image, audiences are likely to fix their eyes at the centre along the vertical line and the scientist especially the face, not only because the human face can present a psychological salience but also because it is placed at the eye level and closer to the surface compared to the background and the bottom part of the visual image (Kress & Leeuwen, 2006; Lester, 2010).

Tonality and colour

The main colours of the visual images are black, white and scientists' natural skin tones. A moderate light intensity illuminates all subjects evenly. There is only an insignificant small shadow between the white paper and the scientist. However, the composition that arranges the darker (black) area around the brighter (white) area at the middle of the image probably make the central area, where a scientist is holding a piece of paper, seem closer to a viewer (Freeland, 2007).

Look and gesture

The scientists portrayed in the visual images were smiling and looking directly into the camera as if they were friendly and looking back at an audience who was also looking at them. With both hands, each scientist was holding a piece of paper containing texts in front of their body as if it was a message he/she intended to communicate or offered to the audience.

Size relationships

Subjects within the photographs seem to be represented in their actual proportions when the A3 paper is large enough to cover the width of a scientist's body, and the cropped area displaying a scientific language at the background shows that the backboard is larger than the scientist. Although its actual size is indeterminable, it is arguably insignificant in this context and does not affect the visual image interpretation.

Accompanying written texts

The written texts contained within the visual images can be separated into three parts as displayed in Table 4.1; the scientific texts at the background displaying scientific facts that possibly suggest different scientific disciplines, the written texts (native languages) on the white paper representing the scientist's attitudes toward Edinburgh as the city in which they are doing the collaborative scientific project, and the written texts at the bottom display the translations of those feelings in English.

Besides the portraits, the exhibition displays an accompanying poster giving information about the collaborative production of the exhibition. It consists of the title Proteus Collaborates with Scotland's Finest Art Photographer- Ron O'Donnell', and the logos of the scientific project and relevant institutions. There are also some subtopics giving information about the photographer; the concept of depicting the scientific content at the background, which is mentioned in the poster as 'scientific language', as one form representing the identities of scientists; the stages and atmosphere of the production process with some small 'behind the scenes' photographs. At the bottom left of the poster, there is an acknowledgement written by the science communicator who developed and facilitated the exhibition.

There is also a leaflet in a postcard size giving the name of the exhibition 'Let The World Keep Turning', and 'A Ron O'Donnell Exhibition' written in italic texts. Below that title, the leaflet gives some brief information about the scientific project, the photographer, and the exhibition with some keywords emphasised in a larger font size (displayed in the boldface in the following description). Such aspects are respectively written as '**Proteus** is a group of **Scientists** who want to **improve** care for **lung disease** patients', '**Ron O'Donnell** is a highly **talented** and **respected** contemporary art **photographer**', and 'Scientists express their **cultural** identity, the blending of the **personal** and the **scientific**'. The leaflet also provides the URLs for the photographer's personal website and the scientific project's website placed beside its logo representing the lungs.

4.1.2 Size and space

The exhibition contains four visual images printed on four individual retractable banners and a poster in size 60 cm (width) x 90 cm (height). The size of each banner is 85 cm (width) x 200 cm (height). The exhibition was displayed in 3 venues; a corridor in the hospital, a foyer area in a university's building, and the space between a grocery shop and the hallway of a shopping centre. At those places, the exhibition created different noticeable spaces depending on the variable arrangements of the banners which can be shown approximately in Figs. 4.2-4.4.

With regard to Fig. 4.2, the visual images were arranged at the same level from one side and directly facing the opposite side of the corridor. Two pairs of visual images were placed

beside each side of a gate for accessing other parts of the building. In Fig. 4.3, the visual images were displayed approximately along a half-circle line and occupied about half of the foyer's space. They also created a space in one corner of the hallway in the shopping centre as shown in Fig. 4.4.

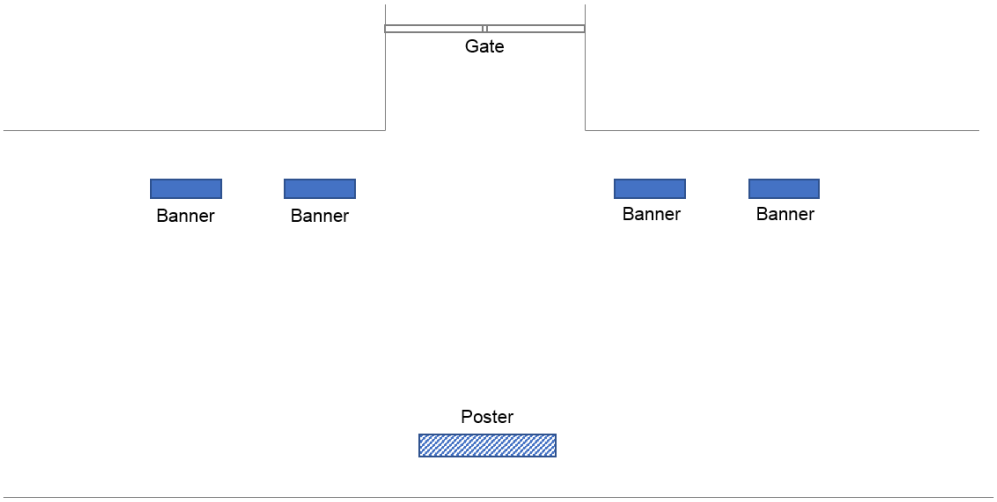


Fig. 4.2: The arrangement of 'Let The World Keep Turning' exhibition at the corridor in the hospital

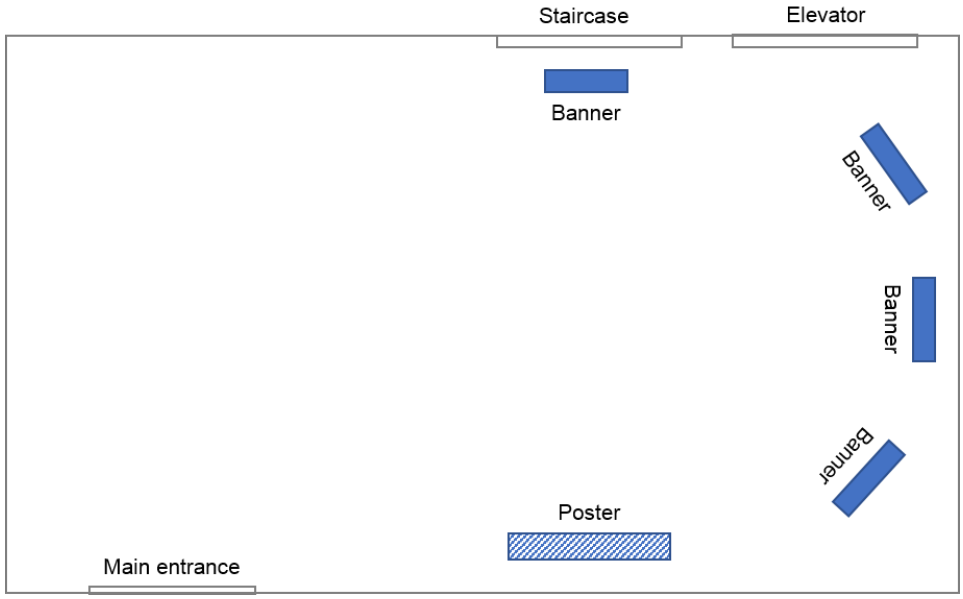


Fig. 4.3: The arrangement of 'Let The World Keep Turning' exhibition in the foyer of a university building

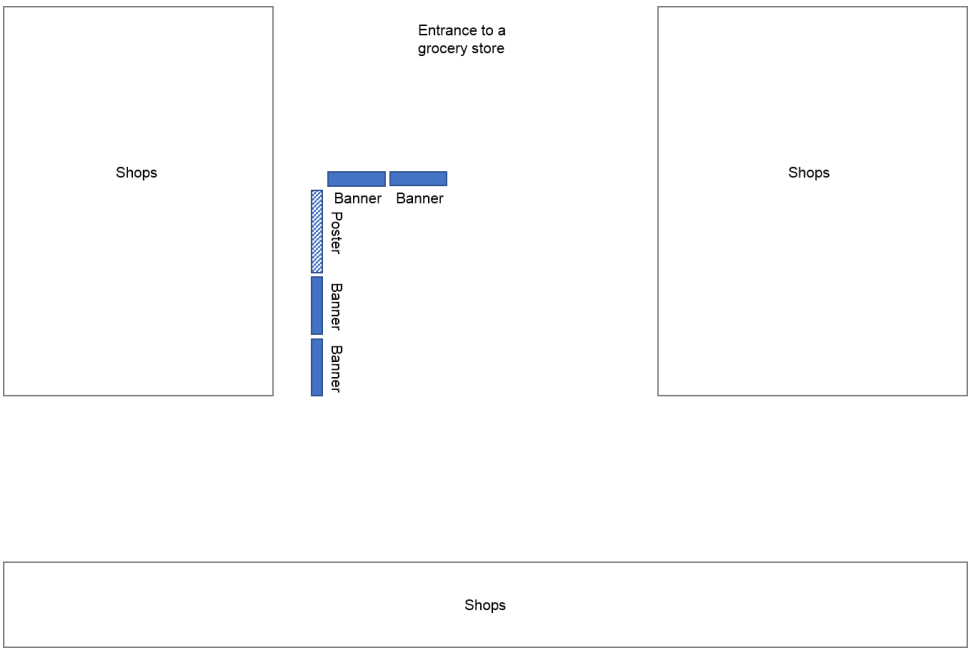


Fig. 4.4: The arrangement of ‘Let The World Keep Turning’ exhibition in the hallway in a shopping centre

4.1.3 Context

Production context

The photographs were created to contribute an exhibition taking part in the Gather festival 2015. It is an annual festival that celebrates diverse communities and cultures at the University of Edinburgh to which the scientific research community also belongs. According to MacQueen et al. (2001), a community is defined as ‘*a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings*’. Such a definition provides a community’s characteristics which are also applicable to Proteus: an ongoing scientific project when the festival took place. Because it is an interdisciplinary research project, it has gathered a group of international scientists who have different scientific backgrounds to collaborate together with a common aim that is to deliver a bedside medical instrument technology to diagnose and manage lung disease. Proteus is working under the management structure complying with expectations stated by the EPSRC (The Engineering and Physical Sciences Research Council) who fund the research. For scientists featured in this exhibition, they are based in the same institution (The University of Edinburgh) as well as the same geographical location that is in Edinburgh city (EPSRC, n.d.; Proteus, n.d.). Moreover, science itself can be considered as a culture having a shared system of knowledge and conventions whereby its specific branches with their own particular paradigms are regarded as scientific subcultures (Aikenhead, 2001). Therefore, the collaboration within this scientific project is undeniable a cross-cultural event between not only scientific subcultures but also cultures to which

scientists as individuals belong. As such, cross-disciplinary skills are arguably required to overcome translational agenda and mindset barriers (Proteus, n.d.).

One value held by Proteus is the responsibility to engage with public audiences and, according to the interview data, the science communicator employed by Proteus attempted to endorse the festival theme by aiming to introduce the existing diversity within the research project through the representation of scientists. Although there might be other inherent characteristics regarding cultures/subcultures which belong to the scientists featured, the exhibition depicts only some of these attributes i.e. their scientific disciplines, attitudes, and cultural identities. The scientific disciplines are represented by scientific content as part of discourses for explaining their science (Aikenhead, 2001), whilst their attitudes may reflect their personalities because it can serve as a way for self-expression asserting an individual identity (Katz, 1960). Besides, cultural identities are depicted by gender, race referring to physical characteristics, and ethnicity represented through native languages (Harris & Rampton, 2003).

The exhibition was created through the collaboration between a science communicator, scientists and a professional photographer who is an expert in contemporary art photography. He is renowned for his aesthetic style usually producing constructed and narrative photographs (Ronodonnell, n.d.). Similarly, in this exhibition, the photographer designed the concept and construction of the photographs to portray the diversity of scientists. There are also accompanying texts giving information about the exhibition on a separate poster and a leaflet written by the science communicator who collaborated throughout the production process. The photographs were taken with a professional digital camera in a professional photography studio equipped with standard lighting tools and facilities and then processed and enhanced through photo editing software.

Distribution context

The photographs were printed and displayed in the form of portable banner stands of which together formed a small exhibition. During the festival time, the exhibition was held temporarily at two public venues including a hospital, and a shopping centre together with a foyer in a busy university department where people were likely to come across the exhibition unexpectedly. It should be noted that at the University of Edinburgh, there is considerable sharing of spaces and so the foyer chosen was likely to have visitors from many different departments in the course of the day. Each place has different space characteristics and institutional contexts which can be explained as follows.

Regarding the hospital, the exhibition was held along the corridor on the ground floor connecting the west and the east entrances. People who passed such a path could be hospital staff members, patients or their guardians, or general public members who might visit there for other personal reasons. Though the corridor was a high traffic area, the

passers-by were intentionally going to specific places and less likely to stop and spend some time at the exhibition. Due to the narrow passage, the visual image stands were placed in a single line facing the opposite side of the corridor as shown in Fig. 4.2. It can be seen that passers-by would need to slightly turn their eyes to their right/left side in order to look at the photographs. The passers-by probably were not able to see the front of the visual images from afar and less likely to make a visit plan with respect to the depicted content (Guler, 2015). Moreover, the viewing area that overlapped with the circulation part might also make people reluctant to stop and contemplate on those visual images due to the concern of a potential blockage.

In terms of the university building, the exhibition was held in the foyer of the informatics and computer science institutions building. It was the space between the main door of the building and the staircase and elevator for accessing the other floors. Hence, the passers-by were mostly academics, researchers especially those who are relevant to science and technology, and some university students or public members who were invited by the event's facilitator from outside the building. The foyer was large enough to arrange the exhibition stands in a half-circle line which covered almost half of the whole area as shown in Fig. 4.3. At this venue, the congestion was less likely to happen, and the passers-by could be either those coming from the main door and approaching the staircase or the elevator or vice versa. They could partially see the exhibition, and from a distance, had a chance to plan whether or not to visit the exhibition (Guler, 2015). Due to the arrangement of the exhibition, visitors could probably see all banners by standing in the middle area and turning around although they might need to approach a reading distance in order to be able to read the written texts (Cotterell, 1992; Guler, 2015).

The exhibition was also held in a shopping centre's space which connected between the entrance of a large supermarket and the main hallway which also consists of two sides of retail shops as well as kiosks and benches in the middle as shown in Fig. 4.4. The shopping centre consists of various shops and cafes and is likely to attract a wide range of visitors. The shopping centre visitors may have different reasons to visit the place such as for browsing or buying products, receiving services such as eye tests and hearing tests, banking, or booking holidays or for leisure (Cameron Toll shopping centre, n.d.; De Juan, 2004). From Fig. 4.4, the passers-by who could see the exhibition partly from afar and make a plan whether to visit it were likely those coming from the right side of the figure who may either intend to go straight along the hallway or turn to the grocery store. Meanwhile, people who were coming from the other directions would merely see the rear side of the exhibition. The space displaying the exhibition was large enough to provide a viewing space where a few viewers could stand or circulate along with the visual images at the same time that would not cause congestion or a blockage in the hallway. However, the shopping centre visitors may be familiar with commercial events or booths that were regularly held there. As a result,

the exhibition might be perceived as one of those commercial booths or events which might be off-putting to some people.

Although the exhibition can be stand-alone, it was facilitated by science communicators who tried to get people's attention by initiating a conversation and inviting them to stop and look at the visual images. Through having a conversation with facilitators, viewers could gain further information about the scientific project, the exhibition, the photographer, or individual scientists, as well as negotiate their understanding about the message conveyed in visual images. This may also have increased the visit time spent at the exhibition giving more opportunities for them to look through and contemplate on the exhibition. Otherwise, they could briefly pass through it within 5 seconds due to the exhibition size (Guler, 2015; Lester, 2010). However, having facilitators at the site could also be off-putting to some people and may hinder them from visiting the exhibition especially when the exhibition was being displayed in the environment which passers-by perceive as a commercial space like in the shopping centre where people may have uncomfortably experienced a 'hard sell' from salespersons (Cotterell, 1992).

It can be seen from these venues that by coming across the exhibition unintentionally, passers-by tended to make a visit when they found it was convenient to them. Hence, not only the presence of facilitators may affect their decision but the available viewing space, time and energy they were willing to spend at the exhibition also played a role (Guler, 2015). When the venue is a passage, it should be large enough to provide a proper viewing space and not be too narrow that likely to cause a blockage such as a corridor in the hospital where people might hesitate to stop and look at the visual images.

Reception context

The visual images displayed in the exhibition are created in the form of portraiture; a recognised genre of art since the 17th century that represents individuals in visual images (Schneider, 2002). Hence, it is presumable that the viewers of this case in the 21st century are familiar with this kind of depiction. Because the subjects were depicted by a digital camera instead of traditional painting, the visual images may comply with a more specific genre namely portrait photography. Such genre is regarded to be realistic and transparent which faithfully renders the representation of the subjects. However, it is arguable that the capturing of a portrait photograph is inevitably influenced by the aesthetic expression of the photographer such as through the settings of lighting, camera angle, composition, props, and pose (Freeland, 2007). In this exhibition, by merely considering the visual images, a viewer might be able to see that they depict each subject in the same settings and composition presumably directed by the photographer. This understanding of visual images can also be affirmed by reading the accompanying poster. In addition, by presenting the individuals in the

same pattern, it may encourage a viewer to observe the differences in addition to the similarities between them (Lester, 2010).

In regard to each individual portrait of the exhibition, it represents each person in a conventional way which essentially projects a particular view of identities through the subject's face and other accompanying elements such as gazing, attire, or surrounding environments (Kapsidou, 2012). Such visual image elements can meaningfully signify either a person's external social identities like origin, gender and age, or inner emotion and personality (Baleva & Cooper, 2014; Freeland, 2007; Stokoe, 2008; Zackodnik, 2005). According to Freeland (2007), the reception of a portrait may be relevant to its four ways to reveal a depicted subject which do not necessarily coexist at the same time including showing accurate likeness, testifying the presence, implying personality, and presenting the uniqueness of the subject.

Regarding the representation of likeness, with the visual perspective and the composition of visual images, they may resemble some forms of photo identification such as 'mugshots' or passport photos in which depict the individual's outward appearance from the top of the head down to a certain extent of the upper body (Bock, Istek, Pain, & Araiza, 2016; GOV.UK, 2017). The accuracy of the representation could be underpinned not only by being realistic portrait photography, but the individuals were also depicted with a frontal camera angle and an appropriate light intensity presenting the distinguishable faces and bodies clearly. By looking at such visual elements, viewers could perceive that the persons featured in the exhibition were young adults including three males and one female. Although they might not be able to identify precisely each person's ethnicity, they may be able to generally distinguish the ethnic diversity among the depicted subjects such as by observing different physical characteristics or skin tones. By being presented within the context of the Gather festival, the different skin tones contrasting with the identical black and white found in every banner may also metaphorically reflect the multicultural institution in which the multiple identities or cultures can be unified by the common culture of the scientific research group.

The depiction of the individuals' likenesses could also provide proof of their presence (Freeland, 2007). In the actual sense, audiences could presume that the four individuals were living persons who were there in front of the camera when the photographs were taken, and all of them were aware of the camera by looking directly into the lens (Stallabrass, 2007). The similar ways of intentionally gazing and posing along with the identical settings and composition may also allow an audience to relate the subjects together as a single unit or a group who mutually participated in the same project of visual image production (Gecker & Doksone, 2014; Lester, 2010; Trendsettersproject, 2014). Moreover, the banner size presenting the individuals relatively in their actual sizes and the gaze looking back at the viewers approximately at the eye level may reinforce the visual awareness of the

portraitures. In other words, viewers may perceptually experience the presence of the subjects as if they were actually there at the exhibition interacting with them (Freeland, 2007; Gombrich, 2002; West, 2004; Wollheim, 1973).

In terms of psychological characterisation, the portraitures may render the subjects' personalities, emotions or attitudes depending on the intention and ability of the photographer to convey such characteristics as well as the ability of the subjects to express themselves (Freeland, 2007). In this exhibition, the personalities of the subjects were purposefully expressed through facial expression and other visual cues; the piece of paper on which displayed attitudes with their translation in English in the form of written texts.

Regarding facial expression, adults can categorise faces and tend to be able to interpret facial expressions accurately (Bruce, Green, & Georgeson, 2003). This ability is not exclusive to the perception of familiar faces, but also applicable for perceiving or reacting to an unfamiliar face. Therefore, a viewer could arguably perceive the emotions of the subjects. In this exhibition, despite the fact that there might be some variation in terms of the explicitness of facial expression among the subjects, all faces could generally suggest happiness which was marked by a smiling mouth argued as the distinctive signifier of happiness, as well as the eyes namely the narrowing eyes which congruently affirm the genuineness of such happiness expression (Calvo, Fernández-Martín, & Nummenmaa, 2014; Maher, Ekstrom, & Chen, 2014). A viewer who could recognise such general features as the expression of happiness could also presume that the depicted subjects were likely to be happy at the time of depiction (Adolphs, 2002; Leppänen & Hietanen, 2007).

Moreover, the subjects were also holding a piece of paper with written texts which may make visual images look similar to Gillian Wearing's photographs in the project title 'Signs that say what you want to say and not signs that say what someone else wants to say' (1992-1993) featuring each subject holding a piece of paper that has a subject's attitude written on it which were acknowledged as photographs displaying the honest self-representation of the subject (Bohnacker, 2013; McElvain, 2008; Montagu, 2001). However, even though audiences might not be familiar with Gillian Wearing's project or understand the written native languages unless they read the accompanying English interpretations, they probably presumed from the familiar gesture pushing the message forward that the depicted subjects were trying to communicate their thoughts.

According to the translations of attitudes written in English: 'The Athens of the North is a wonderful city', 'Historic Beautiful Cloudy', 'Science in a strange land is home', and 'The world is one family', it can be seen that there are words denoting positive attitudes such as 'wonderful' and 'beautiful' and words associated with positive connotations such as 'home' and 'family' (Literary Devices, n.d.; Random House, 1997). Although some words probably suggest negativity like 'strange' or 'cloudy', they are arguably used in the context that

contrasted and accentuated the accompanying ideas of positivity. Each statement might be expanded into various perspectives of meanings. However, some potential perceptions in relation to Edinburgh as the city to which the attitudes of the subjects pointed can be provided as follows.

For ‘The Athens of the North…’, it might be recognised by some viewers as one title of Edinburgh which expresses the sense of its growth and achievement reflecting the classical architecture of the city that is inspired by ancient Greek styles (Edinburgh World Heritage, n.d.). It is argued that such a title has become widespread and recognisable to people since the 19th century. Therefore, the speaker of such a statement may comparatively express that Edinburgh is wonderful. In addition, if a viewer could recognise the Greek language she wrote or gain information from talking with a facilitator that she is Greek, the viewer may also relate Edinburgh and Athens as the capital cities and their significance to the speaker. Regarding ‘Historic Beautiful Cloudy’, these adjectives were selected by the speaker to describe the character of the city which could also resonate with viewers especially those who live in Edinburgh.

Meanwhile, ‘Science in a strange land is home’ may present the contrast between unfamiliarity and familiarity respectively in terms of “strange land” and “home”. It cannot explicitly affirm the scientist’s intention of using the adjective “strange” whether he may literally suggest that Edinburgh as a city is strange in any aspect or personally unfamiliar to him. Nevertheless, the main statement associates ‘science’ as the main subject with the word ‘home’ as if science is home. This may metaphorically carry an idealised emotional characteristic of science as that of a home such as being warmth, comfort, and a place of affection (Literary Devices, n.d.; Random House, 1997).

For ‘the world is one family, it is arguable that the speaker may generally regard Edinburgh in a broad sense as the world. At the same time, the speaker juxtaposed such a large unit with the micro-unit of society as one family as if they were the same unit. The ‘family’ may raise ideas beyond biological relationships. Instead, it may be perceived in a sociological sense as an emerging system functioning as a family with the main purpose to nurture every belonged member under particular empathetic rules and boundaries (Gerlach, 2015). Hence, ‘The world is one family’ may suggest the ultimate relationships between diverse families gathered together as one whole family.

In the aspect of presenting the uniqueness of individuals, the representation of a person’s essence, namely soul or intractable element of identity in a portrait, might be implicit and ambiguous when perceived by a viewer who does not personally know the subject (Freeland, 2007). However, the visual images in this exhibition link such uniqueness by using consistent props including the written text on paper and the written chalkboard background. As mentioned, the texts on the paper were written in the subjects’ native

languages which may not be familiar to the majority of the viewers. However, the viewers may be able to perceive the diversity of the native languages somehow reflecting the subjects who wrote them as well as their unique cultural backgrounds. The chalkboard backgrounds featuring scientific contents may serve as an emblem suggesting the distinct scientific environment and activity relating to each subject. Therefore, despite insufficient knowledge to define precisely the presented scientific disciplines, an audience might be able to generally presume that those subjects are scientists who are likely to have different scientific backgrounds (Christidou & Kouvatas, 2011).

Another noticeable feature of the visual images is that their colours are mainly black and white. Since they are colour photographs, such theme colours were intentionally selected by the photographer to produce certain viewing effects. The black and white not only contribute the visual depth and bring the brighter area closer to viewers reinforcing the perception of presence (Freeland, 2007), but they might also convey psychological meanings (Lester, 2010). Although the perception toward black and white colours either when they are used separately or together might be diverse among different contexts and cultures Triedman, 2015; Jess, 2008), for this exhibition, it might be worth considering the aspects of social representation. By using black and white elements together in the portraits and placing the subjects who have noticeably different skin tones from each other between such two contrasting colours, the portraits not only visually emphasise the individual's identities regarding their appearances but may also be further metaphorically perceived as the convergence or togetherness of such division (Triedman, 2015).

4.1.4 Construction

It is arguable that the exhibition utilises some familiar styles of visual images to create certain effects. The contrasting black and white colours together with the organised composition may resemble 'mugshots' originally used to record criminals' identities (Bock et al., 2016; Kozol, 1994). Some websites or tabloid newspapers publish mugshots of people who do not necessarily commit a crime but instead, the publication may use this format mainly for entertainment purposes. By potentially resembling a mugshot that people usually see in news media or TV crime series, the visual images could be a recognisable hook for getting attention as well as stimulating certain perceptions associated with those familiar scenarios. They may evoke intense feelings ranging from fear to compassion or construct the idea of humiliation, discrimination, or dehumanisation as if the person captured in a mugshot is "the other", "the lessor" or "subhuman" (Greenstein, 2013; Lashmar, 2014; Sando, 2014).

Moreover, by having people expressing their thoughts through the texts written on paper may also comply with some forms of political protests or social movements generally relating to a contentious issue (Bissett, 2016; Forster, 2017; Hargreaves, 2017). These factors may

be deployed to stimulate an emotional response probably increasing a chance of audience participation with the science communication event such as in terms of critical viewing or further discussion about the visual image interpretation (Bowater & Yeoman, 2012; Lester, 2010).

Occasionally, such seemingly provocative visual image may lead to misperceptions and misconceptions especially in those who just pass the exhibition by without deliberately considering its actual details. However, the potential misunderstanding might be overridden by other dominant elements that construct the ideas of positivity. One striking visual element is the observable smiling faces of the subjects that may brighten the emotion of the visual images and generally introduce the concept of happiness as explained in the previous subsection. Such positivity could also be endorsed by the translations in English of the attitudes as well as the verbal information provided by the facilitators. In addition, the accompanying written texts praising the photographer on the exhibition's leaflet and the poster may suggest that the visual images were created by an artist and contain artistic values for appreciation (Elkins, 1999). These elements may be sufficient for a viewer to frame an appropriate context for interpreting the visual images. With regards to the overall message of the exhibition, it is discursively constructed through the presentation of cooperating concepts explained as follows.

The perceptual image of scientists portrayed in this exhibition may be different from their stereotypical image. There are some long-lasting stereotypical features of a scientist such as being a man, wearing safety glasses, wearing a lab coat, or being surrounded by laboratory equipment (Emvalotis & Koutsianou, 2018; Mead & Métraux, 1957; Meyer, Guenther, & Joubert, 2018; Türkmen, 2015). In relation to such a description, it can be seen that the subjects/scientists representing the group of researchers are instead young adults wearing a casual T-shirt and without any laboratory equipment. The visual images also feature scientists with the variation in terms of gender (although in imbalance number between three males and one female), race, ethnicity, and scientific discipline. This not only nullifies the stereotypical image of scientists but also represents the scientific community as an inclusive, non-homogeneous social group (Mead & Métraux, 1957; Weitekamp, 2017).

Besides, the representation of the scientist is shifted from the outward appearance of the individual to the forms of scientific knowledge represented on the chalkboard behind each scientist which can prove their authenticity and expertise in scientific subjects (Christidou & Kouvatas, 2011; Weitekamp, 2017). Moreover, the images of scientists smiling directly at audiences with a posture expressing a written message may counteract a stereotypical image presented in popular media as a nerdy scientist who is physically or socially awkward, socially isolated or absent-minded (Kendall, 1999; Weitekamp, 2017). The faces expressing positive emotions may also propose an alternative viewpoint that scientists, together with

their science, could be enjoyable and attractive instead of always being dull and impersonal (Losh, 2009; Steinke, Lapinski, & Crocker, 2007). Therefore, the visual representation of scientists diverts from the distant or even threatening stereotypical image and instead is more sociable. This is also endorsed by the description of scientists provided in the leaflet and may make them perceptually accessible to public audiences.

In the exhibition, the scientists are depicted as the representatives of the research group which may also construct particular concepts of the scientific research project as well as science in general. Due to being part of a festival focusing on cultural aspects and informally displayed in generic venues where audiences regular visit in their daily life, the exhibition may promote science as a cultural entity relevant to society. This idea is also contributed to by the accompanying written texts. The title 'Let the world keep turning' placed near the description of the scientific research endorses the benefits the project may bring to the public and can postulate that science plays a cultural role in sustaining the dynamic mechanism of society and the world. In addition, by giving information of the image production as the collaboration between a group of scientists and an artist may exemplify that science is not an isolated and inaccessible entity, but it could associate with other cultural entities such as art.

The contribution of the four visual images involving scientists who, in most aspects, belong to diverse cultural groups can illustrate the concept of diversity even without any explicit identification detail of each individual. Diversity is argued to be desirable and appreciated by business and academic institutes (Marvasti & McKinney, 2011). The visual images demonstrate that the depicted group of scientists are also embracing the diversity within their group. Although there might be some forms of communication barriers between either different cultural backgrounds (relating to values and beliefs), native languages or ways of explaining each scientific subject (Pincus, 2011), the visual images featuring English translations, and the identical posture and composition may articulate the concept of unity or oneness as well as systematic organisation. Whereby such assets are regarded as a practical way to overcome potential conflicts that may arise in situations involving the diversity of people (Bell & Hartmann, 2007; Marvasti & McKinney, 2011).

Furthermore, the unity of visual images can clarify the meaning of the exhibition title that is to keep the world turning together rather than turning apart in conflicts. Similarly, this is applicable to the theme of the Gather festival to celebrate multiculturalism. The selected verb 'let' at the beginning of the title, and the visual images of friendly scientists may also create a request or an invitation for the audiences to approve or join such mutual relationships that are desirable for sustainable world movement. The exhibition shows that not only the scientists but also the artist and the science communicators/facilitators have already participated in such collaborative effort. It is arguable that besides depicting positive aspects of scientists and science, the declaration of the image production as a collaborative project

through the accompanying written texts may also create an impact in terms of the group influence to encourage audiences to agree or conform with the proposed viewpoint (Moscovici & Zavalloni, 1969). Whereby, the desirable response might be to support or have a positive attitude toward science especially collaborative scientific research.

4.2 The visual images used in the exhibition 'Enjoy Science Careers'

The 'Enjoy Science Careers' exhibition features ten exhibits with respect to the different introduced STEM careers. It was aimed at raising the awareness of the featured science careers argued to be under-acknowledged in Thailand, as well as to inspire the target audiences who are young people or high school students to pursue STEM-related careers. It was created by an operative design team through the collaboration with the National Science Museum (NSM) in partnership with a private company and a non-profit organisation based in Thailand. The actual exhibition was displayed over a weekend in 2016 at Siam Square One: a shopping mall in Bangkok, Thailand. All featured exhibits/careers were designed in the same pattern of content and style each of which consists of two printed panels conveying visual images and accompanying written texts relevant to each STEM career and its representative professional, behind a table for a hands-on activity. The following analysis considers only one exemplified exhibit which depicts a biomedical engineer.

4.2.1 Content

Subjects

The two visual images created for the exhibit are shown in Figs. 4.5(a-b). At the upper-right corner of all panels, there are the logos of the NSM (National Science Museum) who arranges the exhibition, and the private company who sponsors the exhibition. Meanwhile, the subjects depicted in each panel can be described as follows.

Fig. 4.5(a): The panel has a solid dark red background, and its main subject is the man who is dressed in a black suit with an unbuttoned shirt (at the collar) and blazer, black leather shoes and spectacles. On the left side of the panel, there are three icons each of which, from left to right, respectively represents, in a circle, a stand holding a flask over a lab burner; a structure of DNA, and a microscope. Moreover, the logo of the exhibition is depicted around the bottom area overlapping some abstract opaque wavy lines and circles in different sizes. Within the event's logo, there are representations of various objects surrounding the name of the exhibition in the middle. Such objects include a burette depicted beside a glass graduated cylinder; a round bottom flask; three test tubes randomly rested on a rack; a structure of DNA, the chemical formula of coronene ($C_{24}H_{12}$) (PubChem, n.d.); and a simple cell structure.

Fig. 4.5(a): The panel featured in the exhibition 'Enjoy Science Careers' depicting the representative of biomedical engineers (NSM 2016a)

Fig. 4.5(b): The panel featured in the exhibition 'Enjoy Science Careers' containing information relevant to biomedical engineering (NSM 2016a)

Fig. 4.5(b): This panel has a background colour and the opaque wavy lines and circles in various sizes at the bottom similar to that of Fig. 4.5(a). It is a panel created for mounting a 24-inch monitor for displaying a video of an interview with the represented man talking about careers and relevant qualifications (Kenan Institute Asia, 2017). Below the monitor is the summary of the video content comprising textual description and visual images. In terms of the visual elements, there are two circle-cropped photographs captured while filming the video as well as some graphic illustrations. The first photograph at the left side of the panel depicts the featured man represented in Fig. 4.5(a) with the other two men in a laboratory. The man wears a casual collared shirt and seems to be performing certain kinds of testing or experiment. Meanwhile, the man in the grey shirt seems to be a subject of the experiment

and is sitting in a wheelchair with a particular blue piece of equipment on his head. Moreover, there is another man standing behind the wheelchair, wearing the recognisable uniform of the engineering department, and bending his body to observe the experiment. The second photograph is slightly smaller than the first one and depicts a woman wearing a white lab coat and a man wearing the engineering student uniform. Both of them are operating the instrument simulating a medical operation in a laboratory with some instruments in the background.

Regarding the graphic elements, there is an illustration representing a man with white hair and eyebrows who wears a casual outfit, a white lab coat, and eyeglasses. He is also standing and holding a briefcase and a document folder in the right and the left hand respectively. Moreover, there is the representation of a directional pole consisting of four arrow signs in different sizes and colours. Each couple of the arms are pointing to the opposite sides. Some icons representing lungs, a molecule of naphthalene ($C_{10}H_8$), a heart with a cross-over ECG (electrocardiography) signal, a 3-D structure of a molecule, and joint and bones. These small icons are scattered around the area of the textual information.

Composition

Fig. 4.5(a): The visual image can be considered as two sections on the left and the right side. The left side consists of three parts along a vertical line which are separated by the empty spaces between them including the career name and its short description; three small icons conceptualising the career-related items; and the information about the career and the name of the represented man; and the exhibition's logo. Meanwhile, the right side of the panel features the full body of the man who is depicted as the career representative along with the elements on the left side. In addition, the abstract lines and circles occupy the space across the bottom area of the visual image.

Fig. 4.5(b): The top area of this panel displays a monitor then; it is followed by the textual description at the centre. In relation to such text boxes from top to bottom, the representation of the direction pose is placed on the upper-right corner, the larger cropped photograph is in the middle of the left side while the smaller one is at the bottom around the centre, and the illustration of the man is on the bottom-left corner. Moreover, the other icons scattered randomly surrounding the textual area, and the abstract lines and circles fill the space at the bottom of the visual image.

From the compositions of both visual images, it can be seen that each panel has arranged associated visual elements to balance their weights between the left and the right sides in terms of the size/volume, colour, and salience of elements.

Visual perspective

All panels are vertical rectangles that may create a vertical directional cue. Therefore, it is arguable that such cue may guide viewers to scan the visual images from the top to the bottom with the leftward bias underpinned by the familiar way of reading Thai language following attention being drawn to particular dominant elements of the visual images (Foulsham, Gray, Nasiopoulos, & Kingstone, 2013; Tatler, Hayhoe, Land, & Ballard, 2011).

Fig. 4.5(a): It is a composite visual image with a solid background. Hence, the depth can be primarily perceived from the depicted man standing at a particular angle which creates different observable distances between the image surface to the left and the right sides of his body. Moreover, the gradient background colour and layers of abstract lines and circles at the bottom also reinforce the perceptual depth (Arnheim, 2004). The man is depicted in a social distance with a slightly high camera angle although viewers may look at the man's face approximately from their eye level.

Fig. 4.5(b): In this panel, the dominant part seems to be the video displayed in the top area. Meanwhile, the accompanying textual information and visual images are arranged together on the flat, solid background. Most featured graphics are created without any considerable depth. The two cropped photographs are captured with medium/personal distance and a slightly high camera angle. Although they present the real-world depths within the scenes, they may not be sufficient to create the overall depth of the panel due to their small sizes and the way of using them as the additional elements. Similarly, the abstract lines and circles at the bottom seem to be isolated from other visual elements and merely occupy the space rather than create any depth significant to the focal areas of the visual image.

From the arrangement of visual elements below the monitor, it is arguable that the viewer's eye movement may be guided by the zigzag pattern (Bradley, 2015a; Kennedy, 1985; Rayner, 2009). The eyes may move from the lung icon to the first section of the texts, the representation of the directional pole, the larger photograph on the left, the second section of the texts, the heart icon, the illustration of the man with his right arm creating a diagonal line pointing to the third section of the texts and the DNA icon, the smaller photograph, and the icon of bones. By having such visual images displayed in such zigzag positions surrounding the textual area may increase a chance for viewers to sweep their eyes across the in-between textual information and may also read them.

Tonality and colour

The theme colour of this exhibit is dark red which is adopted mainly as the backgrounds of Figs. 4.5(a-b). Meanwhile, the colours of the depicted subjects in each panel include those distinct from the background colour such as black, white and other bright colours (Bradley, 2014a; Kennedy, 1985). For all photographs, they generally contain naturalistic colours and lighting.

Look and gesture

In Fig. 4.5(a), the represented man is standing at an oblique angle with one leg forward and arms crossed. He is smiling and looking directly at the camera as if to make personal contact with viewers (Kress & Leeuwen, 2006). On the other hand, most people and characters represented in other visual images are either photographed from behind while they were undertaking their work and looking at other directions without making any eye contact with viewers. As a result, the viewers may look at such visual images as the observers standing at particular perceptual distances from the depicted subjects (Kress & Leeuwen, 2006). Regarding the illustration of the man in Fig. 4.5(b), he is depicted with arms in an open gesture, smiling and looking at something not included in the panel as if he is interacting in a welcoming manner.

Size relationships

It can be seen in the photographs featured in this exhibition that most subjects are represented in the proportion found in a real-world situation. For the composite panel comprising cropped photographs and graphics such as Figs. 4.5(a-b), the sizes of visual elements are adjusted according to the weights assigned to them to create the intended overall visual image as opposed to the life-size configuration (Bradley, 2014d). For example, in Fig. 4.5(a), the size of the represented man is enlarged to be approximately the same as his real-life size. Therefore, the sizes of other elements as well as the exhibition logo and spaces on the left side are regulated to balance the visual weights of elements between both sides of the panel.

Accompanying written texts

Fig. 4.5(a): The first section of the accompanying written texts includes the name of the career “Biomedical engineer” and its short definition “who develops technology applicable to healthcare”. This section is followed by the three small icons suggesting scientific emblems relevant to biomedical engineering. Then, the second section of the written texts begins with the topic “Let’s get to know a biomedical engineer” which is followed by the textual description: “A biomedical engineer is a person who designs or invents standardised and practical medical devices. The biomedical engineer also researches innovative technology for diagnosing, preventing, following up, relieving, or healing sickness, as well as developing medical equipment, devices, or software that are beneficial and safe to patients and medical staff”. At the end of this section, there are the name and the affiliate of the representative of biomedical engineers depicted at the right side of the panel. In association with such a general description of a biomedical engineer, the visual representation of the role model may particularly portray the professional as someone who is young and smartly dressed. Moreover, in the bottom area, the exhibition name is written in its logo “Enjoy Science Careers” in English that is surrounded by various icons of scientific emblems. In addition, at

the top-left corner under the logos of the exhibition facilitator and sponsor, there are URLs of the exhibition's web page which is part of the sponsor's website, and the facilitator's website.

Fig. 4.5(b): The written texts in this panel summarise the information presented in the accompanying video. They consist of information related to three topics: the significance of medical technology to the sustainable development of the country; the educational routes to becoming a biomedical engineer; and the job opportunities of such career. For the second section, it indicates four optional undergraduate qualifications relevant to biomedical engineering which are also restated in each arrow of the directional pole as the visual analogy depicted above the topic name. Moreover, both accompanying cropped photographs exemplify some learning tools and environments that may be experienced in the relevant undergraduate courses. Regarding the third section, it suggests that a biomedical engineer might be able to attain a job in a hospital or in health-related organisations either public or private, domestically or abroad. It is arguable that the illustration of the man on the right side may represent a professional biomedical engineer.

4.2.2 Size and space

The actual panels are produced in the same size approximately 2 m (height) x 1 m (width). They are arranged together to form a rectangular space for the exhibition covering around 6-8 m^2 that is large enough for a table displaying actual, relevant materials or devices, and the space for facilitators or viewers to walk through the exhibit as shown in Fig. 4.6. When installed with the other nine exhibits, they create a whole, large exhibition in which each booth has its own space. With such size of the panel, it can represent the standing man in Fig. 4.5(a) approximately in his real-life size.

Fig. 4.6: The arrangement of biomedical engineering exhibit at a shopping centre

4.2.3 Context

Production context

Science, technology, and innovation play a significant role in the development of Thailand. However, human resources in such areas are still insufficient for the current demand, and the related careers are scarcely acknowledged by people in Thai society (Manager online, 2016; NSM, 2016). As a result, the National Science Museum (NSM) as the agency for raising science awareness in Thailand in partnership with Chevron Thailand Exploration and Production, Ltd, and Kenan Institute Asia develop the exhibition named “Enjoy Science Careers”. The exhibition is developed in order to introduce ten under-recognised STEM-related careers. The featured professions are argued to provide significant skills and knowledge for improving the population’s quality of life and economics of the country. The ten careers include petroleum geologist, plant breeding technician, product designer, animator, drug researcher, biomedical engineer, food scientist, forensic scientist, cosmetic scientist, and software developer.

The exhibition aimed to raise awareness of the science careers presented, to promote positive attitudes toward science and technology, as well as to inspire the target audiences (young people or high school students) to pursue STEM-related careers, a process which begins by selecting relevant subject choices at school. The visual images used in the exhibition are created by the collaboration between science communicators, the representatives of each profession, and a design team. In such collaborative project, the science communicators initiated the initial concept of the exhibition attempting to represent the career representatives in the style similar to the depiction of entrepreneurs usually found in business magazines (Entrepreneur, n.d.).

It is arguable that in the last decade, entrepreneurship has become an area of interest in most societies including Thailand. It is portrayed through various media channels primarily by utilising young, smart and successful role models (Ewing Marion Kauffman Foundation, 2015). Therefore, the representatives featured in the exhibition are supposed to be young adults (under 40 years old). This may reduce the age gap between the represented professionals and the target audiences and possibly make the exhibition more engaging. The role models also provide information about their career to be presented in the forms of visual images with accompanying written texts and video. Such materials are produced by the associating artist team who took some required photographs by a digital camera and created the composite panels by using graphic design software. Moreover, the theme colour of some exhibits/careers might be devised based on the colours adopted for representing Thai university’s faculties associating with the featured careers such as dark red for engineering (KMITL, n.d.; Mahidol University, 2016).

Distribution context

The visual images are printed on removable panels and arranged at the event space situated on the ground floor of Siam Square One shopping mall (OBA, n.d.; PMCU, n.d.) which can be accessed in several ways including the entrances at the street level. The venue is a recently built shopping mall in Siam Square: the most contemporary shopping district in Bangkok, Thailand. The shopping mall is surrounded by other popular shopping malls, schools and a university. It comprises a variety of shops and restaurants focusing on technologies, fashions and lifestyle and is popular among teenagers and university students (Novotel, n.d.). Diverse events are also regularly held there such as mini-concerts, markets, or competitions to attract such groups of visitors. The exhibition being discussed was displayed between the 27th and 29th of May 2016 (Friday-Sunday). Therefore, it is arguable that it could be encountered by a large number of young people who usually visit or pass by the venue after school and on the weekend.

For each exhibit/science career, the visual images are delivered and accompanied with a short video introducing the career, a table displaying tools and materials relevant to the career, and at least one facilitator who supports learning from the exhibit and answers emerging questions. From Fig. 4.6, it shows that the visual images are placed farther back from the table and the facilitator. As a result, the reading of the textual information written on the panels may be hindered by the distance between the texts and audiences (around 1-2 metres) which is also fixed by the table blocking audiences to come closer the panels (Kelly, 2012). Having the facilitator at the exhibit might also be off-putting to some viewers. However, such potential barrier may be mitigated by the friendliness of the facilitator and particularly when audiences visit the exhibit as a group of few people that could make them more comfortable to spend some time at the exhibit (Kamolpattana et al., 2015).

In addition, since the exhibition consists of several individual exhibits and is also surrounded by commercial shops, audiences may briefly survey the available career booths in order to decide whether to stop at booths they find interesting to further explore those science careers in detail (Guler, 2015). The dominant elements of the exhibits taken into such selecting process might be the name of the career, the image of the role model, and the career-related actual tools or materials which are displayed on the booth's table as shown in Fig. 4.6.

Reception context

In front of the exhibition, the logo containing the title "Enjoy Science Careers" is conspicuously displayed and is also repeatedly presented on the desks and panels of the ten exhibits. Although the title is written in English, it is arguable that its translation could be understood by most high school students due to using familiar English words people use in their everyday life. For example, "enjoy eating" is one phase many people tend to say in

English rather than its translation in Thai. For Thai people, the understanding of the word “enjoy” is similar to “having fun doing something” (Longdo, n.d.). This means it might raise attention to particular actions associated with the word in the presented context which is science career in this exhibition. Therefore, from the title, science careers might be perceived as practical activities or applications rather than the aspects of scientific facts or knowledge.

Such potential enjoyment of science careers is also represented through photographs exemplifying the working environment of each career. It can be seen from the small photographs featured in Fig. 4.5(b) that biomedical engineering is visually narrated as a discipline taking place in the laboratory and relating to practical skills and specific tools instead of learning in a lecture room. The title may also be perceived by audiences as an invitation to enjoy exploring the exhibition. In other words, it suggests that the exhibition is enjoyable which is underpinned by presenting a variety of science careers with multiple modes of communication, friendly facilitators, as well as the use of bright colours in the exhibits.

The theme colour of the exhibit may also denote the characteristic of the associating science career. In this case, the dark red colour of the exhibit of biomedical engineer can clarify its dominant academic discipline like engineering. In Thailand, most students acknowledge the colour codes assigned to each academic discipline which can be different from university to university. However, for some long-established disciplines, they tend to have universal colour codes applicable to all universities such as dark red for engineering, or green for a medical degree (KMITL, n.d.; Mahidol University, 2016; USCE, 2010). Despite being recently established and unrecognised by large audiences, the career name “biomedical engineer” in Thai comprises words suggesting three familiar careers including engineer, biologist, and medical doctor (AdmissionPremium, 2016; BME, n.d.-a). Therefore, the use of dark red as the exhibit theme colour might pinpoint that the career is primarily considered in the field of engineering rather than biology or a medical discipline although some of their elements are taken into account (BME, n.d.-b) as denoted in the name and depicted in accompanying graphics representing their emblems such as the DNA structure, aspects of human anatomy, or scientific tools in the visual images.

Such clarification is also provided in the accompanying written texts explaining the career characteristics and qualifications relating predominantly to engineering. Otherwise, some audiences may be confused from the representation in Fig. 4.5(b) between the familiar image of engineering students who usually wear a particular dark blue jacket in the laboratory depicted in the larger cropped photograph and the white lab coat depicted in the smaller cropped photograph and the graphic of the man on the right side which could be recognised as the matter relating to either science or medical doctors.

In terms of the career representative depicted in Fig. 4.5(a), from his outfit and gesture, he might be perceived as a friendly smart young professional. It is arguable that people in Thailand do not usually wear a suit except for a special occasion or a formal business circumstance. By having the man wearing a suit in this visual image, it may distinguish him from ordinary working environments and present the formality and speciality of his profession. However, he is still accessible which could be perceptually understood from the social distance between him and viewers, his smiling face, and the eyes looking at the viewers. This is also supported by the video featured in Fig. 4.5(b) that presents him sharing information about the career in a friendly and inviting way.

Similarly, such positive expression could also define the meaning of his posture: the crossing arms and one foot forward. Although the crossing arms may express some barriers or blocking behaviour, in this exhibit, such body language is likely to portray the man as being comfortable and confident (Sol, 2012; Lin, 2015; Tipper, Signorini, & Grafton, 2015). Moreover, the man is depicted in a slightly high-angle shot which may rebut the interpretation of the crossing arms as the expression of power or superiority over audiences (Navarro, 2014). As such, viewers seem to look at the man from above as if they were observers or had power over the represented man (Kress & Leeuwen, 2006). The expression of self-confidence by the crossing arms corresponds to his leg posture (Lin, 2015; Tipper, Signorini, & Grafton, 2015). With one foot pointing forward, this displays the man's intention i.e. that he points his foot directly to audiences as if he is attending to and engaging with them.

The self-assurance and other desirable traits of the role model are also suggested by other visual elements and accompanying written texts. The video and the larger cropped photographs featured in Fig. 4.5(b) can present the representative of the career as being knowledgeable and skilful, being able to operate and create specialised tools for patients, as well as being able to work in collaboration with others. This representation is emphasised in the written texts describing the products derived from this career as being safe to apply in real-life circumstances and innovative. The third section of the career information in Fig. 4.5(b) also gives suggestions of various job opportunities offered to a biomedical engineer. These representations of the career may be perceived by audiences as a desirable profession among other choices.

Nevertheless, the perception of career accomplishment may be impeded by several factors. Firstly, by displaying the working environment of the career representative (an academic) which mainly takes place in the educational context of the university's laboratory without presenting different working environments potentially occur in other contexts such as in a hospital or industry, audiences might not be able to perceive how taking such a career path may look like from merely the written premise of the potential jobs happening in healthcare-

related organisations. Secondly, by having the role model as an academic working in a university who has also attained a higher degree of education stated in Fig. 4.5(a) and the graphic representing the white hair or aged biomedical engineer in Fig. 4.5(b), it might be perceived that it could take years of study or working experience in order to be successful in this career. The depiction of the character with both hands holding a folder and a briefcase may suggest that a biomedical engineer usually deals with a large number of documents or data which seems to be tedious and contradictory to the career emphasising practices represented through the featured photographs, written texts, and the title as mentioned above. In addition, it can be seen that the visual images, as well as the accompanying video, mainly feature male with only a small photograph containing a female in Fig. 4.5(b). As a result, it may discourage some female students to aspire to biomedical engineering.

4.2.4 Construction

It is noticeable that the career name ‘biomedical engineer” is repeated several times throughout both panels because the exhibit tries to introduce the less-known career. The simple repetition of the name may increase the frequency of the exposure of it which may reinforce the acquisition of the career name into an audience’s recognition memory (Hintzman, Curran, & Oppy, 1992; Moutsopoulou, Yang, Desantis, & Waszak, 2015). Similarly, by regularly presenting the exhibition logo containing the verb ‘enjoy’ may advise the way an audience would explore the exhibition as well as the presented science careers. In other words, the title may prime particular meanings to both the exhibition and the science careers that they are enjoyable. Besides being suggested by the title, such potential enjoyment can also be reinforced by viewing the visual images. The exhibition comprises a variety of colourful graphics and backgrounds which can brighten the learning environment and evoke emotional responses (Jalil, Yunus, & Said, 2012; Kuzinas, 2013).

From the contribution of visual images and accompanying written texts, it is arguable that they can construct particular aspects of professionalism relevant to a biomedical engineer. Professionalism can be defined as a multifaceted system of beliefs or values that guide the desirable practice of a profession (Kaslow, Johnson, Grus, & Kaslow, 2014; Wynia, 2010). According to the association for project management (APM, 2017), professionalism is considered in five interrelated dimensions including the body of knowledge significant for the profession; the competence in required skills and behaviours; the achievement of related qualifications; the commitment of the career; and the accountability of the conduct. It can be seen that these characteristics of a biomedical engineer might be perceived from the exhibit which can be explained as follows:

Regarding the body of knowledge, the exhibit represents it mainly through the exhibition title and the small graphics scattered in the logo and throughout both panels. The title “Enjoy Science Careers” and the graphics representing scientific objects and body parts can

construct the context of the presented career. In other words, they suggest that biomedical engineering primarily relates to the knowledge of science and human health. By using the theme colour as dark red signifying engineering may specify further that the science in this context is the applied science emphasizing the practical applications or technology. Such a construction is also underpinned by the texts written on both panels.

In terms of the skills and behaviours desirable for a biomedical engineer, different aspects of skills are constructed by visual images with the written texts to support the visual proposition. The technical skills are presented through the photographs featured in Fig. 4.5(b) which depict the ability to use specialised tools and operate associated tasks. Also, the graphic representation of the man in the white lab coat holding a document and a briefcase (in Fig. 4.5(b)) may suggest his skills relevant to the management of information (in the context of being a health-related professional) such as to retrieve/record, process, use, or report information (Bytheway, 2014). Furthermore, the photographs portray the groups of people working together which can illustrate the interpersonal and communication skills of a biomedical engineer who can work collaboratively. Such construction corresponds to the portrait of the career representative in Fig. 4.5(a) depicting him as a friendly and engaging person. In addition, by expressing the self-confidence and positive attitudes through his gesture, the portrait may also present his interpersonal skills (Kaslow et al., 2014; National Research Council, 2011).

The qualifications at different levels and career paths relevant to a biomedical engineer are provided in the second section of the written texts in Fig. 4.5(b). For undergraduate level, the different education paths are also metaphorically presented in the form of different arms of the directional pole which may re-emphasise the available choices for the target audiences who mainly are high school students. Meanwhile, the career commitment is primarily explained in the written texts of both panels defining the profession to consider the actual societal needs and the applicability as well as the safety of the services or products provided by them. Such aspects may also be indirectly constructed by the portrayal of the career representative in Fig. 4.5(a) in a manner that is responsive and attentive to audiences. Similarly, the accountability of the career is asserted explicitly in the written texts in Fig. 4.5(a) mentioning the standardisation of the professional conduct as one priority. Also, the adherence to such a requirement may be constructed through the photographs in Fig. 4.5(b) adopted as evidence of the actual practice that involves some aspects of training and testing processes.

By constructing the professionalism of a biomedical engineer, the exhibit postulates some expectations or requirements associated with the career. The represented concepts may be used by some audiences as self-reflection criteria to examine whether they are interested in or capable of pursuing the profession. In addition, rather than being introduced from a

neutral stance, the career is represented together with several components of persuasion. In other words, the role model is depicted in the similar style of presenting entrepreneurship admired concurrently by young generations i.e. to suggest that a biomedical engineer can also be smart and attractive (Ewing Marion Kauffman Foundation, 2015). Similarly, several accounts of the accompanying written texts add some values of esteem to the profession toward the aspects of humanity, morality, and national economics and development. Nevertheless, the exhibit introduces the career in an inviting manner which corresponds with the use of an inviting style of language and the low camera angle to depict the visual images. In such a fashion, the audiences can be relaxed whilst considering the information presented and develop their own interpretations of the career (O'Sullivan, 2003).

4.3 Summary

This chapter provides the descriptive explanation of two individual cases portraying scientists. It shows that both cases can convey messages relevant to science especially regarding scientific community and practice, as well as science enterprise and purpose. Namely, both case 4.1 ('Let The World Keep Turning' exhibition) and case 4.2 ('Enjoy Science Careers' exhibition) represented scientists and their associated cultural contexts. The collaborative nature of a multidisciplinary scientific project and their endeavour to engage with the public would be shared with audiences who visited the exhibition of case 4.1. The information about scientific equipment or working environment might be perceived through the accompanying panel of case 4.2. Meanwhile, the information about scientific research for the treatment of diagnosing of lung diseases, or the beneficial research outputs of biomedical engineering can be embedded in cases 4.1 and 4.2, respectively.

The construction of messages observable from cases 4.1 and 4.2 is that they adopt some iconic signs to represent subjects. This means the visual representation resembles some of the subjects' significant features such as overall shape, attributes, or colour such as seen in cases 4.1 and 4.2 representing persons' appearances and identities. Meanwhile, the collaboration between visual images and written texts or verbal conversation may occur in different manners. The accompanying posters in cases 4.1 and 4.2 can expand the understanding of visual images by adding relevant information. Such information may also be obtained from a verbal conversation with an event's facilitator. The exhibition titles 'Let The World Keep Turning' and 'Enjoy Science Careers' may suggest an implication of how to perceive the featured visual images in coherence with the intended messages. Namely, the acknowledging and embracing of multiculturalism in case 4.1 and the desirability of science-related professions in both cases. In addition, the text which communicates the positive attitudes of the scientists in case 4.1 and the written description promoting a desirable career in case 4.2 also reinforce the positivity portrayed in the visual representation such as the smiling face or friendly expression of the depicted subjects.

As mentioned in Table 3.1, the two cases featured in this chapter are considered as the examples of events which mainly aim at developing positive attitude or value toward science. It is arguable that the formation, change or endorsement of an attitude or value might be primarily achieved through the interdependent construction between a visual image and accompanying written/verbal information. The interdependent combination necessarily requires both entities of content to collaboratively convey an intended message (McCloud, 1994). Such dual requirement might be underpinned by the elaboration likelihood model (ELM) which is extensively applied to consider the mechanism of influencing one's attitude especially in the sphere of persuasive communication (Kitchen et al., 2014; Petty, Cacioppo, & Schumann, 1983). There are two approaches to attitude change including the central and peripheral evaluations of a proposition which involve different extents of required cognition to process information and sources of argumentation. Namely, the central approach relies on the rationalisation and quality of given arguments, and the peripheral approach is based on the attractiveness of or an audience's subjective emotion/feeling toward the proposition. In this context, in order to determine the relevant proposition from given written/verbal information, it notably requires a high level of cognition or to be processed via the central route. Meanwhile, the visual representation may be evaluated peripherally by a lesser level of cognition.

The appropriation of a visual image and written/verbal information in an interdependent fashion therefore potentially affects the audience's attitude towards the proposition in both central and peripheral routes (Lacey, 1998; Messaris, 1997). In both cases 4.1 and 4.2, the visual images may serve as the icons to represent some esteemed perceptual images of scientists and their associated science such as regarding their positive appearance, manner, or emotional expression. Although the perception of such visual cues can be polysemic, they play an essential role in stimulating affective responses toward the depicted subjects. However, it can be seen that the visual representation alone may not be sufficient to articulate the proposition toward the subject matter. As such, the written texts or verbal conversation with a facilitator in both cases cognitively relate such emotional responses to the notion of the subject matter such as science, scientific practice, beneficial outcome, or scientific community and career. Vice versa, the textual/verbal information might be perceived as objective factual information or less compelling in relation to attitude change without the concrete evidence provided by the visual images (Kulvicki, 2014; Manghani, 2013).

Chapter 5
Murals as science communication

The following cases (5.1: “Seeing red” and 5.2: “We are the same blood”) are murals painted on the walls in the USA and Thailand, respectively. Both murals arguably convey conceptual messages through visual representation and short written texts. Similar to Chapter 4, this chapter presents individual case analyses based on the discourse analysis framework (Kenney, 2009) which suggests some answers for RQ1: How is the message constructed by a visual image and accompanying information in a science communication context? and RQ2: How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)? Meanwhile, it may contribute to the answer of RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements corresponding to the fulfilment of Generic Learning Outcomes (GLOs)? especially for the learning outcome of providing entertainment or inspiration.

5.1 The mural “Seeing red”

The ‘Seeing red’ mural was designed and hand-painted with the use of stencils by Diane Arrieta a visual artist in South Florida, USA who uses the title ‘Birds are Nice’ (BAN). The mural was painted in 2013 on the side of a building situated in Boynton Beach Arts District (BBAD), Florida, USA. Although the actual mural has been painted over, its photograph taken from the actual venue as well as the mural’s graphic design are still available on the artist’s web page (Birdsarenice, 2013). It was adopted as a science communication tool to inspire audiences and encourage discussion about issues relevant to biodiversity and conservation.

5.1.1 Content

Subjects

The design of the mural is shown in Fig. 5.1. The mural consists of a background of a red rectangular shape with uneven curves at the bottom-right corner (to look like dripping paint or blood). For its foreground, there are five very similar images of a girl’s (female child of between 8-12 years old) head and upper body. There are six of these images painted on the actual mural as shown in Fig. 5.3. Between each girl’s image and the red background, there is a shape resembling a white cross situated behind the image of the girl’s upper body. The girl has a fairly expressionless face and black hair in a ‘bunches’ hairstyle. She wears a black long-sleeve top underneath a white short-sleeve T-shirt which features an animal on the front. Whilst the image of the girl (aged around 8-12 years old) is repeated on the mural with an identical spacing, the T-shirt which she is wearing has a different animal on the front. From the design in Fig. 5.1, there are several kinds of animals depicted including a California condor, a panda (Giant panda), a Hawaiian crow, a rhino (Black rhino), and a black stilt with

red/pink long legs. In addition, for some animals, namely the condor, the crow, and the rhino, there is a red-white stripe tube resembling a lifebelt on their bodies. In other words, the representation of the animals on the T-shirts alternates between one with and without a lifebelt.

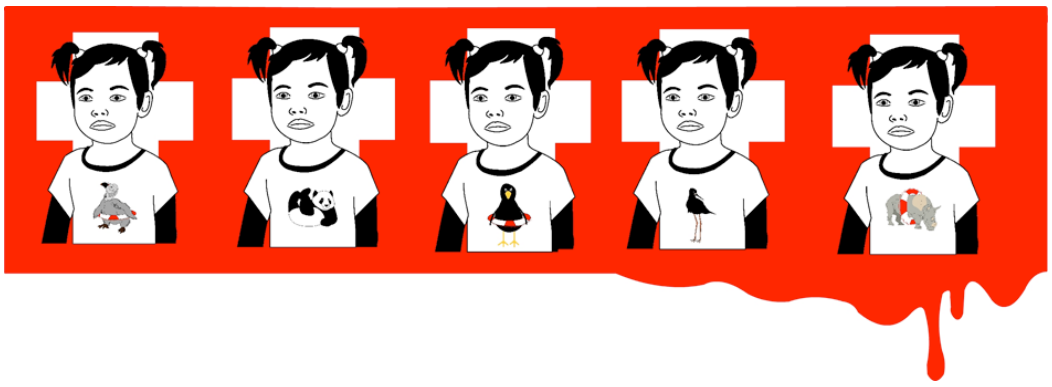


Fig. 5.1: The design of the visual image to be painted as the 'Seeing red' mural (Arrieta 2013)

Composition

The mural has the red background as the main space and presents the subjects on the white background of the crosses. Such white space entails the repetition of the patterns comprising groups of elements of the same category. All five groups of elements are identical except for the different species of animals represented on the girl's T-shirt and the presence or the absence of a lifebelt around their bodies. The elements are aligned at the same horizontal level with the approximately identical interspaces between them and between the edges of the background.

Visual perspective

The whole mural has a 2-dimensional or flat appearance even though the layers of visual elements create a compressed depth between the foreground (the girl image) and the background (the red rectangular shape). Viewers may also perceive the depth or spatial distance created from the acute angle between the girl's body and the background. By placing the girl in the foreground with such angle, it potentially makes the girl distinct from the white cross and the background. As a result, the viewers are encouraged to look at the girl (Foster & Ward, 1991; Wolfe, 1998). The mural seemingly encourages viewers to look at the depicted subjects from their eye level, and also from the left to the right as a result of several factors: the girl is facing the left side of the mural, there is a systematic repetition of the patterns forming a perceptual directional line, and the uneven curves at the bottom-right corner imitate the natural end of a brushstroke. This is also congruent with the line of the written texts below the mural as shown in Fig.5.3 which may suggest the familiar leftward reading of English written texts (Foulsham et al., 2013).

Tonality and colour

The mural is solid coloured mainly with bold colours (white, red, and black), and small areas of grey and yellow. There is no noticeable tonality or particular light and shadow in the mural. This may be because the conceptual painting primarily emphasises the representation of the intended message and may omit some naturalistic features such as in terms of colour differentiation and modulation or its lighting and shading (Kress & Leeuwen, 2006). Without natural colour modulation and tonality, it can be seen that the mural uses contrast colours to create the boundaries or shapes of subjects. For instance, the continuation and closure of the black line can form the image of the girl separated from the contrast white cross and the red background (Bradley, 2014a; Kennedy, 1985).

Look and gesture

The girl's body and face turn slightly to the left side of the mural. She seems to look at something far away with a rather inscrutable facial expression. However, from the expression of her mouth and eyes, it is clear that she is not smiling or does not show any sign of happiness (Maher et al., 2014). In addition, despite the lack of eye contact with audiences or any gesture demanding for a response, the mural could draw attention by representing the girl as the subject which intrigues an audience to contemplate potential meanings. (Kress & Leeuwen, 2006).

Size relationships

Because the composition of the mural places the animals on the girl's T-shirt, the sizes of the animals and live preservers are rather small compared to other elements (the girl and the cross) within each group when the sizes of the girl and the cross are relatively the same. Nevertheless, the red rectangular background is large enough to contain all groups of visual elements.

Accompanying written texts

Below the mural, there are accompanying written texts as seen in Fig. 5.3. They are featured in capital letters without spaces between words and consist of the URL: 'BIRDSARENICE.COM' at the bottom-left corner of the mural, and the hashtag: '#SEEINGREDMURAL' placed approximately one metre away from the URL. Both written texts can be arranged in the phrases "birds are nice" and "seeing red mural", respectively. On the left side of the mural, there is also a QR code near the bottom-left corner. The written texts are not explicitly the mural's commentary, though they have some relevance. In other words, for the URL, the mural coherently features some birds. Meanwhile, the hashtag may directly describe the characteristic of the painting as dominantly containing red colour, as well as serve as the mural title: "Seeing red" (Arrieta, n.d.).

5.1.2 Size and space

The actual mural was painted on a property of Boynton Beach Arts District (BBAD) situated in an industrial area in Florida, USA. The district is approximately 0.6 acres and consists of 4 blocks of buildings. It contains eleven industrial warehouse studios of which outside walls create an outdoor exhibition or art showcase comprising more than 40 individual spaces/walls as shown in Fig. 5.2. The mural was part of such outside showcase situated at the rear end of a building (opposite the entrances and the main street). The mural was painted on a large white wall approximately 3 m (height) x 6 m (width). Meanwhile, the mural dimension was approximately 1.2 m (height) x 5 m (width) covering around one-third area of the whole wall in a rectangular shape with the 1:4 (height: width) ratio as shown in Fig. 5.3. The viewing distance between the mural and a viewer was probably limited within the width of the private road on the rear side of the district which is approximately wider than ten metres. Therefore, it is arguable that with such large dimension, the details of the mural and the accompanying written texts could be easily seen by an audience standing within such available viewing space.

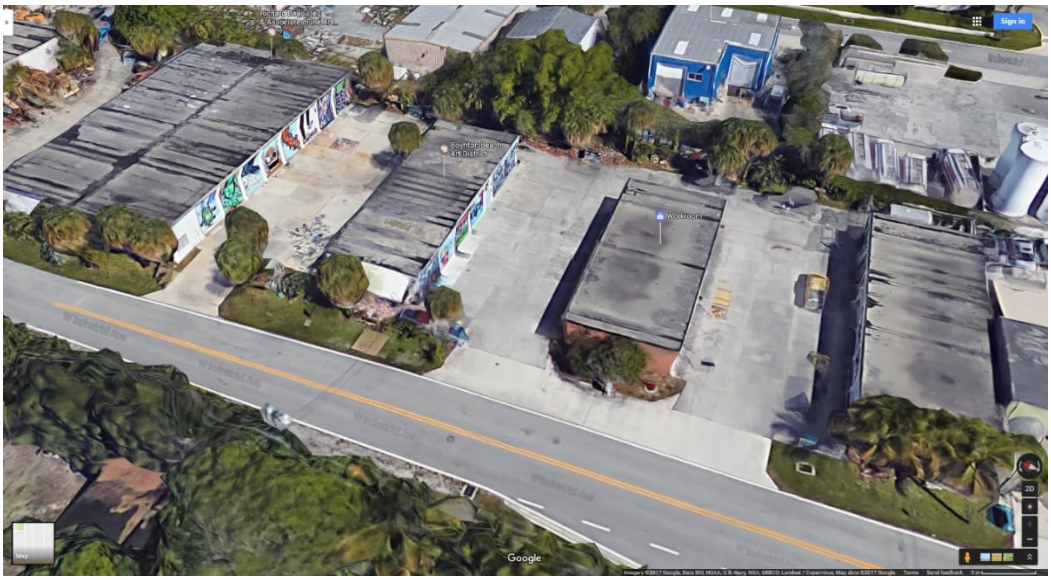


Fig. 5.2: The satellite map of Boynton Beach Arts District (BBAD), Florida, the USA where the mural was painted on a wall at the rear side (Google Earth, 2016)

Fig. 5.3: The mural located at 422 West Industrial Drive, Boynton Beach, FL 33426 USA. (Birds are Nice, 2013. ‘Seeing Red’ mural: Boynton Beach, Florida, USA)

5.1.3 Context

Production context

The subject matter of the visual image relates to biodiversity and environmental conservation which is an issue widely covered in various media outlets such as newspapers, magazines, broadcasting and the Internet. Although the public may be aware of environmental issues, studies showed that the understanding of the topic in terms of their underlying concepts or cause-effect relationships is still insufficient for motivating effective environmental stewardship (Coyle, 2005; Ibrahim, Salman, Kee, Mustaffa, & Ahmad, 2012). It is argued that environmental education should be endorsed in the environment of formal education as early as in primary school. This may result in constructing knowledge and values in children leading to informed decision-making and lasting desirable behaviours toward environmental conservation (Ballouard, Brischoux, & Bonnet, 2011). Moreover, one strategy adopted for such a development is to generate a sense of relevance and ownership that may be supported by learning in informal contexts outside the classroom (Coyle, 2005). With formal and informal environmental education, it may create a well-rounded understanding that is applicable to the real-life context of the learners.

Therefore, the mural in this project may indirectly support environmental education by inspiring public members in all demographics, especially those who live nearby or could visit the mural’s site. The mural is created mainly as a catalyst to encourage discussion among audiences regarding the interpretation of the subject matter and conveyed a message. The artist intended to fulfil such purpose by making the mural ambiguous and without providing any explicit information. Instead, the accompanying QR code and written texts merely

include the URL (linking to further information on a website) and the hashtag associated with the mural project. As such, the mural could perform its secondary function as being an incentive for self-motivated environmental learning. By relying on the Internet and QR readers to access information about the mural, it may impose a digital gap to some audiences such as older adults, people with less educational attainment, or those who live in lower-income households (Perrin & Duggan, 2015). However, such potential alienation can be mitigated when there were occasions the artist was present to provide relevant documents or information about the subject matter. Also, as mentioned earlier that, for this case, the attainment of information is rather a contingent outcome, the use of such digital technology would not significantly affect the fulfilment of the primary aim to inspire audiences or encourage a discussion.

The creator of the street art: “Birds are nice” is an artist based in the US who, through her works, has been advocating animal conservation and environmental issues. Much of her work employs the characteristics of informal cartoons featuring ambiguous symbolic phrases and shapes, bold colours, and female figures recalling mainstream Disney’s cartoons (Arrieta, n.d.). From the interview data, the artist herself created the mural project by both designing the visual image and assigning its accompanying written texts. In other words, she could independently express her ideas, artistic license and style into the visual image. In this particular project, the artist used street art as the form of communication with the realisation that it could reach a large number of people, particularly the community living in the area in which the mural is situated. During the time of production, street art has already become a mainstream or acknowledgeable public art in the US as an approach adopted for activism or a social movement. It can be distinguished from graffiti which is rather perceived as vandalism or the public writing without any message significant to public members in general (Bengtsen, 2013; Gleaton, 2012; Irvine, 2012; Riggle, 2010).

In addition, the expansion of street art can be observed in the variety of its content, styles or production techniques as well as the emergence of some well-known street artists. Whereby, environmental issues were also the subjects selected and represented in this form of visual images that coincided with the environmental or ecology movement in society (Borghini, Visconti, Anderson, & Sherry, 2010; Kang Song & Gammel, 2011). Similarly, the creation of the mural considered in this chapter intends to conceptualise aspects of the ecosystem and biodiversity, especially threatened species which are in need of attention and conservation unless they become extinct. The association between such environmental issue and the mural is arguably suggested through the inclusion of some animals recruited from the IUCN red list of threatened species (IUCN, n.d.) and lifebelts as the emblem of the rescue of their lives. The artist’s design concept is that the environment is being destroyed which could be evident in the loss of species or the account of endangered species. Such continuing degradation potentially leads to undesirable outcomes whereby children who are usually

regarded as the hope of the future should be educated to prevent such scenario by preserving species and environment hence the image of the young girl and the shape comparable to the Red Cross symbol.

The decision made for the mural design and production is hugely dependent on the required functions that result in its form and features. The selection of subjects and visual elements to suggest ideas about the mural is likely influenced by certain conventions or the familiarity of attributes to make it approachable to the public (Irvine, 2012). For example, the featured animals consist of some recognisable flagship endangered species such as giant panda, black rhino, and New Zealand black stilt (ARKive, n.d.; Ballouard et al., 2011) together with some less well known endangered species found in the US such as the California condor, and Hawaiian crow. However, the artist's style may also affect the decision made in this project when the mural adopts the image of a girl and multiplication of visual elements which can be observed in several works of the artist (Arrieta, n.d.). Also, the representation of the mural in a conceptual way might be based on her personal artistic style and belief that tends to encourage people to learn new things by presenting an artwork containing an innovative or contradictory concept.

Distribution context

The mural was purposely situated in a public space where public audiences may notice and look at it spontaneously. As a result, the mural needs to be conspicuous enough to capture the attention of passers-by. From Fig. 5.3, the mural stands out from the white wall and captures attention by its large size, colour contrast, and the use of bold colours especially the striking red background (Masters, 2014; Proulx, 2010; Triedman, 2015). The venue of the mural was an art district: BBAD which has been established since 1989. It is well-known by local communities and groups of artists as the place to meet and experience art. It regularly showcases various forms of art such as paintings, murals, sculptures, photographs, or performances (City of Boynton Beach, 2015). In other words, the mural was painted in the art space surrounded by other murals or events whereby its significance and authenticity may be inevitably weakened (Irvine, 2012; Manghani, 2013). However, the attention to the mural may still be secured by its unique subject matter that features a meaningful message relating to scientific issues which probably makes it exceptional among its surrounding murals (Riggle, 2010).

The mural was displayed on a wall at the rear side of the art district as shown in Fig. 5.4 which seemingly cannot be seen from the main road as shown in Fig. 5.5. It could be presumed that people who had a chance to see the mural were those driving through or visiting the district. It is arguable that they have an expectation of seeing or experiencing art and cultural expression as well as to exchange some ideas with their fellow audiences. However, the venue is not exclusive to people who are interested in or familiar with art since

it is a public space within the community where everybody may visit simply for recreation. Rather than being unsanctioned street art, this project sought permission for the display space (Bengtsen, 2013).

Nevertheless, permission to paint at an ideal place might be difficult to obtain. There might be some constraints regarding time, fee, and monitoring for a public art project (Gleaton, 2012). In this project, the artist received permission and painted the mural at the public art district where a population of visitors has been established. This specific venue allows the mural to be seen by many people throughout the predetermined period of time without the concern that it would be potentially removed (Bengtsen, 2013; Riggle, 2010). In addition, some audiences might access the mural online as it is disseminated through the artist's website and social network sites. Although in such virtual dissemination, the richness of meaning and the impact of being large scale public mural may be lost to a certain extent, it may increase the mural's visibility and be still able to perform its primary purpose that is to inspire and encourage further exploration about biodiversity even to global audiences (Bengtsen, 2013; Irvine, 2012).

Fig. 5.4: The rear side of Boynton Beach Arts District (BBAD), Florida (USA), of which a wall displayed the 'Seeing red' mural

Fig. 5.5: The front side of Boynton Beach Arts District (BBAD), Florida, the USA from the main road (Google Earth, 2016)

Reception context

The visual image creator is familiar with the art district and from her experience of the place, she expected that the majority of audiences would likely to be groups of artists or people usually interpreting and appreciating art. Since murals are one form of art which can portray an artist's ideas and the venue is constantly used as the place for showing artworks or other kinds of cultural expression, by visiting or viewing the mural, audiences may be encouraged to interpret the intended message the artist tried to introduce (Irvine, 2012; Lefebvre, 2003; Riggle, 2010). However, the interpretation of the mural may not be explicit which subsequently may intrigue the audiences to contemplate its potential meaning. For this reason, the mural may generate a discussion among the audiences, and in this 21st century when people are familiar with using technological tools for accessing information, they could realise that the accompanying QR code, URL, or hashtag are the provided online channels for gaining relevant information through their mobile devices (Kivunja, 2015). Such immediate channels could encourage the audiences to access the relevant website which gives information about the mural and about environmental issues particularly biodiversity which is the mural's subject matter.

Regarding the mural itself, though some variation of the interpretation might arise among the viewers, some potential meanings associating with the mural can be explained as follows. The groups of visual elements within the mural can be distinguished from its background due to the dissimilarity between their shapes and colours (Lester, 2010). The consistency among the groups of elements in terms of simple shapes, striking colours, the distinctive cartoon character, and their arrangement with the identical intervals may suggest the classification of the featured subjects (Kress & Leeuwen, 2006). It may also represent a rhythm by which reinforces the visual image to be stored in an audience's mind and repeatedly stimulates visual perception (Taylor, 2013). In addition, such repetition of visual elements may metaphorically introduce the concept of the concurrent manufacturing of multiple products potentially reflecting the unconcern consumption or overconsumption that undermines the limits of environmental resources valuable to sustain the healthy environment and biodiversity (Moldavska & Welo, 2017; Mulligan, 2015; National Research Council, 1982). In addition, in terms of the mural as an artwork itself, the repetition of the visual elements may associate with the artistic style introduced by Andy Warhol. Warhol's pop art using screen printing with a blocking stencil not only reflected his interest in mass production of artwork, such printing technique also allowed convenient duplication and dissemination of the same visual image to different venues or groups of audiences (The Andy Warhol Museum, n.d.).

Although the same pattern of visual elements in the image could sometimes make the viewing become tedious, it may accentuate the dissimilarity of some elements among the groups including the different animals and whether or not they have a lifebelt (Kennedy, 1985; Lester, 2010). By featuring the recognisable endangered species such as the panda or

rhino (Ballouard et al., 2011), an audience might be able to assume that the other animals presented in the mural are also endangered species. This perception is also endorsed by using the noticeable icon representing a lifebelt: a red and white striped tube suggesting that those animals are in a critical condition and probably need to be rescued. Meanwhile, the absence of the lifebelt on some animals might also imply that not all endangered species are being protected.

By considering the visual elements within each group, the animals and the lifebelt are portrayed as the decorative image on the T-shirt dressed by a girl who seems to be the main character of the mural. The use of a character in a visual image might stimulate emotional responses in audiences in terms of their impression toward the character's appearance, gesture, or facial expression (Buchanan, 2007). By using circle/round shapes and smooth lines to visualise the girl wearing a bunches hairstyle, it can represent the girl as being harmless and innocent despite the fact that audiences might not be able to identify her specifically (Ekström, 2013). The character may encourage the perception of childhood as the generation who are vulnerable and dependent whereby their well-being, as well as interests, should be nurtured by adults (Sorin, 2005). By looking closely at her face, the girl seems to look at something in the distance without smiling or making any contact with the audiences. Such representation of the girl, who is perceived as the representative of the current generation and deserves a bright future, places the audiences as the observers of the situation which may make them feel empathy or even sympathy toward the girl. It probably raises a sense of responsibility as an adult who is supposed to nurture and protect the younger members of society.

Such a perception can be reinforced by the noticeable icon behind the girl. The white cross, despite being displayed in the incomplete form, contrasts with the red background colour, and the combination of such visual attributes (shape and colour) may introduce the perception of a red cross in an audience's mind. The familiar icon of the Red Cross can draw the audience's attention to the consideration of human well-being by preventing and alleviating suffering and particularly children should be attended to in this context (British Red Cross, n.d.). In addition, the depiction of the girl in this mural may also represent her as an active agent who is aware of the environmental issues. Namely, by wearing the T-shirt featuring endangered species with lifebelts, she probably expresses herself as an advocate for the conservation of biodiversity (McElvain, 2008). Moreover, a reflection that she could be dressed in such a T-shirt by her parents in reality may also encourage adult audiences especially parents to raise awareness or educate about environmental issues to their children.

Regarding the background of the mural, the red colour can not only capture an audience's attention, but it may also serve as a visual cue stimulating emotive and physical responses

(Evans, 2014; Triedman, 2015). Red has the potential to introduce a perception of alarm and urgency, signifying the seriousness of the associated issues that may cause excitement or an action (Triedman, 2015). Moreover, red has been adopted in several social movements as the symbol reflecting emotions associating with radicalism, revolution, solidarity and power, as well as passion (Sawer, 2007; Triedman, 2015). As a result, the red colour can bring certain connotations from those possibilities into the reading of the depicted subjects that might influence how an audience perceives the visual image. For example, the perception of the red cross and the red colour may suggest the empathy toward the girl; the repetition of the visual elements showing the girl turning in the same direction several times is congruent with the solidarity connoted by the red colour; or the use of bold colours as black and red may introduce the radicalism as the tone of the intended message. Also, the combination of the red colour and the uneven edge at the bottom-right corner of the mural's background may engender the perception that it possibly represented dripping blood which could emphasise the seriousness of the proposed issue.

Such perceptions of the red colour might also be reinforced by the accompanying written text '#SEEINGREDMURAL' which can be read as 'seeing red mural'. Besides literally inviting audiences to pay attention to the mural especially the red elements, the meaning of the English idiom 'seeing red' may also arouse their emotions toward the visual image as if they are supposed to be angry about by the proposed issue (Farlex, 2015). By using capital letters with the handwritten text, it might be perceived as the authoritative shouting of the artist to the audiences in order to emphasise the tone and significance of the issue (Holdridge, 2010). In addition, the accompanying written texts regarding the URL 'BIRDSARENICE.COM' which can be read as 'birds are nice' may offer a positive perception toward birds or animals which should be treated appropriately due to their 'niceness' or goodness.

5.1.4 Construction

This visual image is created to be a catalyst encouraging audiences to reflect and discuss its meaning which may not be explicit. However, it can be seen that the mural and the accompanying written texts represent some fundamental concepts associated with environmentalism and ecology sustainability. Environmentalism is a long-standing philosophy concerning environmental problems. It has at its core the appreciation of nature and highlights the negative consequences of human's actions imposed on the environment (McCormick, 1989). The initial focus was on the issue of deforestation threatening wildlife, subsequently, environmental movements expanded their consideration to other environmental spheres such as pollution, industrial development, or the deterioration of natural resources (McCormick, 1989; Radkau, 2014). Environmental activists adopt several approaches and techniques used in other popular social or political movements. The activities are undertaken with the primary aims of raising awareness and drawing attention to

the unsustainable exploitation of natural resources by humans; and to foster values and behaviours that are beneficial to the improvement or preservation of the environment (Barr, 2011; Doyle, 2011; O'Riordan, 1981).

In terms of the visual image's subject matter, it is notable that the depiction of the girl and various animals may arguably present some major elements considered in environmental issues particularly in the domain of biodiversity. They are relevant to the concept of a healthy ecosystem consisting of several types of diversity such as species, habitats, or functions within a living community in which a human's well-being is part of and affected by such systems regarding physical and psychological provisions (Mulligan, 2015). In addition, this construction might also be endorsed by the written URL reading 'birds are nice' that can support the idea suggesting the goodness of plurality as well as diversity.

The inclusion of some familiar endangered species may encourage the presumption that all animals are at risk of extinction although audiences might not be able to identify their actual scientific taxonomies. The status of those animals are recorded in the IUCN Red List (IUCN, n.d.), and it can be seen that the mural visually emphasises such idea of the threatened species by its main colours: red, black, and white coherent with the Red list's logo especially the striking red colour which is also literally the name of the archive. Also, it is underpinned by the written hashtag reading 'seeing red mural' that may promote the consideration of the red elements depicted in the mural and probably the Red list for audiences who are aware of this conservation initiative. By featuring endangered species, the idea of loss or deteriorating biodiversity is emphasised whilst being placed together with the image of a child portrayed in an inscrutable facial expression possibly connotes the uncertain or hindered hope and future (Sorin, 2005). Thus the mural may construct a tension between the demand and decline which is a primary concern in the realm of ecosystem sustainability (Mulligan, 2015).

Some aspects of environmentalism may associate with the effects of industrial development and do not always reject such a development (Barr, 2011). Nevertheless, it is arguable that the mural may construct the idea of unsustainable economic and industrial capitalism. The repetition of the visual elements not only functions cognitively to keep the attention and reinforce visual perception (Taylor, 2013) but may also imply the concept of mass production in industrialisation and overconsumption (McCormick, 1989; Mulligan, 2015). The variation of animals and the identical girl and cross icon featured in those groups of visual elements possibly introduces an idea that more duplication can lead to a higher number of endangered species, as well as an increased consideration and remedy required by future generations.

The construction of antidote and protection through the perceivable icons of the red cross and lifebelt also underpins the primary aims of environmentalism. It may raise awareness of environmental issues particularly the loss of biodiversity that calls for conservation (Mulligan, 2015). By having red as the predominant colour, the mural can psychologically create a

sense of urgency or alarm which is an element appropriated in many environmental movements in order to stimulate changes or desirable actions (Evans, 2014; Radkau, 2014; Triedman, 2015). Similarly, this is endorsed by the accompanying written texts: 'seeing red mural' which may stimulate certain emotional responses toward the message perceived from the visual image (Farlex, 2015). In addition, by providing the accompanying URL, QR code, and hashtag for accessing relevant information online, it is arguable that the mural can peripherally support public education which is an approach used in environmentalism to foster the understanding of biodiversity and suggest practical ways for audiences to play their part in wildlife conservation (Barr, 2011; Radkau, 2014).

5.2 The mural "We are the same blood"

This section features a hand-painted mural on the wall of a public zoo (Dusit Zoo) in Bangkok, Thailand. The mural was painted in 2012 and has been preserved until recently on the zoo's outer wall on the side facing the main street: U-Thong, and opposite the Thai parliament. It is part of a whole decorative wall featuring different murals with a coherent theme of content relevant to animals and the environment. Besides decorating the wall, the mural was designed to evoke sympathy from audiences to animals via the visual and textual representation analogous to the concept of family relationship. The zoo has been recently closed down since September 2018 and relocated to a new site and the mural has been removed as a result. Nevertheless, the mural's photograph is still available on the zoo's web page (Dusit zoo, n.d.-a).

5.2.1 Content

Subjects

A photograph of the mural can be shown in Fig. 5.6 (Dusit zoo, n.d.-a) which comprises the representations of animals, plants, and various icons. There is a tree, which is the habitat of a squirrel, an owl with a heart shape pattern on its wings and a type of chameleon. At the foot of the tree, there is also a rabbit with a pink bow on its left ear. Beside the tree, there are two mushrooms with a snail on the larger one; a body resembling a human body with an eye as its head; and a bird flying over a plant consisting of two leaves and a flower with multi-coloured petals surrounding a circle resembling a smiling face. The bird's beak is open and pointing at the symbol of a speech bubble containing colourful texts: "We are the Same Blood". The spaces within both "o" alphabets of the word "blood" potentially resemble a heart shape. Around the speech bubble, there is a bee flying at the top-right corner and a deer standing at the bottom-right corner in front of a green bush. Meanwhile, at the top-left corner of the speech bubble between the bubble and the tree, there is a white symbol representing the Lord Ganesha. The symbol resembles some of the physical characteristics of the Lord Ganesha, namely his head which looks like the head of an elephant (Wongnet, n.d.). In addition, a number of peace symbols are depicted randomly within the mural, and the rows of spot ladybirds are featured along both sides of the mural.

Fig. 5.6: The mural ‘We are the same blood’ painted on the wall of Dusit Zoo in Bangkok, Thailand, Nantrika [online image] Available at: http://www.dusit.zoothailand.org/ewt_gallery.php?category_id=4#prettyPhoto/19/ [accessed 23rd March 2018]

Composition

The mural can be considered as the composition of two parts based on the sizes of two visual elements: the tree on the left side and the speech bubble on the right side. The animals, plants and human being are depicted on and around the tree with observable overlapping areas or attachment between them as if they belong to the same aspect (Kress & Leeuwen, 2006; Wagemans et al., 2012). Similarly, for the speech bubble, its surrounding animals are also connected to its boundary. It is arguable that the mural may draw viewers’ eyes to the speech bubble not only because it is the largest element but also because the majority of animals turn their faces toward it and this may suggest a directional cue. However, the viewing flow could be inconsistent and scatter around different visual elements due to their perceivable dominance in terms of vivid colours and, for some elements, their unusual depiction differing from ordinary or familiar images such as the representation of a human being (Bradley, 2014c, 2015a).

The mural is very ‘busy’ with visual elements and written texts. As a result, there are not many empty spaces to separate them. Also, it can be seen that a number of peace symbols are depicted around the mural especially in the bottom half area to fill those empty spaces. Meanwhile, the symbol of the Lord Ganesha is arranged at the top area between the tree and the speech bubble. In addition, the spot ladybirds are depicted in a consistent rhythm with the same intervals between them which creates two perceivable vertical rows serving as the frame on the left and the right sides of the mural (Bradley, 2014a; Wagemans et al., 2012).

Visual perspective

The perspective of the mural is rather flat and seems to display all visual elements at the same distance from a viewer. There are some overlapping areas suggesting layers of elements such as the tree and its surrounding animals, or the bush and the deer. However, without any observable shadow between them, the spatial depth becomes inconspicuous or absent from the visual image. It is possible that some perceptual depth might be created by the use of gradient colours for the background, the tree, and the eye of the human body which may imitate some realistic light and shadow created by the depth of actual objects.

Tonality and colour

The mural is colourful with various vivid colours, and the colours of some depicted subjects are congruent with their natural colours to a certain extent while others are painted in colours utterly different from their natural ones such as the bright blue rabbit or the pink owl. It is observable that the theme colour of the mural could be a pink to red tone because it covers most areas of the mural including the background and various depicted subjects and written texts. In addition, the perceivable gradient colours of some visual elements may create some tonality and the sense of depth as mentioned in the previous subsection. For the other elements, there is no significant perceptual light and shadow that may generate any significant visual effect.

Look and gesture

The subjects of the mural that feature facial attributes primarily display a mouth and eye(s) in order to represent types of facial expression. It is arguable that the majority of the depicted subjects express happy faces with their eyes wide open and smiling mouth (Leppänen & Hietanen, 2007; Maher et al., 2014). The representation of the human body lifting the left arm higher than the right arm is connected to the bird lifting up its head and pointing its beak at the speech bubble. Such continuation may create a perceptual directional line drawing the eyes to the speech bubble as if it was the element to be attended to by viewers (Bradley, 2014a; Wagemans et al., 2012). This is also coherent with the bee and the deer which turn their faces toward the speech bubble. Moreover, it is notable that most characters within the visual image are looking directly at viewers seemingly to make contact as if they are communicating with them. Meanwhile, some characters could be depicted in the manner looking at something else instead such as the squirrel, the rabbit, or the bird. Such latter group of the subjects might be represented to be observed by the audiences without making any contact with them (Kress & Leeuwen, 2006).

Size relationships

It can be seen that the majority of the subjects are depicted independently from their relative proportions and actual sizes. For example, the standing deer is depicted approximately in the same height as the rabbit, the owl, the bird, the mushroom and the flowering plant.

Similarly, the representation of a human being for which the head is replaced with an oversized eye is not naturalistic. As a result, it is arguable that the visual image focuses mainly on constructing an intended message through the appearance and combination of its visual elements rather than their naturalistic properties (Kress & Leeuwen, 2006).

Accompanying written texts

The written texts of the mural can be considered in two parts: the sentence displayed in the speech bubble and the information of the image creation at the bottom of the mural. The main written texts: “We are the Same Blood” may also be perceived as a visual stimulus besides giving the meaning due to its significant size, shape, and colours (Bradley, 2015b; Hagen, 1978). Also, the letters “oo” of the word “blood” display the visual elements of heart shapes. By having the sentence within the speech bubble surrounded by characters turning their faces toward it, such depiction might present the relationships of such components as if the characters are speaking or proposing such statement and the word “we” is appropriated to represent themselves. The inclusion of the heart shapes as part of the word “blood” is also coherent with the relationship between the heart and blood, namely the heart pumps the blood through parts of the body. Moreover, this word is written in a red colour which is associated with the familiar concept of the colour of blood being red. Regarding the detail of the image creation, it comprises two short lines written “Khaokheow team” and “Natrika 2012”, respectively. Such potentially recognisable names can suggest that the mural is created through a collaboration between a group of people and an individual artist in 2012.

5.2.2 Size and space

The mural is painted on one block of the zoo’s wall in a rectangular shape. The whole wall aligns with the main street and is around 125 metres in length (Thai PBS, 2012). The wall is painted throughout with a number of murals. Between the street and the mural, there is a pavement wider than 10 meters which can provide a considerable viewing space and different viewing distances. The dimension of the mural considered in this case is approximately 3 m (width) x 1.5 m (height) (Zoothailand, 2012). The size of the mural might not affect the perceptual sizes of the depicted subjects since they are represented independently from their actual proportions. As a result, their sizes perceived by viewers can be either larger or smaller in comparison with their actual relative sizes. With the large size of the mural itself, it is arguable that the mural can be seen from afar including by people travelling on the street or looking from the opposite side of the road. Nevertheless, in this case, the mural’s size might become less significant in relation to the whole length of the wall that is condensed with other large and colourful murals as shown in Fig. 5.7.

Fig. 5.7: The mural of interest depicted among other murals on the zoo's wall in Bangkok, Thailand

5.2.3 Context

Production context

The mural was created as part of the mural painting project called "Sansil Sarasut Suansut Dusit" meaning creating murals to depict a variety of animals at Dusit Zoo. The project was initiated by the zoo in 2012 to celebrate its 75th anniversary which invited members of the public to create murals on the zoo's wall which comprises more than 50 blocks of empty space (Voice, 2012). The primary aim of the mural painting is to decorate the wall to be attractive and inspiring by displaying the representations of different animals. As a result, it may encourage passers-by, who can be people from all demographics, to visit the zoo behind the wall. This might also lead to the secondary purpose of raising awareness and promoting desirable values relating to wildlife conservation (Prachachart, 2012; Zoothailand, 2012). In this project, the broad concept for creating murals assigned by the zoo is that they should be relevant to animals and conservation and be colourful and striking. The prospective participants could use any technique and style to depict any type of animals. Moreover, they were required to submit the mural design beforehand presented on a piece of A3 paper and the approved ones would be actually painted on the provided wall.

Various groups of people participated in the mural painting project including university students, volunteers from different organisations, artists, and celebrities (Matichon, 2012; Prachachart, 2012; ThaiPR, 2012). For the mural considered in this case, it was designed by Natrika and collaboratively painted by herself and the volunteers from Khao Kheow Zoo (Zoothai ZPO, 2012). Natrika is a well-known Thai actress who is also acknowledged as an artist. She regularly creates artworks and arranges art workshops for children in which she teaches them to draw and paint visual images (ThaiPR, 2017a, 2017b). The majority of her

works are colourful brush paintings that usually include handwritten texts as part of the visual elements. Moreover, Natrika has been an activist in various wildlife conservation movements in Thailand and some of her paintings were auctioned for fundraising in some conservation projects (Thai PBS, 2013; ThaiPR, 2009).

The Khao Kheaw team collaborated with Natrika in at least one previous project (ThaiPR, 2009). The Khao Kheaw team are the volunteers from Khao Kheaw Zoo which is an open zoo in Chonburi: a province in the eastern part of Thailand. Khao Kheaw Zoo is known to be a significant organisation in terms of conservation that not only displays wild animals to visitors but it also educates and encourages public members to protect the deteriorating forest and wildlife through a variety of activities (Khao-Kheow, n.d.-a). Besides, it also conducts research studies relating to conservation particularly in Thailand such as the research for breeding rare or endangered species, rehabilitating wild animals before sending them back to the natural forest, or plant breeding to conserve the forest (Khao-Kheow, n.d.-b). The inclusion of the Khao Kheaw team as volunteers to help the artist producing the mural comparatively arranges the science communication event as a two-way communication in the form of citizen science. Instead of scientists taking the benefit of the citizen or public contribution regarding data collection and analysis for a scientific project and the citizen gain some understanding of science (Bowater & Yeoman, 2012), it is clear that in this project, the citizen's contribution was through providing labour support to the artist while the volunteers were probably inspired to learn about or preserve the environment.

Regarding the design of the mural of interest, it can be seen that Natrika substantially appropriates her artistic style to the visual image. In other words, the mural was created with brush painting that adopted various vivid colours and included handwritten texts within it. According to an interview with the artist (Zoothai ZPO, 2012), the mural design was underpinned by her personal presumption that both animals and human beings have similar red coloured blood, and to a certain extent, wildlife may also have some kinds of feelings similar to those experienced by human beings. The visual image is primarily aimed at inspiring viewers to have sympathy for animals that may then lead to conservation or behaviours which avoid imposing any threat on them (Thai PBS, 2012). It features a variety of species in order to emphasise their differences and the similarity in terms of their blood colour (Zoothai ZPO, 2012). In addition, the artist intended to create the mural to be perceived as an artwork. As such, besides promoting zoo visitation, the exhibit of the mural along with other murals may create a wall that is striking enough to attract audiences to visit the site merely for viewing those visual images on their own account.

Distribution context

The mural was painted permanently on the outside of Dusit Zoo in Bangkok in 2012 and was there from 2013-2018. Dusit Zoo is situated in the central area of the country and has been

established since 1938 as the first public zoo in Thailand (Dusit zoo, n.d.). It accommodates more than 1300 wild animals and attracts around 2.5 million visitors each year (Thai PBS, 2017). The zoo area covers approximately 46 acres surrounded by several sides of the concrete wall and gates as shown in Fig. 5.8 (Dusit Zoo, n.d.-b; Teeteawthai, 2013). In order to decorate the wall, the zoo started to paint sections of it in 2009 and has been arranging mural painting events around every two years to expand the painted area to the other sections of the wall (Dupont, 2009; MGR, 2009). It is notable that all murals relate to the same theme associating with wildlife and conservation regardless of the years they were painted (Prachachart, 2012; Zoothailand, 2015).

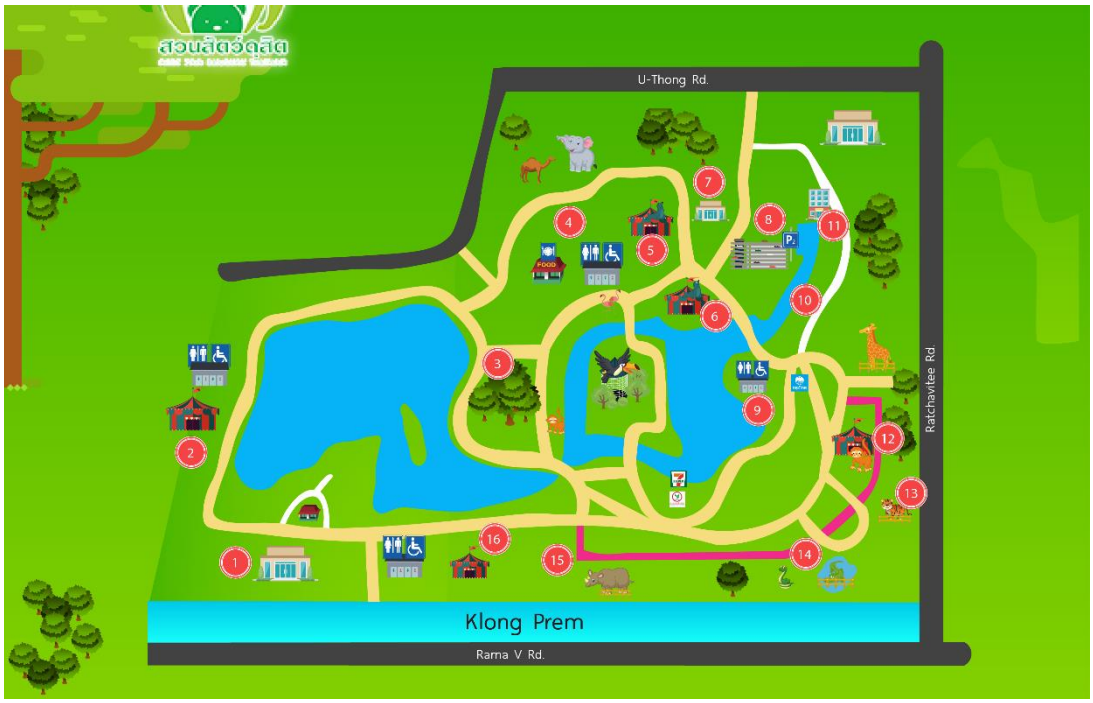


Fig. 5.8: The map of Dusit Zoo, Bangkok, Dusit Zoo [online image] Available at: http://www.dusit.zoothailand.org/en/ewt_news.php?nid=175 [accessed 6th April 2018]

From Fig. 5.8, the mural considered in this case is painted on the wall on the side facing U-tong street (the top side of the map). This side of the wall has a high volume of traffic either from people travelling by cars or from pedestrians because it is opposite several significant places including the Thai parliament and tourist attractions such as Vimanmek mansion museum, or Ananta Samakom Thron Hall (Iverson, 2017; TourismThailand, n.d.). Therefore, the mural is potentially seen by a large number of people and also repeatedly by people who regularly use this route for commuting. It is arguable that the mural is displayed at the position where people are likely to stop and have a greater chance to look at it. This is because, from Fig. 5.7, it can be seen that the mural is near a bus stop which is also opposite the parliament entrance and the zebra crossing. In addition, by having a broad pavement, this side of the wall provides good viewing space for pedestrians in which they

can spend some time viewing the mural from different angles and distances without causing any congestion.

It is notable that the mural is depicted alongside a number of other murals on the same wall. As a result, the continuation of several colourful murals containing the same theme of their subject matters may cause habituation or the decline of attention in the mural viewing (Irvine, 2012; Manghani, 2013). Nevertheless, such an effect might be mitigated since the mural is distinct from the neighbouring murals through its featured components. The mural of interest contains written texts as part of its visual elements which is not only different from other murals mainly depicting objects (Kennedy, 1985; Riggle, 2010), but it also provides both visual and verbal stimuli for viewing. As such, the mural may be attractive to audiences with different learning styles and probably requires less effort for the determination of its meaning (Kolb & Kolb, 2013; Paivio, 1990; Tabbers, Martens, & Merriënboer, 2004). Moreover, the shapes of the tree and the speech bubble within the mural which potentially resemble a couple of large clouds may increase the visual weight and rhythm of the visual image allowing it to become dominant from the surrounding murals (Bradley, 2014c, 2015a; Kennedy, 1985).

Reception context

Regarding the subjects represented within the mural, they are recognisable through the selected outline shapes and colours. These visual attributes may be sufficient for recognisability (Abell, 2005; Hopkins, 1998; Hyman, 2006). Therefore, viewers are able to recognise the subjects even although they have encountered them in other contexts with other representations. Viewers are able to recognise the images of animals, plants, and human being. For the representation of the human, although it might be irrational and not naturalistic, it can be perceived as the image of a person (Bradley, 1997; Waldberg, 1997). This might be because the body consists of parts and proportions, as well as the eye features which might be sufficient to partly resemble a human being. Such perception is also underpinned by the context of the mural in which primarily depicts living things found in nature rather than any type of fantasy or imaginative representation. In addition, the inclusion of several creatures and plants can suggest some general ideas associated with the mural. By depicting them together, the mural may represent some aspects of biodiversity or plant-creature relationships found in the ecosystem (Armstrong, 2017; Howe, 1988). For example, the mural can illustrate one function of a tree as being the habitat for some animals.

By having the bird with a noticeable open beak attached to the speech bubble, the visual image represents human verbal communication generally via the use of language. The speech bubble is argued to be a familiar shape regarded as the symbol containing a thought or speech, and in this case, the viewers are intended to be the receivers of such offered messages due to the absence of a particular listener or receiver of such message within the

image (Laurier, 2014; Rigaud, Burie, & Ogier, 2017). This is also endorsed by the gesture of most animals looking directly at viewers as if they are addressing them (Kress & Leeuwen, 2006). It is arguable that the message written in the speech bubble might be fundamentally perceived as the bird's speech. Similarly, the depiction of the bee and the deer facing and overlapping the speech bubble may also suggest that not only the bird but also the other two animals are proposing such message together. Moreover, although the representations of other animals and the human are not directly attached to the speech bubble, their gestures through smiling faces and the human arm pointing to the speech cloud might show that they are aware of the message and likely to agree with it (Klausner, 1993). As such, the plurality of the living creatures that unitedly acknowledge the same message may suggest ideas of group behaviour. As a result, it potentially influences viewers to pay attention to the statement contained in the speech bubble and to consider it in relation to their personal values and beliefs whether to agree with the proposition or not (Gahagan, 1975).

In terms of the texts written in the speech bubble: "we are the same blood", it is arguable that its colours may emphasise the associated meaning regarding the similarity and difference among the depicted subjects (Goodman, 1976; Kennedy, 1985; Triedman, 2015). The appropriation of several colours for the words "we" and "are" may underpin the variety of the group members and their different characteristics. Such expression is congruent with the depiction of various living creatures to illustrate their diversity. Due to their gestures of proposing the message, the word "we" in this context can be understood as the pronoun referring to all of them as one group. Nevertheless, the differences perceived either through the visual representation or the several colours chosen for the written words are contrasted with the single colour of the words "the", "same", and "blood". As a result, it may promote a literal meaning regarding their identity as the group of members who possess a common feature: their blood especially their blood colour. The single red colour of the word "blood" not only emphasises their similarity but it may also underline the fact regarding the colour of the blood as being red itself. In addition, it is notable that the texts are written in English while the majority of audiences are likely to be Thai people who use English as a second language. Presumably, some of them cannot understand such written texts. However, with the national EF EPI (English Proficiency Index) at the low proficiency level corresponding to CEFR level B1, it is arguable that viewers with some basic English skills might be able to read and interpret such simple English sentence (Jotikasthira, 2017).

Particularly for Thai viewers who can understand the English sentence, besides the literal interpretation, they might attain further associated connotations. The phrase "the same blood" can be interpreted as *"Luad Deaw Gun"* in Thai which denotes lineage or family (Longdo Dict, n.d.-h). It is arguable that Thai people are familiar with such connotation in which the word *"Luad"* (blood) is usually related to family relationships. For example, there is a saying *"Luad Kon Kwa Nam"* corresponding to "blood is thicker than water" which is

commonly used in people's daily life to connote that the relationship with persons belonged to the same family is stronger or more significant than that with others (Longdo Dict, n.d.-g). Incidentally, this is also a saying in English. Hence, the sentence "we are the same blood" can be contextually perceived as "we are the same family". It is notable that Thai people are accustomed to living in a large or extended family. It is the result of a value esteemed by Thai people to take responsibility for one's parents by living with them or continually taking care of them (Klausner, 1993). Such practice in a family is also extended to other social structures such as in workplaces. It becomes the norm of pseudo-sibling relationship to treat others kindly as if they were one's family members (Burapharat, 2009). As a result, most Thai people can recognise such type of relationship conveyed in the mural and well acknowledge its associated proper social behaviours. Therefore, the written text probably suggests the family-like relationship as the desirable relationship leading to harmony between depicted creatures including human beings. Also, such perception may be endorsed by a number of peace symbols which can be understood by viewers who have learned their meaning.

It is possible that the depiction of the human being in the mural is featured to represent viewers themselves as being the members of the ecosystem, and the exaggeration of the eye part may suggest their role within such system. By viewing the eye in the unusual representation, a viewer may be encouraged to negotiate its potential meaning from all possibilities (Anglin et al., 2004; Lester, 2010). In such a context, one possible idea relevant to the eye can be its primary function to look or watch corresponding to two Thai verbs *"doo"* or *"lae"*. (Longdo Dict, n.d.-b, n.d.-c). Then, in Thai, there is also another verb combining the two words: *"doo-lae"*. Nevertheless, the word "doo-lae" denotes a distinctive meaning that is to take care of, to protect, or to preserve (Longdo Dict, n.d.-c). Therefore, it is arguable that the representation of the oversized eye performs a communicative function by associating the visual element with the meaning in linguistics (Goodman, 1976). As such, it may peripherally bring the Thai verb *"Doo-Lae"* into a viewer's mind and probably be perceived as the role a human being (the viewer) supposed to do that is to preserve or protect things in the ecosystem.

Furthermore, there are Thai synonyms of the word "doo-lae" including "rug" (รักษ์) or "rug-sa" (รักษา), and the homophone of "รักษ์" is "รัก" which means "to love" or "affection" (Longdo Dict, n.d.-a, n.d.-d). While the idea of protection or preservation through the words "doo-lae" (ดูแล), "rug" (รักษ์), or "rug-sa" (รักษา) may be perceived from the depiction of the eye and the surrounding context primarily relevant to conservation, the perception relating to love might also be promoted through the pink tone background colour and the heart shapes as part of the written word "blood". Pink has been adoped commonly in association with romance for decades (Triedman, 2015). Hence, it is presumable that viewers are familiar with such connotation. For Thai viewers, the evidence of such presumption can be seen in the case of

a common phrase *"Kwam Rak Tum Hai Lok Pen See Chom Pu"* meaning "love turns the world into pink colour" (Anakkamontee, 2018). Similarly, there is a well-known Thai song with the hook meaning "let us turn the world into a pink colour by loving each other" (Bodyslam, 2010). The background of a visual image can provide its environmental context in general, and in this case, it might be perceived as the representation of a pretend world which accommodates the featured creatures and plants (Gombrich, 1985; Kress & Leeuwen, 2006). As a result, a viewer possibly understands that there is love in the depicted ecosystem which is also reinforced by the heart shapes commonly acknowledged as the symbol of love (Docevski, 2017).

Last but not least, the symbol representing Lord Ganesha might not significantly contribute to the intended message. However, it may culturally imply a certain characteristic of the mural. Namely, in this context, although such an iconic symbol contains elements resembling the head of an elephant, it is less likely to denote an elephant in general. It is different from other representations of different animals featured in the mural which depicted the full body of those animals rather than just some parts of their bodies. The symbol features only the head part and particularly represents Lord Ganesha who is also widely acknowledged as a character with an elephant head. Most Thai audiences seem to interpret the symbol with such assumption since it is ubiquitous and well-known in Thai society (Wongnet, n.d.). Although the concept of Lord Ganesha is originally associated with wisdom and success, Thai viewers potentially relate such a symbol to art. This may be because the representation of Lord Ganesha has been adopted as the logo of the first Thai college of art for almost a century, and the Lord Ganesha is widely worshipped by Thai people especially artists from most artistic disciplines (SU, n.d.; Wongnet, n.d.). Subsequently, most Thai viewers may be able to recognise the symbol and perceive it as the suggestion that the mural is an artwork or somehow relevant to art. In addition, by arranging the symbol at the top above other depicted subjects, it may also display the respect the mural creator gives to Lord Ganesha which is a familiar practice of worship most Thai people usually enact to their respected gods or idols (Klausner, 1993).

5.2.4 Construction

The visual image and the accompanying written texts considered in this example can construct several aspects associated with the philosophy of environmentalism as in the previous example 5.1. As explained in section 5.1.4 above, the construction of this example can also be considered to present environmental issues and desirable values or actions related to conservation (Barr, 2011; Doyle, 2011; O' Riordan, 1981). In terms of suggesting environmental subject matter, the mural depicts visual elements resembling aspects of the ecosystem found in nature. It consists of several plants, human and non-human animals which may propose the idea of biodiversity. Besides the representation within the mural itself, such construction toward environmentalism is also underpinned by its distribution

context where the venue: the zoo, and the surrounding murals primarily involve wildlife and conservation. Moreover, the representation of the human being in the mural does not only make the mural relevant and engaging to audiences, but also introduces the notion that rather than being an outside observer or alienated from nature, human beings are part of the ecosystem and their interactions within such system can affect all inhabitants including themselves (Crist, Mora, & Engelman, 2017; Kennedy & Krogman, 2012; Stone, 2014).

Nevertheless, instead of explicitly raising elements of environmental problems or their associated fear, or alarming people, this mural may represent an ideal world of the ecosystem. It potentially suggests the goodness of the healthy nature that leads to happiness and harmony within the diversity of its members (Stone, 2014). Such construction can be observed through the accounts of bright colours, smiling faces, and the symbol of peace (Maher et al., 2014; Triedman, 2015). This is also congruent with the romanticism approach adopted widely in environmental movements which sentimentally honours and esteems nature (Park & Allaby, 2017; Radkau, 2014). The primary consideration of romanticism is the characteristic of the relationship between the constituents of a system which is argued to accommodate liberty, solidarity, and equality (Burgum, 1941). In this context, the mural focuses considerably on such a type of relationship between human beings and nature primarily consisting of plants and wildlife.

As such, the mural crystalises the concept of romanticism into the recognisable aspects of love and family-like relationships. As explained in the previous section, the idea of love is constructed by the pink background colour and the heart shapes while the family relationship is mainly articulated by the written texts: “we are the same blood”. Particularly for Thai viewers, this sentence in English can be translated into a Thai sentence that commonly denotes a family relationship. When such representation is presented to Thai people who are argued to hold a cultural value to take responsibility for their family members (Klausner, 1993), it may metaphorically introduce such familiar human relationship to the realm of the ecosystem making the association of a relationship between humans and nature. As a result, a viewer may be encouraged to extend the sense of responsibility toward non-human animals and plants. Such a concept espoused by romanticism potentially raises the idea of kinship and sympathy for nature which may also lead to the prevention of animal cruelty or deforestation (Jones, 2009).

Furthermore, the appropriate behaviour of humans within the ecosystem can be suggested by the depiction of the human with the oversized eye as the head. Such surrealistic representation diverse from reality not only captures viewers’ attention through the element of surprise but, due to being claimed to be logically articulated by the image creator, it also prompts viewers to figure out its intended meaning (Bradley, 1997; Jorgensen, 2014; Messaris, 1997; Waldberg, 1997). In this case, the representation of the eye, together with

the familiarity of Thai words regarding synonyms and homophones associating with the eye, potentially leads a viewer to attain the proposed behaviour for conservation that is to protect or preserve nature. Besides the surreal eye depiction, the overall mural is also constructed with several elements of surrealism such as the use of colours or the unnatural proportions of depicted subjects (Bradley, 1997; Waldberg, 1997). By depicting the visual image in such surrealistic fashion, it is arguable that, despite the absence of some realistic features, the mural is capable of constructing imaginative concepts as well as dreams or expectations such as the ideal ecosystem in this case potentially to inspire values and actions for conservation (Bratu, 2010).

5.3 Summary

The exemplified visual images analysed in this chapter are murals which contain conceptual messages relevant to science. From both cases, a science-related worldview or proposition, which contains certain aspects of value or evaluation toward science (Hill & Helmers, 2004; Messaris, 1997), might be perceived by audiences. Namely, cases 5.1 (mural 'Seeing red') and 5.2 (mural 'We are the same blood') can peripherally direct an audience to the consideration of a science-based movement like environmental conservation.

They adopt some iconic signs to represent subjects like the depiction of a girl, animals, and plants as the components associated with the subject matters. However, the recognition of some depicted subjects might not be achieved straightforwardly such as in case 5.2, the mural represents a human being in an unusual form. This may raise an audience engagement or contemplation by provoking one's mind to resolve the challenge of visual search (Rumelhart & Norman, 1981; Winn, 2014; Wolfe, 1988). Both cases also appropriate certain symbols to suggest intended meanings. For example, case 5.1 depicts the white cross on a red background which may be structurally close to the symbol of the *Red Cross* movement, or case 5.2 depicts the nuclear disarmament logo, heart shapes, speech cloud, and the 'Om' syllable(ॐ) to respectively suggest peace, love and affection, speech, and art. The determination of a symbol is based on prior knowledge stored in one's mental schemata, namely the structural memory outlining the relationship between a symbol and its interconnected facts or idea (Winn, 2014). Nevertheless, such learnt knowledge required for accurately perceiving a symbolic representation might not be accessible to a broad range of audiences but exclusive to one culture.

Besides the visual representation, the written texts provided in case 5.1 (mural 'Seeing red') possibly provoke a certain emotional response to be brought into consideration. Namely, the written hashtag: 'Seeing red' may stimulate a sense of anger to be included in the mural interpretation. This relies on the audience being familiar with the idiom 'seeing red' and its associated meaning. The audience's prior knowledge arguably plays a major role in determining the potential meanings which are not always explicit and rather regarded as a

given context for articulating a concept (Anderson et al., 1977; Bransford & Johnson, 1972). As a result, a textual cue can promote learning by giving a chance for creativity or creation of relationships between factors which consequently either augment or alter a preexisting schema or creates a new one (Rumelhart & Norman, 1981; Kornalijnslijper, Theune, Van Dijk & Karreman, 2012).

Regarding the aspect of learning outcome primarily associated with cases 5.1 and 5.2: enjoyment or inspiration, it might be enabled through visual images since viewing them can be satisfactory or aesthetically pleasurable (Arnheim, 2004; Reid, 1973; Watzl, 2017; Wolfe, 1988). In relation to this aspect, the accurate interpretation constructed through textual/verbal information may be less significant. The polysemic nature of visual representation also notably plays a significant role in inspiring an audience to reflect on the associated subject matter (Bloomer, 1976). For instance, murals 5.1 and 5.2 are presented through the additive combination of a visual image and the written texts. That is the main contents are visually depicted in the form of cartoon illustration, and the written texts may serve as the amplification of such portrayed message.

It can be seen in these cases that the visual representations heavily rely on the capacity of the visual images regarding the pretence or make-believe property which does not necessarily comply with the familiar or realistic images of things (Kulvicki, 2014). Together with containing aesthetic features, they are suitable for representing an imaginative or conceptual aspect not necessarily occurring in reality. As such, they may resonate with certain feelings or stimulate the reconstruction of meanings in a viewer's mind which occasionally initiates an idea or creativity similar to innovation in the scientific practice (Gardner, 1982; Gregory, 1980; Spearman, 1930).

Chapter 6
Visual images adopted for science communication

This chapter continues providing the analyses of two exemplified cases based on the discourse analysis framework (Kenney, 2009) similar to the two previous chapters which also contribute to the answers of RQ1 and RQ2. Meanwhile, the aspect of learning outcomes associated with this chapter is to give information or develop knowledge. The two visual images examined in this chapter are sampled from the same exhibition: 'Light Works' arranged in the UK. 'Light Works' is a photographic exhibition organised by the Royal Photographic Society (RPS) which happened at the same time as the International Year of Light celebration in 2015. Each featured photograph was printed on a large, custom panel and the actual exhibition was displayed outdoor across the UK in cities such as London, Belfast, and Edinburgh which is the venue focused on in this chapter. The 'Light works' exhibition is also digitally published online containing all photographs and their accompanying written texts (title and description) which is available at http://www.rps.org/exhibitions-and-competitions/exhibitions-archive/rps-light-works-exhibition/1).

Since both cases are associated with the same exhibition, this chapter comprises two aspects of analysis including the consideration of the overall exhibition (section 6.1), and the discourse analysis of two individual visual images selected from the exhibition (sections 6.2 and 6.3). Regarding the exhibition overall, all deployed photographs were examined through the analysis of their contents and characteristics. The image contents were classified regarding the associated type/wavelength of light, scientific subjects, applications, type of images i.e. scientific images, images of light application, microscopic images, and medical imaging following the categories adopted by the curator to gather potential visual images (RPS, 2015b). Image characteristics considered include the approach of representation i.e. narrative, analytic, or classificational process; the size of frame i.e. close, middle, or far distant of a depicted subject to the image's surface; and the image's point of view/camera angle i.e. high/low angle or eye-level and frontal/top-down or oblique view. These latter aspects of consideration are congruent with the visual analysis framework proposed by Kress & Leeuwen (2006) which provides a useful guidance for analysing the semiotical construction elaborated through the structure of a visual image. The results of the overall analysis are shown in Appendix D and explained as follows.

6.1 The overall ‘Light Works’ exhibition

6.1.1 Overall content

Subject

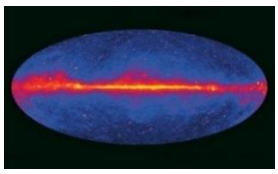
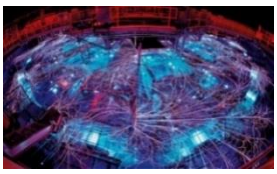
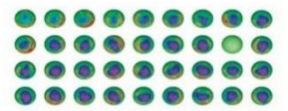
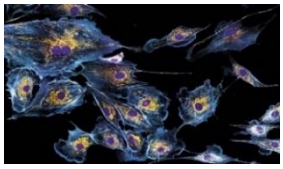
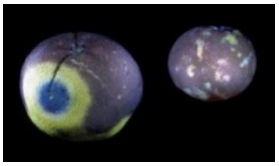
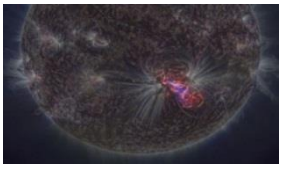
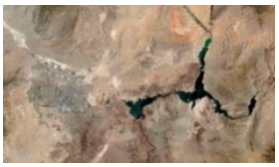
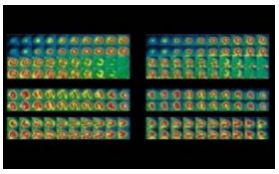
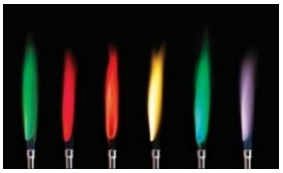
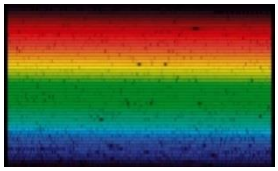
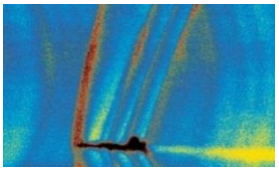
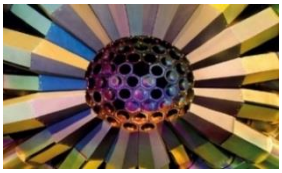
The exhibition consists of 50 photographs as shown in Table 6.1 or Appendix D. The analysis in this chapter refers to individual visual images in the exhibition corresponding to their numbers assigned in Table 6.1. The exhibition features the various roles of light and involves several scientific disciplines and areas of application. The exhibition entails different types of light corresponding to their wavelengths, ranging from the shorter wavelength: Gamma-ray to the longer one: radio wave. From Table 6.1, it can be seen that various subjects are depicted in those photographs including some visible or directly observable phenomena such as images 2, 5, 13, 25, 32; some phenomena that are invisible without technical observing devices such as images 3, 7, 10, 27, 34, 39, 44, 48; and the representation of non-visual data obtained from observation or measurement such as images 42, 46. As such, to explain the overall information portrayed in the exhibition, it might be useful to consider the content structure of the photographs which can be distinguished into two major groups: narrative or conceptual representation, although some visual images may include both types of representation by embedding one structure with the other one (Kress & Leeuwen, 2006).

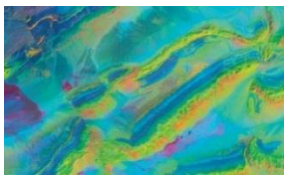
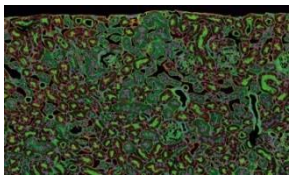
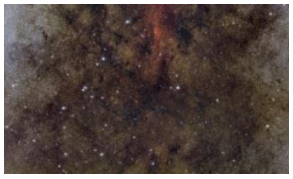
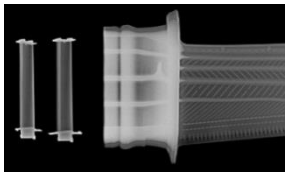
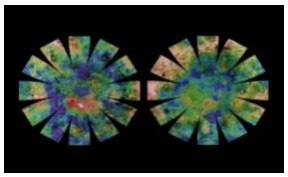
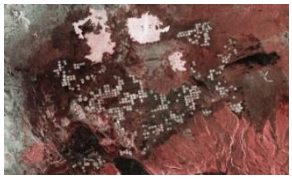
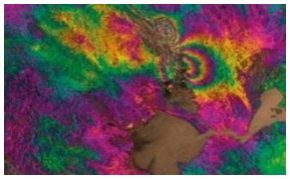
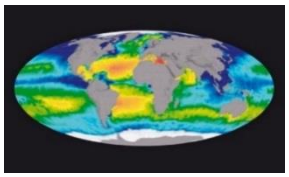
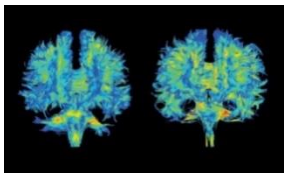
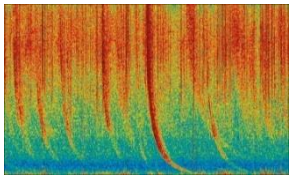
The narrative representation indicates visual images which contain at least a form of action observable through a perceptual ‘vector’ associated with a depicted subject. The vector may demonstrate either an action between depicted subjects, an action/reaction toward something outside the visual image, or an action toward the image’s viewers. By considering the depicted subjects of visual images in this exhibition, it can be seen that some of them may involve different types of actions. Some of the visual images in this group display the role of light as the performer depicted within a visual image, namely the direct application of light such as image 2: the firing of light, image 19: shining light on the baby, or image 32: melting chocolate shells. Meanwhile, others present the light as the entity enabling the featured occurrence to be observable which, otherwise, might be invisible to the naked eye such as image 18: the bending path of sunlight is adopted to observe the depicted shock waves, or image 45: X-ray technology is utilised to capture the kissing couple in the skeletal form.

Nevertheless, the majority of the featured photographs in the exhibition are arguably conceptual representations which depict their main subjects without any particular action. Also, some of them are represented in a decontextualised fashion, namely there is the absence of their surrounding contexts or background. Conceptional photographs mainly display attributes of depicted subjects which allow viewers to see their physical appearances or significant features such as image 1: the whole sky, image 7: Lung cells, image 50: the Centaurus A galaxy, or different types of maps like images 11, 14, 26, 39, 40. Some of these

visual images, rather than depict a light phenomenon, are arguably adopted to promote the role of light in enabling the observation or visual recording of things such as some microscopic or X-ray images. Moreover, there is a visual image in this group: image 13 which can be particularly considered as classificational representation illustrating the variations of different colours of burning salts (Kress & Leeuwen, 2006).

Table 6.1: The visual images featured in the 'Light Works' exhibition (RPS, n.d.-a)

No.	Visual image	No.	Visual image	No.	Visual image
1		2		3	
4		5		6	
7		8		9	
10		11		12	
13		14		15	
16		17		18	
19		20		21	
22		23		24	

No.	Visual image	No.	Visual image	No.	Visual image
25		26		27	
28		29		30	
31		32		33	
34		35		36	
37		38		39	
40		41		42	
43		44		45	
46		47		48	
49		50			

Composition

Several photographs depict their main subjects with the absence of background contexts (Kress & Leeuwen, 2006). Instead, they primarily contain either white or black background or fill the frame with a cropped area focusing mainly on the selected subject. From such a group of visual images, those depicting only a single subject tend to place it at the centre of the frame such as, from Table 6.1, images 1, 10, 42, 47, 49. Meanwhile, visual images containing several elements may arrange them in the left-right or top-bottom fashions which also correspond to the order or location described in accompanying written texts such as images 3, 6, 12, and 37. It is noticeable that a visual image containing three subjects/elements such as image 35 places them along the horizontal line congruent with a conventional composition used in various kinds of visual media (Kress & Leeuwen, 2006). Such composition normally places a well-known or familiar content on the left side and introduces a new or unfamiliar one on the right side, whereby the content presented in the middle may serve as the bridge or connection between such two aspects. Similarly, the symmetrical composition of the classificational representation as seen in image 13 is also a feature commonly found in this kind of visual images (Kress & Leeuwen, 2006). In addition, although some visual images may retain some background details, their subjects are still perceivably dominant such as images 15, 30, 31, 36. The inclusion of background details probably suggests the surrounding context of the main subject and may also increase the photographs' authenticity affirming that it is likely to represent an actual phenomenon happening in reality as opposed to a contrived image (Kress & Leeuwen, 2006).

Visual perspective

For some de-contextualised visual images (those without background details) as explained above, they display some generalised aspects of objects. They appear to communicate with audiences in a one-way delivery mode since there is no gaze or contact made by the portrayed subjects (Kress & Leeuwen, 2006). In other words, visual images do not directly demand a viewer's interaction. Instead, they are presented in the exhibition for contemplation and viewers are the onlookers who might perceive or engage with the photographs to an extent depending on their willingness. Such implications can also be asserted by considering the visual perspective of visual images. It shows that most of them depict subjects from a top-down or direct/frontal angle which can diminish the perceptual depth within the visual images and highlight the depicted subjects.

Some photographs display subjects from a high camera angle which might suggest the power of viewers over them such as images 8, 14, 15, 37. However, such potential attitudinal effects might be neutralised by an image's oblique horizontal angle that may suggest the detachment between viewers and the depicted subjects (Kress & Leeuwen, 2006; Lester, 2010; Messaris, 1997). Similarly, the visual distance or framing of visual images are rather at

a middle or long distance that may also suggest impersonal or formal relationships. Nevertheless, there might be an exception for image 45 in which portrays the cropped subject at close up. It is arguable that such a close-up photograph might be able to stimulate a sense of personal relationship and involvement with audiences although such effect might be reduced by the decontextualisation and neutralisation of the visual image through the reduced depth and the absence of background as mentioned above.

Tonality and colour

Besides naturalistic photographs and three-dimensional representation, some photographs feature a variety of tonalities to form perceptual depths of the depicted subjects such as seen in images 1, 42, 44, 45, 46. For naturalistic photographs such as images 5, 15, 25, and 36, they present some colours that might be consistent with the object's properties observable by the naked eye. Meanwhile, some photographs contain particular scientific or technological colour coding in which colours convey scientific facts or measurable data such as seen in images 6, 31, 41, and 46. For the majority of these visual images, colours are mainly used for a functional or objective purpose rather than social or emotional ones.

Look and gesture

The absence of a gaze looking at viewers may underpin the impersonal relationship between the depicted subject and the viewer which may emphasise the objectivity of these photographs. For example, image 4 depicts hands in the gesture that probably asks for a viewers' response. However, the magnitude of intention for personal interaction might be reduced by several factors such as the absence of its relevant context (background details), human face, and natural skin colour. These features can also present the depicted hands as an object to be observed rather than to have an interaction.

Size relationships

Although the size relationships of subjects in the photographs are diverse, it is notable, particularly in the classification representation like image 13, that the variables under the same category tend to be depicted in the identical size. This is also the case for visual images comparing different versions of a subject such as images 6, 35, or 44. Moreover, some visual images manipulate the scale of featured elements corresponding to a geometrical perspective. This results in the imitation of realistic size relationships between objects situated at different distances such as images 8 or 37. By scaling and arranging the subjects in such fashion, it may enhance the viewing experience by making the subjects become more tangible and attractive on a flat surface (Heller, Brackett, & Scroggs, 2002; Ling, Nefs, Brinkman, Qu, & Heynderickx, 2013).

Accompanying written texts

By considering the composition of each panel which displays a large visual image with a small text box at the bottom-left corner, the exhibition primarily engages audiences through visual elements and provides more information about the visual images through written texts. The written texts accompanying each visual image consist of three parts including the image title, the narration of relevant information and details of the image creator. For most panels, the image titles mainly identify what is depicted in the visual images. Meanwhile, the descriptions may include information, specific names or terminologies relevant to the visual image and in some cases, an analogy is given to support audience understanding, for example, image 38. Regarding the image creators, they may be designated as the name of scientific institutes, companies or individuals. Some names of image creators, which might not be recognisable by audiences, potentially serve as keywords for acquiring more information about the visual image probably via the Internet. Furthermore, along with the written texts, there is also the QR code for accessing the exhibition online, and a diagram identifying the type and wavelength of the light associated with each visual image.

6.1.2 Overall size and space

There are 50 photographs displayed in the exhibition, each of which is printed on a rectangular panel along with its accompanying written texts and a QR code. The panel's dimension is 2 m (width) x 1.5 m (height). Each pair of the panels are assembled together back-to-back, hence, there are 25 stands of photographs and some other stands giving general information about the exhibition itself. The exhibition was held in public spaces across the UK where the stands were arranged according to the venue characteristics. Subsequently, there were different sizes and shapes of the exhibition space. However, it is notable that the arrangement of the exhibition might direct viewing paths for viewers to walk along with the panels such as that shown in Fig. 6.1 when it was held in the courtyard at Burlington House, London. In Edinburgh, the exhibition was displayed at the Northeast corner of the St Andrew Square garden as shown in Fig. 6.2 where the stands were placed around an area covering approximately 900 m^2 as shown in Figs. 6.3(a-c). With a number of visual images and their large size, it is arguable that the exhibition might be dominant and distinct from its surrounding environment and conspicuous enough to attract attention from passers-by. It should be noted that the venue's characteristic of the event may affect its opportunity to be encountered by audiences as well as the demographic of potential audiences. For example, the event arranged at Burlington House, London, which is a cultural centre for learned society about art and science (Burlington House, n.d.), might be exclusive to individuals already having interest in science or being enthusiastic to learn or participate in the event. Such an event may be obscured from the daily life context where the event would be casually encountered by members of the public regardless of their interest in science.

Fig. 6.1: The Light Works exhibition being displayed in the courtyard at Burlington House, London. Credit: Keith Smith/RAS. https://www.ras.org.uk/news-and-press/news-archive/259-news-2015/2582-light-works-exhibition-now-open

Fig. 6.2: The exhibition space when it was displayed in the St Andrew Square Garden, Edinburgh (Google Earth, 2017)

Fig. 6.3(a): A photograph was taken from a position within the ‘Light Works’ exhibition to illustrate the arrangement of its panels in Edinburgh

Fig. 6.3(b): A photograph taken from a position within the ‘Light Works’ exhibition to illustrate the arrangement of its panels in Edinburgh with the presence of an audience

Fig. 6.3(c): A photograph was taken from a position outside the area of the ‘Light Works’ exhibition to illustrate the arrangement of its panels in Edinburgh

6.1.3 The context of the overall exhibition

Production context

The incentive to develop the exhibition was influenced by the theme set by UNESCO (United Nations Educational, Scientific and Cultural Organisation) in 2015. The year 2015 was declared the International Year of Light 2015 when the importance of light and optical technologies in people's daily lives and society were promoted (IYL2015, 2015). The 'Light Works' exhibition was created to emphasise this initiative. The collaboration with a global event is beneficial to the exhibition in terms of a potential higher level of attention when its subject matter is already acknowledged through several mainstream channels promoting the International Year of Light (Bowater & Yeoman, 2012).

The exhibition was organised by the Royal Photographic Society (RPS) which promotes public knowledge and understanding of photography. One major area of the RPS's work entails highlighting scientific imaging technology in addition to science-related photographs (RPS, n.d.). Some photographs within such categories were curated to be displayed in the exhibition to illustrate the use of different types of light (RPS, 2015b). The aims of the exhibition expected by the organisation and the curator might be slightly different though both agents aimed to reach out to the wider public instead of specialist audiences. While the RPS mainly expected to raise awareness that photography can be utilised to portray various disciplines including science, the curator intended to show that science can create beautiful images which are also meaningful. With such intention, the curator tended to include beautiful photographs in the exhibition. In other words, the selected visual image might be perceived aesthetically in the first instance such as with respect to their colours, brightness, shape and composition (Hamilton, 2015).

In addition, there is also the secondary objective to encourage audiences to learn some science. Nevertheless, rather than imposing factual information to audiences as if it was conducted through a deficit-model approach, the exhibition attempts to engage audiences with attractive and inspiring visual images and captions. Meanwhile, the accompanying written texts are included to provide explanations and information about the subjects, application, or imaging techniques relevant to each visual image. Therefore, audiences can explore the exhibition and voluntarily acquire some scientific knowledge at their paces and satisfactory extents.

From the information the curator provided for the event press release (RPS, 2015b), the curation process began by establishing the concept of the exhibition i.e. to provide a journey through the electromagnetic spectrum. As such, the curator listed different kinds of light existing along the light spectrum. The curator then gathered photographs relevant to different wavelengths of light from existing photographs. He also collaborated with scientists and image creators to produce new photographs to complement those in the existing archive. It

is possible that a large number of related images might arise in the process of curation. However, in order to select visual images to be featured in the exhibition, the curator categorised the potential ones into groups and selected some photographs for each category comprising

- Scientific images, particularly showing that light is used as a probe in scientific imaging technique to obtain scientific data and in this dimension, the data contained in visual images are likely to be read or analysed scientifically;
- Photographs showing that light is used to see microscopic items;
- Medical imaging including a series of scan images such as MRI or CT to show that light is also used in medical treatment beneficial to people;
- Light application photographs that do not necessarily convey scientific data but show light applications either in the laboratory or everyday life environment.

Distribution context

Due to the intention to reach a broad range of audiences, the exhibition is displayed in different public spaces where it can be easily seen by public members especially passers-by who might not be initially interested in science. Not only did the global event/theme as the Year of Light influence the exhibition development, but the timing of local events also influenced its venues and durations. The exhibition was held at different venues throughout the UK as part of ongoing local events. This research focuses on the event in Edinburgh between 3rd March and 17th April overlapping with the Edinburgh International Science Festival in 2015. This was also an efficient way to promote the exhibition i.e. alongside the annual science festival which has a high level of publicity. The venue is an open space situated in the central area of the city surrounded by streets, shops, restaurants, bus and tram stops. Therefore, there are a high number of passers-by who may come across the exhibition incidentally, see those large visual images from afar, or deliberately make a plan to visit the exhibition. The large dimensions of these visual images make them attractive, eye-catching and capable of displaying content in detail which is coherently suggested in a previous study as a significant feature for communicating scientific images (Smith et al., 2014). In addition, the long period of display time (longer than a month) may also increase the viewing opportunity as well as give a greater chance for revisitation.

Although the exhibition claimed to be a journey through the electromagnetic spectrum from Gamma rays to radio waves, the presentation of those types of light to audiences seems to be random instead of orderly arranged either from the shortest wavelength to the highest one or vice versa. This might be the result of the different characteristics of the venues selected that may affect the arrangement of the panels such as seen in Figs. 6.1 and 6.3(a-c). Moreover, audiences could access the exhibition from various entrances resulting in several possible viewing paths. Therefore, it is rather difficult to direct a single path for

orderly viewing of visual images. In addition, the visual images are also published online on the project website. In such online distribution, they are arranged by their numbers which seem to correspond to their wavelengths from the shortest to the highest one. However, this is not always the case since some photographs are not arranged in their supposed positions. It can be suggested that the intended exploration and understanding of the exhibition might be enhanced by a well-organised arrangement and viewing path that may lead audiences through the electromagnetic spectrum in an orderly manner.

Reception context

The participation and reception of audiences toward the exhibition can occur by different extents as reflected in the exhibition evaluation results. Some visitors might look at those photographs from an aesthetic aspect in terms of their colours, shapes, composition, or imaging techniques. Meanwhile, other visitors might consider the images further by reading the written details. The degree of audience participation can also be inconsistent for example when audiences selectively explore the exhibition. This might affect the perception of either a selectively-viewed visual image(s) or the overall exhibition. However, both viewing manners are able to demonstrate that science can enable the production of stunning photographs, and the application of light is beneficial to several facets of society.

According to the exhibition evaluation results obtained from the event's facilitator, there were 55 visitors who conducted the online survey and the results can be summarised in Table 6.2. It should be noted that there might be some limitation in the results which may hinder the generalisation of the findings. The survey participants are those who needed to access the provided URL for contributing the evaluation. This probably reflect their considerable interest to participate in the event. As such, the obtained results may not be sufficient to represent the experience and attitude of all audiences such as those who just viewed visual images and barely read their accompanying written texts. Nevertheless, from Table 6.2, it may suggest that more than 80% of respondents were not aware of the International Year of Light 2015 prior to visiting the exhibition, and more than 70% of respondents came across the exhibition incidentally. This may show that the exhibition had the potential to attract audiences on its own account. The respondents were asked to rate particular statements about the exhibition as well as to give an opinion about the exhibition. The results show that the exhibition gained positive feedbacks and could demonstrate that it could fulfil its expected learning outcomes.

The stunning and inspiring images were attractive and able to draw people's attention. They may also have aroused curiosity in some audience members who would like to know more about the visual images. Subsequently, these audience members had a chance to learn some science by reading the accompanying captions. Those captions were written in an accessible and relatable way to explain science associated with the depicted images. Almost

70% of respondents revisited the exhibition online after seeing it at the actual sites and the exhibition was shared more than a thousand times through social network sites. It is arguable that the photographic exhibition could encourage some respondents to learn some science. The exhibition may engage audiences with science through visual images which seems more enjoyable and less distancing than written scientific information. The exhibition enabled audiences to be aware of science in their daily lives as well as to be familiar with scientific images.

Table 6.2: The evaluation results of the 'Light Works' exhibition regarding the participation and perception relating to the event (This data is based on 55 respondents and obtained directly from the event's organiser and used with permission)

Statement	Rating results (%) of 55 respondents				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I found Light Works interesting	90	8	2	0	0
I liked the pictures	87	11	2	0	0
I read the captions	62	38	0	0	0
I found the captions helpful	58	32	2	6	2
I found the captions easy to understand	44	45	2	9	0
I used the QR codes	4	4	11	11	70
I looked at the Light Works/RPS website	34	38	4	7	17
Light Works has increased my interest in science	30	41	25	2	2

Although there are several visual images featured in the exhibition associated with different subject matters, only two visual images would be adopted for the individual case analysis. From all photographs, there are many visual images applicable to the case definition and boundary as mentioned in section 3.4.1. To narrow down the number of potential examples, some specific criteria are set for selecting two examples as also explained previously in the same section in Chapter 3. As such, they are supposed to be existing visual images initially created and used in other contexts outside scientific practice and public science communication. The two selected visual images include pictures 32 ('Chocolate Shells' panel) as an example without human being representation and 45 ('X-ray Kiss' panel) as an example including human being representation. The discourse analysis of both selected visual images is presented in the following sections (6.2 and 6.3).

6.2 The analysis of ‘X-ray Kiss’ image

This exemplified case features a Xogram, namely a colourised and enhanced X-ray image. It depicts a kissing couple which is unusual to the content like the body’s parts often displayed in medical X-ray images. The appropriation of such visual image with the accompanying written title and description in this case not only gives scientific information but it probably also suggests the perspective of the Xogram artist on the authenticity of a close relationship. As a result, it may evoke emotional responses from audiences or encourage their self-reflection.

6.2.1 Content

Subjects

Although the photograph is portrayed in the X-ray format as shown in Fig. 6.4, it might be possible to determine that the visual image depicts two persons who were kissing while it was captured. It might be difficult to define their genders though it seemingly shows that the person on the right side of the image places his/her left hand approximately around the neck and face of the person on the left side. Due to the X-ray image properties, the visual image can illustrate pieces of bone and teeth under the skin surface. Also, the skin tissues can be seen as a combination of opaque layers. Together with the unrealistic colourisation, this may suggest that the visual image might be the modified version of a conventional X-ray image.

Fig. 6.4: ‘X-ray Kiss’ visual image, Hugh Turvey [online image] Available at: http://www.rps.org/exhibitions-and-competitions/exhibitions-archive/rps-light-works-exhibition/5 [accessed 20th April 2018]

Composition

The visual image is a cropped image which excludes some parts of the head and body of the subjects and mainly fills the frame with their faces. The image is presented in a balanced composition between the left and the right sides comparatively between the two persons. The separation between the two sides is noticeable through the black background contrasting the edges of both faces. However, such distinct parts are merged around the middle of the image as the act of kissing. As such, kissing is probably the central focus of the visual image. Moreover, the hand of the person on the right side seen at the bottom-left corner of the image not only emphasises the connection between both persons but also equalises the visual weights. Namely, the inclusion of the hand increases some perceptual volume to the left side which otherwise features the smaller area of the person's head than that of another person on the right side.

Visual perspective

The depth of the visual image can be perceived through the layers of opaque elements forming a certain volume occupied by the couple. However, the space behind them is replaced with a black background. As a result, the environment or the context of the scene is excluded from the visual image. Regarding viewing angle and distance, the visual image presents the subjects in an oblique angle which may suggest detachment between them and audiences. As such, audiences are not part of the scene or the couple but observe the represented event as an outsider (Kress & Leeuwen, 2006). Due to being presented in a close-up shot, it may raise a sense that such observation occurs at a personal distance.

Tonality and colour

The contrast between the black background and the bright colours of the foreground makes the subjects dominant within the visual image. In spite of lacking strong shape outlines, the layers of different opaque elements can form some perceivable shapes such as pieces of bones or teeth. Instead of greyscales seen in regular monochrome X-ray images, warm colours are used to enhance the visual image especially those resemble colours of natural skin tones ranging from white to brown. By using these colours, it might also endorse the bareness of the subjects as if they were exposed to audiences who are able to look through them even parts naturally covered by their skins.

Look and gesture

Although the visual image includes persons, it is notable that there is no contact between the depicted subjects and viewers. The subjects probably look at each other within the visual image but do not express any look or gesture to address viewers or demand any response.

Size relationships

Both subjects are portrayed in realistic relational proportions and they are represented approximately in an equal size occupying each side of the visual image as mentioned in the section of visual perspective above.

Accompanying written texts

The visual image is displayed with the title: *'X-ray Kiss',* and a description*: "Discovered in 1895, X-rays are probably most familiar as an aid to medical diagnosis. However, the ability to see beyond the surface and examine the inner structure of things is also being harnessed as an art form. Images such as this, known as Xograms by their maker, look to explore 'inner shadows". Shot on conventional monochrome X-ray film, the images are scanned and digitally colourised'* (RPS, 2015).

It can be seen that an image title can define the action portrayed in the image (kissing), while the word 'X-ray' might suggest the form or category of the image itself. In terms of the description, although it does not literally explain the depicted subjects, it provides some information associated with the visual image. It starts with the conventional use of X-rays and extends to the application outside medical examination. Subsequently, it introduces the concept and production of Xograms which might not be familiar to audiences. As such, it is arguable that the accompanying written texts can make the visual image more engaging and comprehensible.

6.2.2 Context

Production context

The 'X-ray Kiss' image is produced by a technique called 'Xogram' by its pioneer: Hugh Turvey. He is a British artist and photographer who has been exploring and using X-ray technology to produce his works since the late 1990s (BIR, n.d.). His works are primarily created for commercials and public and private collections, some of which have been featured in well-known publications, as well as interior installations. This art form has also been acknowledged by the British Institution of Radiology (BIR) and he has become an associated artist of the institute and gives him the opportunity to collaborate with medical and scientific practitioners to enhance patient experiences (BIR, 2014a).

'Xogram' is inspired by photogram or rayograph technique in which an object is placed upon a light-sensitive material and then is exposed to visible light to create a negative shadow on the material (Tate, n.d.). However, 'Xogram' uses X-ray technology in the production process instead of visible light. X-rays can penetrate through solid objects and be absorbed to some degree according to the density of substances (Shubber, 2014). As a result, 'Xogram' images can depict both inner and outer structures of things rather than only exterior shadows like those in the case of rayographs (BIR, 2014b). The 'Xogram' images might be either a monotone or colourful image though the latter case seems to be preferable in order to make

‘Xogram’ images distinct from regular X-ray images. In order to produce such stylised images, an artist might use various X-ray machines with different levels of light intensity to obtain pieces of X-ray film (Bradley, 2014). Subsequently, they are scanned and digitised layered and combined to create a monotone visual image. Then, the process is followed by substantial colourisation to enhance the image’s depth and point of view as well as aesthetic value (Modderman, 2014).

The names of two major exhibitions featuring ‘Xogram’ images include “X-POSE: material and surface”, and “X-perimentalist” (BIR, n.d., 2014b) which not only suggest the production technique using X-rays but might also denote the distinct characteristics of the art form. Namely, ‘Xogram’ images are creative and innovative that can reveal parts of things usually hidden from the eyes. In other words, they might reflect the artist’s view associating with the concept of transparency and truth revealing (BIR, 2014b; Bradley, 2014; Shubber, 2014). Similarly, such a concept seems to be applicable to the image “X-ray Kiss” created by the same artist in which X-ray technology is also utilised to proffer a kiss as explained by the artist himself (BIR, 2014b). The visual image is claimed to be *“an antidote to popular culture’s obsession with the superficial…The consummation of material and surface signs of a love that is deep and substantial, a love that comes from within and without”* (BIR, 2014b). The ‘X-ray Kiss’ image might offer a meaningful message relevant to contemporary society.

Within the scientific exhibition context (‘Light works’ exhibition), the visual image is accompanied by a description mainly about its production technique. Moreover, because it was not created specifically for the exhibition, it might have been primarily curated as an example of ‘Xogram’ images: a form of art that science regarding the application of X-rays makes available through the capability of X-rays to visualise inner parts of the body such as bones and teeth.

Distribution context

The visual image and its accompanying written texts are displayed on a large panel which contributes to the “Light Works” exhibition along with other 49 individual photographs. It is arguable that its distribution context is congruent with that of the overall exhibition as explained previously in section 6.1.3

Reception context

By viewing the visual image, audiences may be able to recognise it as an X-ray image. People in the 21st century are familiar with X-ray images through either direct experience associated with such types of visual representation or in the proliferation of medical dramas on television (Cierniak, 2011). Conventional X-ray images are primarily used in a medical examination in which usually display 2-dimensional, monochrome images of certain internal parts of a person’s body (Aichinger, Dierker, Joite-Barfuß, & Säbel, 2012; Cierniak, 2012).

However, it can be seen that the visual image considered in this case differs from such a concept in terms of its colours and the context of the depicted subjects. Viewers are likely to be able to distinguish it from conventional X-ray images although they have no prior knowledge about Xograms (Lester, 2010).

Regarding the depicted subjects, instead of depicting a particular organ or bones of a person as generally seen in traditional or medical X-ray images (Google, n.d.), the considered visual image features the body parts of two persons probably kissing while one person is placing his/her left hand on the other person's neck. Despite being portrayed in the X-ray format, such act of kissing is still perceivable to viewers since it illustrates some significant features of kissing. In other words, its outline may resemble a familiar representation of kissing found in popular media that features two persons especially the upper part above the shoulders in a close distance with their lips attaching to each other (Getty Images, n.d.-b; Hopkins, 1998; Rankin, 2000). Moreover, such perception of the visual image in relation to the aspects of X-rays and kissing is also underpinned by its title "X-ray Kiss".

The accompanying textual description firstly defines the context of the visual image as being relevant to X-rays by providing its background information as well as reaffirming the common use of X-rays in medical diagnosis. After engaging audiences with such a familiar concept, the description then probably leads audiences further to a new concept: 'Xograms'. To accomplish that, it raises a pertinent capacity of X-rays (to depict the inner structure of things) as the bridge between the two concepts since such property can be creatively applied to the production of artworks. Therefore, the written texts may introduce an unfamiliar idea: X-rays being used in the realm of art. Subsequently, it progresses to such new concept by mentioning the specific term: "Xograms" and explaining relevant information about the image creator's inspiration as well as the production process. In this context, audiences may be able to perceive that the visual image primarily serves as an example of Xograms described by the written texts.

Furthermore, the juxtaposition of the words: "X-ray" (suggesting technical or medical practices), and "Kiss" (denoting human interaction) in the image title may also emphasise the visual image distinctiveness as the emergence of such disparate aspects. This is also coherent with the description that recontextualises the phrase: "inner structure of things" to explain the concept of general X-rays and leads to the phrase: "inner shadows" for Xograms. The contrast between the terms: "structure of things" and "shadows" may also present the juxtaposition of the conventional X-ray images and Xograms, respectively in relation to their objective and subjective characteristics (Cambridge English Dictionary, n.d.-b; Merriam Webster, n.d.). In addition, by writing the phrase: "inner shadows" in the quotation mark, it not only suggests the particularity of the term but may also get special attention from readers and encourage further interpretation of the visual image.

One denotation of the word “shadow” particularly in the psychological context involves the essence of an individual. Although shadow is not necessarily a socially unacceptable or inappropriate aspect of a person, it is usually hidden and concealed by one’s outward personality, namely “mask” which is formed through the influence of society or the external world (Bolea, 2016; Meredith-Owen, 2011). Also, this concept of shadow is congruent with the traditional perception of a person’s inner body as the individual’s soul or his/her nature associating with the mind rather than physical organs or parts of the body primarily considered in the discovery of X-rays (Cierniak, 2011). Therefore, such particular concept may serve as the basis for the visual image representation (BIR, 2014b). To reflect the artist’s intention, the curator used the term: “inner shadows” not only to suggest some ideas toward one’s true self but also promote the relevant dialectic between such inward essence and the outward appearance of a person. The synergy of the two dimensions plays a significant role in any social interaction or relationship between individuals (Bolea, 2016; Lamla, 2009), and the visual image in this case probably accentuates such notion particularly in the aspect of love or romantic relationship.

The representation of kissing is usually appropriated as an emblem of love or affection which is often evident in the case of literature or poems, performances, and other forms of popular media (Ratcliffe, 2014; Smith, 2012). Nevertheless, in contemporary capitalism where society esteems outward characteristics and couples rely heavily on goods and consumer settings to sustain their relationship, it is undeniable that the suggestion of romantic love may also be accompanied by some challenges like its authenticity especially for adult viewers who may have experienced such a relationship (Bolea, 2016; Lamla, 2009). There might be some observable overlapping tissues or layers in the X-ray image (Aichinger et al., 2012) as if there were remaining complexities within the relationship. Nevertheless, the opaque kissing depicted in the visual image probably suggest the love relationship that attempts to pursue honesty or openness between each other rather than to superficially rely on external factors. Such perception is coherently emphasised by the image title: “X-ray Kiss” in which the word: “X-ray” can also involve the act of examination (Oxford Dictionaries, n.d.), as well as the phrase: “look to explore inner shadows” featured in the description. As a result, it may encourage viewers to approach relationships further than the extent of outward appearance, and acknowledge the other’s true identity especially in a close relationship such as love as exemplified in the panel.

6.2.3 Construction

The visual elements and written texts may articulate two aspects of construction. They can deliver some factual information in the context of the overall exhibition. Meanwhile, the visual image on its account may also culturally construct particular meanings. By being part of the exhibition together with other visual images, the visual image may get the viewer’s attention through its substantial size and characteristics which are different from conventional X-ray

images (Lester, 2010). Besides functioning as a visual stimulus for drawing attention, the visual image in association with the written texts is presented to exemplify Xograms: a visual art form adopting X-rays in the production process. In this context, the textual description can posit the advantage of scientific advancement to several aspects of people's lives including art and culture. The description asserts a familiar application of the scientific discovery of X-rays as their significance in medical examination. The first section of the description is arguably recognisable to viewers and may activate their prior memory about the well-known benefits of the use of X-rays in medicine and prompt them for assimilating further new information (Mandler, 1984; Winn, 2014).

The description then proposes another usage of X-rays that is not exclusive to the laboratory or the spheres of science and medicine but is applicable to cultural disciplines such as art. In this latter section of the written texts, some words suggesting aspects of art such as "art form", "shadow", "digitally colourised" might be appropriated in contrast with the phrase: "conventional monochrome X-ray film" in order to accentuate the distinctiveness of Xograms from usual X-ray images. Such perception can be endorsed by the featured visual image regarding its colours and depicted subjects. As a result, the proposition of the written texts evidenced by the exemplified photograph of Xograms potentially affirms that X-ray technology is not only capable of revealing the inner parts of one's body beneficial for medical examination but it also enables artists to visually portray an intended message. They can express the reflection of cultural perspectives in an innovative and aesthetic way.

Based on the researcher analysis of "X-ray Kiss" image, the visual image may culturally construct ideas advocating the myth of authenticity. Authenticity is a social motive based on the assumption that every individual is equipped with an inner essence or true self that may be asserted through interaction with other people (Ferrara, 2009). From essentialist perspectives, in such a process of identity formation, the subjective self, such as one's desires, feelings, or rationality is distinguished from his/her physical appearance or outward behaviours which might be constrained by moral norms within society (Lamla, 2009; Weigert, 2009). A value informed by the authenticity movement is that one's self is worth realising and deserving recognition. As a result, it primarily considers the congruence between outward conducts and one's internal self (Ferrara, 2009). However, in the present world, there are always tensions between the two dimensions, and the quality of authenticity seems to be decreasing to the state claimed by scholars as to the crisis of authenticity (Vannini & Williams, 2009).

From literature relevant to the realm of authenticity, a subject significantly considered in this area is the challenge that contemporary capitalism imposes on the recognition of one's self, and intimate relationship can be one type of human interaction extensively contributing to the understanding of authenticity (Lamla, 2009; Vannini & Williams, 2009). It is argued on the

basis of authenticity that a pure love relationship is supposed to pursue the establishment of mutual emotional stabilisation through the coherence between the outward and inward identities of a couple (Lamla, 2009). Nevertheless, a research study showed that within the contemporary capitalism, couples tend to cultivate their love relationship via the consumption of love's symbolic objects or activities which may reflect, but cannot be sufficient to guarantee, the internal affirmation of their self-identities (Illouz, 1997). There is a wider gap between the outward conducts and the partners' selves, and the outward expression of love tends to become the superficial mundane practice adopted to avoid an effort to establish a deeper level of self-recognition.

In regard to this visual image, it might be able to reflect the artist's view on such cultural paradox within the intimate relationship that appeals for authenticity and challenges the ongoing movement of capitalism. The visual image adopts the scientific phenomena of X-rays to represent the cultural occurrence metaphorically. In other words, the characteristic of X-ray images to display elements beneath a person's skin is applied to visually elaborate the aspect of authenticity seeking the openness and recognition of one's inner self probably hidden behind an outward mask (Bolea, 2016; Ferrara, 2009). Moreover, the visual image realises such concept of authenticity particularly in terms of the love relationship as a relatable area in which some audiences probably have experienced an extent of authenticity deprivation (Lamla, 2009). It depicts a familiar emblem of love: the kiss performed by a couple to construct the idea of affection in the viewers' mind (Smith, 2012). The cultural construction is also endorsed by written texts using words encouraging the exploration of the inner self that transcends outward appearances and conducts.

6.3 The analysis of 'Chocolate shells' image

This case examines a visual image originally created as a marketing tool to endorse the specifications of a thermal infrared heater. It was included in the product brochure and its associated commercial web page. However, the case analysis explained in this section primarily considers the visual image being used in the context of science communication with a different purpose. In 'Light Works' exhibition, the 'Chocolate shells' image is utilised in combination with written texts to provide an exemplified light application. It not merely gives information relevant to infrared application and the machine but also emphasises the scientific enterprise as a key basis and solution for manufacturing.

6.3.1 Content

Subjects

The visual image as shown in Fig. 6.5 can be considered as two dominant visual elements including the thermal infrared heater and the background area. The heater depicted in the foreground consists of the upper section for installing a light system and the lower part containing plastic moulds. For both parts of the thermal infrared heater, there are

respectively six rows of infrared emitters alternating with sections of hole-punched stainless steel and numerous halves of chocolate shells. The halves are moulded in the same size with uneven rims. Regarding the background, it contains the space behind the infrared heater to a large windowpane as well as some further space behind that the window pane. Although the visual image partially depicts the infrared heater, the diagonal lines corresponding to the rack's shape can present the perceptual continuation of the scene (Bradley, 2014a; Kennedy, 1985). As a result, it is presumable that some further length of the infrared heater and a number of chocolate halves are not included in the visual image as the equipment extends beyond that depicted in the image.

Fig. 6.5: 'Chocolate Shells' visual image, Heraeus Nobelight [online image] Available at: http://www.rps.org/exhibitions-and-competitions/exhibitions-archive/rps-light-works-exhibition/38 [accessed 21st April 2018]

Composition

It can be seen that there are two primary parts of the visual image: the foreground and the background. It is arguable that different sections can be distinguished by their colours and shapes (Bradley, 2014c; Kress & Leeuwen, 2006). In other words, the overall orange colour and the shape of the infrared heater can separate such foreground from the dark background. Also, the infrared heater structure has some space between the light equipment above the plastic moulds which allows the appearance of the background. These two aspects can break the visual volume of the visual image into the dominant top and bottom areas. As a result, it may also encourage audiences to look at them along the vertical line from top to bottom (Bradley, 2014a, 2014c).

Visual perspective

In terms of horizontal angle, the photograph is depicted from an oblique angle which may suggest a disengagement between the represented subjects and viewers (Kress & Leeuwen, 2006). Furthermore, by depicting the infrared heater in this way, it may increase the perceptual depth of the visual image which is also endorsed by the almost endless dark background. Consequently, this may present the illusory size of the infrared heater that is seemingly able to operate a large number of chocolate halves at the same time (Gombrich, 2002).

Regarding the vertical angle, the section of infrared emitters is presented in a low camera angle which may suggest aspects of social power (Kress & Leeuwen, 2006). Therefore, in this context, the visual image not only shows that the light is flooded from above the plastic moulds but it also accentuates the agency of light (infrared) playing a significant role in regulating such operation. Meanwhile, the chocolate shells at the bottom part of the visual image are depicted approximately at the eye level. By doing that, it may diminish the gap between each chocolate halves resulting in the perceptual blending of their rims. It emphasises the countless number of the chocolate halves which is congruent with the illusory effect on the size of the infrared heater mentioned above.

In addition, the overall depth of the visual image can be perceived in the background area. Although it is rather dark, the brighter area of the window pane can define a certain depth to the visual image such as from the closest chocolate halve at the front to the wall of the room. By keeping such naturalistic depth, the visual image provides the environmental context of the scene which may increase its realness (Kress & Leeuwen, 2006).

Tonality and colour

It is notable that the light emitted from the infrared equipment illuminates all dominant subjects in orange or yellowish colour and creates natural highlight and shadow within the visual image. The vivid orange colour of the foreground can also present a strong contrast with the dark background. Such a visual image characteristic not only emphasises the depicted subjects but may also get an audience's attention (Bradley, 2014b; Kennedy, 1985; Lester, 2010). Furthermore, the orange colour of the visual image may affect viewers psychologically. In other words, it can resemble the warm colour of the light bulb people experience in their daily lives usually associated with a sense of heat or warm temperature (Triedman, 2015). As a result, this may underpin the fact provided in the written description regarding the heat generated in such operation.

Look and gesture

This aspect is not applicable to this case since there are no persons or characters depicted within the visual image.

Size relationships

The visual image represents the subjects in their realistic relational sizes without any special predominance among them. By depicting the scene at an oblique angle, the visual image represents the subjects in a geometric perspective in which the chocolate halves closer to the surface look bigger than those farther away. However, it is arguable that people are familiar with the idea of perception in their everyday lives and are able to analyse the image accordingly (Bloomer, 1976; Howard & Howard, 2012). As a result, viewers can perceive the actual relative sizes of the chocolate halves and acknowledge their identical size.

Accompanying written texts

The accompanying written texts consist of the image title: “Chocolate Shells” and the description: *“Half shells of chocolate pass under a thermal infrared heater at a confectionary factory. This process is used where the final product is made as two half shells, for example chocolate Easter eggs. The two halves are moulded with slightly raised edges. As the halves pass under this lamp, the edges melt. If the product is to have something inside, such as a toy, this is dropped in before the halves are put together, trimmed and allowed to solidify. The halves can be joined empty if a complete filling is added later. Use of heater lamps allows very rapid heating of highly localised areas, preventing the whole item from melting in its mould”* (RPS, 2015a).

The image title identifies one main subject depicted in the visual image: the chocolate shells which some audiences may not be able to recognise them at the first instance of viewing the visual image. Meanwhile, the description plays a crucial role in explaining the operation happening at the moment the visual image was captured. It also provides information about the relevant procedures not depicted in the visual image (i.e. prior and potential latter stages), as well as an example of the final products. It can be seen in this case that the visual image might be presented as an engaging element that can lead to its associated information provided in the description.

6.3.2 Context

Production context

The visual image is owned by Heraeus, an international technology group based in Germany who is a material supplier as well as delivers various technological solutions including the infrared heat application for industries (Heraeus, n.d.-a). In the context of business and marketing, the visual image is professionally created for a primary purpose to introduce or advertise a product or service. Therefore besides representing the likeness of the product, it may be intentionally created with production techniques in order to propose certain values that contribute to the persuasive accounts of the product (Messaris, 1997). Particularly for visual images appearing in technological product advertisement, they potentially emphasise

the product's significant attributes either in terms of its physical appearance or favourable features (Johnson, 2008; Korgaonkar, Bellenger, & Smith, 1986).

Such characteristics of advertising images are also applicable to the visual image considered in this case. It was originally produced for target audiences who are likely to be food industries or technical staff. As described earlier in the section of visual image content, it illustrates the structure and main attributes of the thermal infrared heater, especially while it is operating. Furthermore, the visual image may present several elements endorsing the product's key facts provided by sales-persons or accompanying written descriptions. Corresponding to the features of the infrared heating system proposed by the company (Heraeus, n.d.-b), the visual image may emphasise the capacity of the infrared system. In other words, by representing innumerable chocolate halves identical in their size, the visual image can suggest that the infrared heater is capable of managing the industrial scale of production and delivering an exceptional control regarding the finished products' consistency. By depicting the light shining on the area of the chocolate halves placed in the plastic moulds, it can demonstrate the ability of the infrared system to localise the heat which is a significant feature required in the heat application for filled products such as Easter eggs. Moreover, the bright area of the infrared heater in the foreground contrasting with the dark background space not only underlines the heat localisation but also offers an economic benefit in terms of space and energy saving.

On account of the visual image itself, it depicts the subject stylistically in order to add some aesthetic features such as its vivid colour and high contrast or a visual perspective that may increase its attractiveness. In addition, there are also some potential advantages of using a photograph as the medium for advertising. It can contribute to the credibility of the advertisements since the photograph can serve as the evidence explicitly proving the product's existence and its claims regarding the actual structure of the infrared heating system and its effectiveness (Abell, 2005; Messaris, 1997). However, in the context of the "Light works" exhibition as explained in the section 6.1.3, the visual image is curated and accompanied with the texts written by the RPS primarily to give an example of the light (infrared) application. Instead of emphasing the favourable features of the infrared heating system, the accompanying description in this case mainly introduces one of its practical use through the narration of the relevant procedures that bring a finished product relatable to public audiences. This is also coherent with the image title: 'Chocolate shells" focusing on the infrared system's outcome rather than the system itself.

Distribution context

Although the distribution context of the visual image is generally similar to that of the overall exhibition as explained in section 6.1.3, the subject matter included in the visual image in relation to the exhibition display duration might bring certain effects to the viewing. The

image title and the description respectively mentioning chocolate shells and Easter eggs and the visual representation of chocolate halves were displayed in Edinburgh during 3rd March – 17th April 2015 which was overlapping the Easter season (the Easter Sunday was on 5th April 2015). Because the Easter date is never fixed but can be different from year to year according to the lunar calendar, people in society might be aware of the season from late March to April even after the Easter date has passed. In such time of year, people in the UK usually think of or encounter several accounts relevant to more commercial aspects of Easter namely Easter eggs, egg hunts, or bunnies (Leonard, 2016).

Regarding Easter eggs, they have been considered for centuries as a tradition associated with the Easter season (Leonard, 2016; Simpson & Roud, 2003). The popularity of chocolate eggs during the Easter season can also be affirmed through several economic statistics. Studies showed that the Easter time is a great yearly occasion for chocolate confectioners to cultivate their turnover (Hills, 2012; North, 2017; Parfett, 2013). Easter chocolate eggs in a variety of sizes, recipes, and brands are displayed on shelves across UK retailers. As a result, during the exhibition period in Edinburgh, many members of the public were arguably aware of the Easter season as well as encountering Easter chocolate eggs in supermarkets. Therefore, the visual image and its accompanying written texts associating with Easter chocolate eggs can become relatable and accessible to audiences in such a timing and seasonal context which potentially results in a greater level of attention and information acquisition (Anderson et al., 1977; Bransford & Johnson, 1972; Kolb, 1984).

Reception context

With regard to the dominant subjects of the visual image, the chocolate shells depicted at the lower aspect of the image might not be recognised by viewing them briefly. This might be because of their orange or yellowish colour affected by the light which is different from the usual colour of chocolate. Besides, the perceptual integration of the chocolate halves due to the selected camera angle may hinder the identification of their shapes. In other words, the visual representation in such fashion cannot provide sufficient visual cues to resemble the familiar characteristics of chocolate shells (Hopkins, 1998; Hyman, 2006). However, such difficulty is mitigated by the indicative image title: “Chocolate Shells”. Since the upper part of the visual image is less likely to be perceived as chocolate, viewers can presume that the title mentions what represented at the bottom part. Therefore, the collaboration between the visual image and the title allows the correct perception of the chocolate shells especially for viewers who have seen an actual chocolate-filled eggs and can recognise their halves. On the other hand, the light system at the upper part of the photograph suggests ideas about infrared light because it represents some visual elements in terms of shape and colour that may resemble the familiar domestic infrared lamp or heater (Hopkins, 1998; Hyman, 2006).

Besides the image title, the written description can give further clarification relevant to the visual image. By reading the description, an audience might be able to perceive that the photograph captures a process taking place in a confectionary factory in which the rims of chocolate shells were being melted by the infrared heater. The visual image can emphasise such ongoing industrial production through the large scale of the infrared heater with countless identical chocolate halves and the shining light and the uneven rims of the halves. From the production stage depicted in the visual image, the written description also provides some information about certain following stages as well as finished products. Although it does not exactly explain how those procedures would be done, it suggests an overall production process that may allow audiences to imagine those following stages from what depicted in the visual image. In addition, the superior outcomes of using the infrared heating system proposed in the written description might be approved through the audience's prior experience regarding the sophistication and quality of actual chocolate-filled eggs.

In terms of the potential perception of infrared light, from the written texts, audiences may understand that infrared radiation can generate some optimum heat to melt the rims of chocolate halves. Whereby, the structure of the infrared heater represented in the visual image can expand such a statement. It demonstrates that the heat is transferred without any physical contact between the infrared emitters and the chocolate halves. Nevertheless, the appearance of the image subjects in orange or yellowish colour as the ongoing operation of the infrared heater may lead to a misconception about infrared light. There is a diagram below the written description indicating that the wavelength of infrared is longer than that of visible light, namely, it is usually invisible to the human eye. Due to the diagram's small size and inconspicuous position, such fact about infrared might be overlooked by audiences (UCSB, 2013). Without an explicit explanation of infrared characteristics or the detail of the featured thermal heater utilising infrared emitters that also radiates some visible light, some audiences may incorrectly generalise that the infrared light could be seen in orange or yellowish colour.

6.3.3 Construction

In relation to the overall exhibition, the visual image and the accompanying written texts considered in this case can endorse the aim of the exhibition to demonstrate the use of light in several sectors. This case exemplifies the application of infrared light in food industries, particularly in the chocolate factory. Among other visual images featured in the exhibition, the photograph of interest might be able to get attention through its conspicuous size, vivid colour and high contrast (Kennedy, 1985; Lester, 2010). Moreover, the depiction of a subject that differs from its familiar properties may intrigue an audience to identify or explore the visual image instead of just passing it by (Bloomer, 1976; Messaris, 1997), and such curiosity can be answered straightforwardly by reading the image title. Subsequently, the written description provides further information relevant to the photograph. It starts from

narrating the depicted manufacturing process, giving a relatable example of finished results, and then overviewing stages in the production process that results in the exemplified product. The photograph may serve as the visual precursor for the verbal description. In addition, after identifying the visual image, the written description introduces Easter eggs as an exemplified outcome of the production system. As a result, the recognisable anecdote of Easter eggs may prompt audiences to learn the following unaccustomed information which may provide a greater chance for knowledge acquisition (Winn, 2014).

Besides giving factual information about the infrared application in the production process, the combination of the visual image and the written texts can construct several social aspects characterising industrialism. Since the mid-18th century as the result of the industrial revolution, the concept of industrialism has been exhibiting in different facets of societies across the world (Sullivan, 2009). The primary notion of industrialism is the association with manufacturing production system, and one of its outcomes is the capacity of simultaneously producing goods in a mass volume which is distinct from the traditional production of craftsmanship (Scott, 2014; Turner, 1975). In this case, the photograph may illustrate such implication of industrialism through the visual representation of the large infrared heater and the countless chocolate halves. The identical size of the chocolate halves probably emphasises the multiplication of the factory production. Also, the context of industrialisation is underpinned by the written description identifying that the photograph was taken “at a confectionery factory”.

Furthermore, there are other major characteristics of industrialism potentially constructed in this case including the element of mechanisation, the division of labour, and the adoption of scientific methods and techniques for solving problems (Scott, 2014; Turner, 1975). The visual image might be selectively created to represent the infrared heater as a stand-alone infrared heating system with no human beings present. As a result, such representation can visually demonstrate the factory production system that significantly relies on machinery. Regarding the division of labour, in spite of lacking explicit accounts presenting this aspect, the written description explaining the production of chocolate filled eggs might indirectly suggest that such manufacturing process consists of different parts to which probably different groups of people are assigned. Moreover, the visual image and the written texts can demonstrate the application of scientific knowledge and technology of infrared. In other words, the visual narration of light shining on the chocolate halves with the camera angle depicting the lamp elements from a low angle may also accentuate the dominant role of infrared as well as the technological innovation in such manufacturing production system. Likewise, the use of science and technology in industrialisation is coherently highlighted at the end of the written description with several modifiers such as “very rapid heating” and “highly localised areas” proposing its beneficial outcomes in terms of giving superior control to solve the problem commonly found in these specific production processes.

In addition, for an industrialised society, its development is propelled by technological determinism and scientific progress (Turner, 1975). Accordingly, science-informed principles and scientific rationalisation can predominantly influence or even modify social aspects of people's lives such as their traditional culture and institutions, as well as social behaviours (Horne, 1986; Scott, 2014). For example, due to its capacity for mass production, industrialism is argued to be the precedent of consumerism. At the same time, it is endorsed by the development of mass media advertising that generates a greater demand for goods across society. As a result, it leads to the transition of social behaviours regarding the way people consume goods (Sullivan, 2009). The consequence of industrialism in relation to social sectors may also be articulated in this case. The written texts mentioning Easter eggs as the product of the production process can suggest that industrialism manifests in and becomes part of a traditional event like Easter by providing the pertinent consuming goods (Easter eggs).

6.4 Summary

The two visual images featured in this chapter are sampled from the same science communication event: 'Light Works' exhibition and considered in relation to the learning outcome of giving knowledge or information. They rely on the capacity of photographs to visually capture the subject matter (Hopkins, 1998; Hyman, 2006) such as case 6.3 illustrating the infrared heating machine, and written texts to further explain the information relevant to the images. Visual images in these cases are arguably attractive which not only makes such an event more accessible to audiences but may also promote the referential processing of information. Namely, the inference of a striking visual image potentially engaging with one's emotion to a fact or concept conveyed in the written texts or vice versa may enhance the assimilation and recall of information (Frewen & Lundberg, 2011; Paivio, 1990). The visual images may primarily perform as the precursor leading to several aspects provided in the written description.

Meanwhile, the delivering of factual information in both cases is undertaken mainly through textual modes of communication. In other words, an audience may attain relevant scientific facts or information about the event primarily by reading accompanying written texts. In order to achieve an understanding of the information, the interpretation of the associated messages is intended to be precise. Therefore, the construction of meanings relies heavily on linguistic information that is argued to provide more specific information than a visual representation. The relationship between a visual image and textual/verbal information for this aspect of learning outcome is in the mode of additive combination whereby written texts identify or further describe a visual image, or a visual image reinforces written texts (McCloud, 1994). As such, the intended message is obtained mainly through textual or verbal communication.

Chapter 7
Visual images in public campaigns

This chapter provides the analyses of two exemplified cases associated with public campaigns promoting desirable behaviours. Similar to Chapters 4-6, it contributes to the answers of RQ1 (How is the message constructed by a visual image and accompanying information in a science communication context?) and RQ2 (How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)?). Nevertheless, regarding the fulfilment of the Generic Learning Outcomes, this chapter mainly focuses on the aspect of encouraging a behavioural change. The examined cases (case 7.1: poster "Keep Antibiotics Working" and case 7.2: the billboard campaign for alcohol-drinking abstinence during Buddhist Lent) were science communication events casually encountered in the UK and Thailand, respectively. The accounts of their analyses are provided as follows.

7.1 Poster "Keep Antibiotics Working"

"Keep Antibiotics Working" is the headline of a health-related poster created by the Scottish Antimicrobial Prescribing Group (SAPG) in 2017 to raise awareness of antibiotic resistance and suggest the prudent use of antibiotics. The poster was publicly distributed throughout Scotland and more particularly at community pharmacies. The distribution happened at the same time as the European Antibiotic Awareness Day (EAAD): an annual campaign taking place on the 18th November each year. This section examines the poster in relation to two examples of places where it was displayed, namely in front of two pharmacies in Edinburgh, UK. The actual poster was printed in A1 paper size and was displayed in print to members of the public for a few weeks. Nevertheless, the digital version of the poster is still available online at the SAPG's archive (SAPG, 2017b).

7.1.1 Content

Subjects

The poster, developed for the campaign to try and halt antibiotic resistance as shown in Fig. 7.1 (SAPG, 2017b), comprises both visual and textual elements. Regarding the visual elements, they can be considered to be in two primary parts including the graphic illustration which seems to be the dominant subject of the poster and the logos of the event and organisations associated with the campaign.

There are visual representations of antibiotic-resistant bugs with different characteristics regarding their shapes, sizes or attributes. The illustrations of three characters in various sizes are presented within a circle. The circle has a white background and is enclosed with a light grey inner rim and a red outer rim. The biggest character is depicted in its full body and is circular with some smaller circular appendages in various sizes and lengths with stems

connecting each appendage with the central circle. The largest character has a face consisting of two open round eyes, an open mouth exposing uneven triangle teeth and fangs as well as the groups of small circles on either side of its mouth.

Meanwhile, the other two characters featuring face attributes are partially depicted as if the excluded parts are beyond the focused circular area. The character at the bottom-right corner of the circle is depicted in the same shape as the biggest one previously explained except it has some different facial attributes. Its face includes one open round eye, a straight line mouth with two fangs, as well as two groups of green circles like those of the biggest character. For the third character depicted at the top-right corner of the whole outline circle, its central circle is surrounded by only two smaller circles which are also represented as its two open round eyes. Also, within its central circle, there is a slightly curved line representing its mouth between the two eyes near the rim of the central circle.

Moreover, there are also three groups of uneven circles without any facial attributes scattered around between the characters. Above the grey and red-bordered circle containing those characters, there is a dashed trajectory line which seemingly comes from the right side of the poster toward the circle. It can be seen that the path meets the red rim of the circle before changing the direction in a downward trajectory back to the right side again. At the end of the path, there is the representation of a capsule as if it had moved towards and bounced off the circle along the dashed path. In addition, within the section of the written texts, there is a tick symbol depicted as part of the word “working”.

In terms of the included logos, the logo of Healthcare Improvement Scotland may be explained as the synergy of interwoven two ovals/circles or the loop of a twisting band. Meanwhile, the logo of the Antibiotic Guardian represents two hands holding a capsule. Regarding the European antibiotic awareness day logo, it represents a two-coloured capsule (blue and green) surrounded by a grey stethoscope. Under the logo, there is also a small icon of the European Union flag.

Composition

The overall composition of the poster could be considered to have three primary parts corresponding to the characteristics of the elements and the spaces between them (Bradley, 2014a). It includes the area of graphic illustration in the upper part, the textual information at the lower part, and the arrangement of the three logos at the bottom. The first two sections seem to be the dominant elements each of which covers almost a half the area of the poster. The poster’s elements in terms of their areas are primarily weighted to the left side of the poster, and the focal point of the graphic illustration is placed around its top-left corner. Such location is arguably one of the areas of attention according to Arnheim’s structural map (Arnheim, 2004; Bradley, 2014d).

Furthermore, for the area of the written texts, they could also be considered to be separated into three distinct parts corresponding to the noticeable spaces between them and their different font sizes. They entail the headline, the main statement, and further details. Regarding the graphic illustration, it can be seen that the circular shape emphasised with the light grey and the red edges can create the sense of separation between the visual elements depicted inside and outside the circle (Kennedy, 1985). The composition of the area inside the circle can be considered as a visually balanced arrangement regarding the sizes of the depicted subjects. In other words, the left side of the circle depicts one large character which is counterbalanced by the two smaller characters on the right side. Meanwhile, the continuation of the logos arranged along the horizontal line at the bottom area may also endorse their grouping (Kennedy, 1985).

Fig. 7.1: Keep Antibiotics Working poster for EAAD 2017, SAPG [online image] Available at: https://www.sapg.scot/media/2819/keep_antibiotics_working_poster.pdf [accessed 9th May 2018]

Visual perspective

It is notable that the poster is created in a two-dimensional representation. In spite of the appearance of some layers between the foreground and background, there are no significant shadow or the sense of depth within the visual image. As a result, audiences can view all elements approximately at the same surface level or distance. However, the composition of the poster described above may engender certain viewing directions. As mentioned earlier the elements are placed from top to bottom and slightly weighted on the left side which may engender audiences to sweep their eyes to read the poster following an F-pattern corresponding to the leftward reading bias (Bradley, 2015a). Similarly, the arrangement of the logos at the bottom area can create a perceptual horizontal line which may encourage audiences to view them in the left-right fashion (Foulsham et al., 2013). On the other hand, the dashed line may serve as the directional cue drawing viewer's eyes beginning from the right side of the poster, moving along the line through the change of direction, and backwards to the right side and the capsule.

Furthermore, the representation of characters with their heads pointing in different directions and the absence of visual depth may engender an audience to view them as if they were seen from the top-down angle. This might not be coherent with the potential viewing angle of the capsule movement which seems to be observed from a frontal angle corresponding to the usual up-down movement of a bouncing object based on the law of gravitation. However, such contradiction of viewing angles might be less significant in this context due to the characteristics of the conceptual graphic representation that are not scientific or realistic representations.

Tonality and colour

It can be seen that the poster primarily contains solid colours without tonality or colour modulation which may suggest that it visually conceptualises the intended message rather than realistically represents the likeness of the resistant bugs and the phenomenon (Kress & Leeuwen, 2006). However, the colours adopted to represent the capsule potentially resemble some actual two-tone antibiotic capsules (Google images, n.d.). Meanwhile, the green colour used for depicting all the characters may suggest that they belong to a common group or category despite their different physical appearances (Kennedy, 1985). Such classification is also identified and underpinned by the same colour as the nearby written texts: " Antibiotic Resistant bugs". Besides the white spaces, the dominant elements of the poster appropriate only a few colours including grey for the inner boundary of the circle, a half of the antibiotic capsule, and written texts; red for the outer boundary of the circle, a half of the antibiotic capsule, and the majority part of the title; and green for the antibiotic resistants bugs and their nearby textual denotation. It is notable that grey is a neutral colour while green and red oppose each other on the colour wheel, namely they are complementary colours for each other bringing forth the strongest contrast within the visual image as shown

in Fig. 7.2 (Triedman, 2015). As a result, the combination of these colours within the poster can visually increase the harmony and balance of its design which may also make the poster pleasurable for viewing (Triedman, 2015). However, such an effect might be impeded and distracted by the distinct colours of the logos at the bottom area.

Fig. 7.2: The colour wheel of complementary colours (adapted from Karen Triedman, *"*The ultimate guide to colour: Understanding, appreciating and mastering colour in art and design", 2015, p.44)

Look and gesture

In this case, the gaze can be perceived from the depicted characters with facial attributes. Although they have different head orientations, their eyes are looking directly at the audiences of the poster as if they were making contact with him/her (Kress & Leeuwen, 2006). Nevertheless, it is arguable that such communication is less likely to be in a friendly way which might be evident through their overall facial expressions. For the biggest character, in spite of the raised mouth corners potentially suggesting smiling, the appearance of the triangular teeth or fangs can create tension to the facial expression and rather suggests aggression (Ekström, 2013). Such an unfriendly expression can also be endorsed by the two fangs of the character with one eye, as well as the pulled-down mouth corners of another character. As a result, it is arguable that the representation of these characters potentially arouses emotional responses in audiences through the character designs and their facial expressions.

Size relationships

In this case, the poster might appropriate different sizes of elements for the purpose of emphasising certain aspects. For the written texts, it can be seen that the large font size is used to accentuate the headline "Keep Antibiotics Working", and the variation of the font sizes may also distinguish sections of the written texts from each other. In terms of the graphic illustration, the sizes of the depicted resistant bugs and the capsule arguably oppose their actual relational sizes. Whereby, the size of a bug (a microorganism) is remarkably bigger than that of the capsule which contradicts their actual relational sizes since bacteria are usually invisible to the naked eye. However, the larger size of the bugs in relation to the antibiotic capsule probably suggests that it is the representation of their magnified image and may also highlight their substantial existence and power within the poster's context.

Meanwhile, the approximately identical height of the logos arranged at the bottom area might endorse the harmony of their cooperation.

Accompanying written texts

The texts written in the poster can be considered into two primary sections comprising the texts included in the graphic illustration and those written in the textual area below the illustration. It can be seen that the texts *"Antibiotic resistant bugs"* and *"Antibiotics"* are embedded in the visual representations, and in this case, they are used to explicitly denote their coordinating depicted subjects.

In terms of the main written texts, they can be classified into three primary sections corresponding to their characteristics in terms of font sizes and colours as well as meanings including

"Keep Antibiotics Working";

"Taking antibiotics when you don't need them means they are less likely to work for you in the future"; and

"The best way to treat common colds, coughs or sore throats is plenty of fluids, rest and painkillers if needed, not antibiotics. Colds and sore throats typically last about 7 days and coughs can last for up to 3 weeks. For more information, if you are worried, or if symptoms continue for much longer than this then talk to your pharmacist or doctor. Find out how you can help at Antibioticguardian.com" (SAPG, 2017b)

Each part may serve respectively as the headline, the main statement, and further details relevant to the subject matter. It is arguable that the graphics depicted in the poster metaphorically illustrate the occurrence of antibiotic resistance contradicting the headline albeit emphasising the main statement. Whereby, the graphic illustration visually presents that the antibiotic capsule cannot penetrate and address the resistant bugs within the circle. Meanwhile, the written details give practical suggestions to prevent the increase in antibiotic resistance. There is also the URL provided for audiences who may be interested in accessing further information or supporting the campaign. Moreover, the names of the organisations associated with the campaign written as part of the logos not only denote the logos but may also serve as the written texts in their own accounts. As such, these names of the organisations can provide some keywords underpinning the overall context of the poster.

7.1.2 Size and space

The poster is printed on a piece of A1 paper with a dimension approximately 59.4 cm (width) x 84.1 cm (height). It is notable that the A1 poster is the standard size for printing posters generally used for indoor or shop window publications (Kerr, Eves, & Carroll, 2001). Moreover, it is large enough to be seen from afar potentially resulting in a great opportunity

to reach wider audiences (Kerr, Eves, & Carroll, 2001). This is also applicable to the poster considered in this case whereby it is placed on pharmacies' front windows approximately at the eye level as shown in Figs. 7.3(a-b). Therefore, the poster could be encountered by people visiting the pharmacies as well as passers-by.

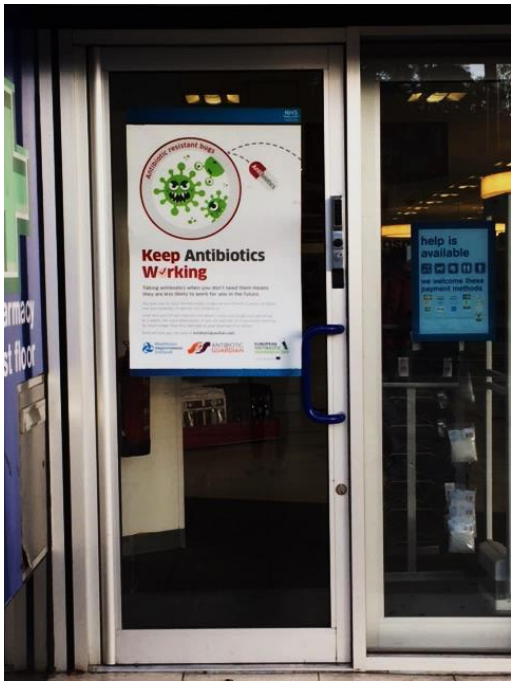


Fig. 7.3(a): The display of the poster in front of a pharmacy on Princes Street, Edinburgh, UK

Fig. 7.3(b): The display of the poster in front of a pharmacy on N W Circus Pl Street, Edinburgh, UK

7.1.3 Context

Production context

The poster was created as part of the work contributing to the UK five-year (2013 - 2018) Antimicrobial Resistance (AMR) strategy (Department of Health, 2013). The strategy is developed to tackle the enduring AMR which is argued to be a threat to human health. Whereby, the inappropriate use of antimicrobials can lead to an increase of resistant microbes like bacteria, viruses, and fungi when the existing antimicrobial medicines become less effective in treating infections caused by those microbes. It demands the collaboration of several government departments and organisations to achieve the primary goals of addressing AMR. One primary goal relevant to public engagement is to improve the knowledge and understanding of AMR which might associate two areas of actions including educating and training related professionals and reaching out to public members.

From the five-year strategy (Department of Health, 2013), a practical way of contributing to such goal, especially in the aspect of preserving effective antibiotics for treating bacterial infections, is to raise awareness of the issue that may also lead to behavioural changes. Moreover, the collaborating departments can implement such an action plan through the occasion of an existing campaign: European Antibiotic Awareness Day (EAAD). It is an annual public health campaign which has been held on the 18th November each year across Europe since 2008 before extending to a global scope when the World Health Organisation (WHO) started the World Antibiotic Awareness Week (12 – 18 November) in 2015 (ECDC, n.d.; WHO, n.d.).

An additional aim of EAAD in 2014 to monitor the level of engagement with public members and healthcare professionals, besides raising awareness and changing behaviours toward the use of antibiotics, led to the formation of the Antibiotic Guardian (AG) campaign (Chaintarli et al., 2015). Antibiotic Guardian (AG) is an online system allowing people to engage with the issue of antibiotic resistance by promising to use antibiotics prudently and to comply with prescribed behaviours corresponding to their status in relation to the issue (AG, n.d.). Subsequently, in the association with EAAD and AG campaigns, the UK organisations responsible for improving knowledge and understanding of antibiotic resistance adopt several approaches and educational materials to communicate with different target groups (Bhattacharya, Budd, & Ashiru-Oredope, 2014). In regard to engaging with members of the public, it is primarily undertaken in the form of informal public education through printed materials such as advertisements in newspapers, posters, leaflets, or letters.

This is also the case for the EAAD outreach implemented by the Scottish Antimicrobial Prescribing Group (SAPG) in Scotland whereby posters and leaflets are also utilised as tools for communicating with the public. Regarding the poster considered in this case, it was used for the EAAD 2017 campaign with the main theme “Keep Antibiotics Working” (SAPG,

2017a). Such theme was appointed by the European Centre for Disease Prevention and Control (ECDC) based on the realisation that without any measure to diminish antibiotic resistance, existing antibiotics could be ineffective for treating bacterial diseases within 70 years (ECDC, 2017).

Accordingly, EAAD-related organisations including SAPG and AG also adopted such a theme for communication in 2017 (SAPG, 2017a). Although the poster was developed and distributed particularly in Scotland, not only the type of the material used for science engagement, some of its features also comply with the common regulations ECDC requires for materials used for EAAD campaign (ECDC, 2008). For example, the poster contains some key messages relevant to antibiotic resistance assigned by ECDC as well as the appropriation of the EAAD logo which is accompanied with the written texts: “A European Health Initiative” and the EU flag. In addition, the poster also features the logo of the Antibiotic Guardian (AG) campaign and provides the URL for accessing its webpage online. From the report of the antibiotic awareness campaigns in 2017 published by PHE (2018), although the campaign is primary aimed at some long-term goals such as to reduce inappropriate prescribing in the UK by half by 2020, the campaign shows the potential to progressively promote interest in, awareness of, and engagement with the issue. Also, visual images are considerably utilised in most relevant activities with a variety of roles either to be featured in posters, leaflets, interactive demonstration, panel discussion, or posts and video shared on social media platforms which were viewed more than 10 million times (PHE, 2018).

Distribution context

Because EAAD is the national campaign, the poster is distributed along with other channels such as online video, social media platforms, or leaflets to disseminate coherent messages in relation to antibiotic resistance in various communication contexts. In the context of this case, the poster was placed primarily in hospitals and community settings throughout Scotland for approximately two months prior to the EAAD on 18th November 2017 (SAPG, 2017a). Therefore, members of the public may come across the poster casually during such a time period. In regard to community environments, they include places relevant to healthcare especially pharmacies which is one sector which the government demanded should cooperatively promote the antibiotic awareness to members of the public (Department of Health, 2013). Although the poster was distributed to cooperating pharmacies and supposed to be presented in conspicuous areas such as in front of the stores, by being displayed in different locations, it may involve a variety of viewing contexts. Nevertheless, it may be worthwhile analysing two particular locations as the examples shown in Figs. 7.3(a-b) which can be explained as follows.

From Fig. 7.3(a), the poster was placed on a pharmacy's emergency door beside a large automatic front door. Therefore, in usual circumstances, such area can serve as the shop's window. The pharmacy is situated on Princes Street which is the main shopping street in Edinburgh (Edinburgh Council, 2007). The street is also surrounded by several amenities such as a public park, monuments, hotels, residential areas, as well as being a hub for transportation. As such, Princes Street can generate a high volume of traffic and attract a large number of people both tourists and locals. Subsequently, the poster could be encountered by a wide range of members of the public using the street.

With the broad pavement in front of retail units at street level, passers-by may view the poster from different distances, and faraway viewers may be able to see only the poster's large elements such as the graphic illustration and the title: "Keep Antibiotics Working". This might also be the case for people entering the pharmacy through the nearby automatic door which requires a flow of visitors to pass through the entrance to avoid blockage. On the other hand, there is some empty space in front of the poster-attached emergency door where people can stop and spend some time viewing the poster especially those waiting outside the shop. Therefore, in such environment, it is arguable that the written details about antibiotic resistance and practical suggestions might be overlooked by the majority of viewers unless they have a chance to stop and thoroughly view the whole content of the poster from a legible viewing distance. Based on the poster's size, the main statement under the headline and the descriptions are displayed with letters' heights less than 2.5 cm which can be read approximately within the ~3 metres viewing distance (Adams, Rosemier, & Sleeman, 1965).

With regard to the pharmacy's window shown in Fig. 7.3(b), it is situated on a public street in Stockbridge which is a local area in Edinburgh (Edinburgh Council, n.d.). Stockbridge has a village atmosphere and has a number of shops, restaurants, and attractions such as the Water of Leith and Inverleith Park (Edinburgh Guide, n.d.). Similar to the setting on Princes Street, the poster could be seen by a large number of people though probably with less traffic and available viewing distance. Such a location may provide a good environment for passers-by to stop and spend some time viewing the poster. Nevertheless, from Fig. 7.3(b), the poster is displayed alongside other striking commercial advertisements. As such, it may encounter the competition of gaining attention when a viewer is subjected to different visual stimuli at the same time (Manghani, 2013). However, through the attentional mechanism in which attention is selectively assigned to particular visual information (Hogendoorn, Carlson, Vanrullen, & Verstraten, 2010), the poster's graphic illustration may overtake the visual stimuli of other advertisements. That may be because it is presented approximately at eye level with the direct gaze of antibiotic-resistant bugs pointing at viewers to make contact. As a result, such featured facial representation can raise a demand for a viewer's response while the other visual stimuli (from the neighbouring posters) such as the images of products'

packages are presented without such psychologically salient element (Kress & Leeuwen, 2006; Pilelienė & Grigaliūnaitė, 2016).

Reception context

From the two examples of distribution contexts explained above, the poster was displayed on the pharmacies' front windows in commercial settings. Subsequently, with a glance, the overall poster might be mistaken as print media advertising especially for the case shown in Fig. 7.3(b) when it was presented beside several ads. As such, it may lead to certain reactions similar to the viewing of commercial posters. Being bombarded with an abundance of print ads, viewers probably allocate a low level of attention in terms of the viewing duration to perceive different stimuli contained in the poster, and some passers-by may ignore those elements altogether (Pieters, Rosbergen, & Wedel, 1999; Pilelienė & Grigaliūnaitė, 2016). On the other hand, audiences who had a chance to view the poster in detail may be able to negotiate the message delivered through the poster's elements. Some possible perception of the poster can be explained as follows.

In regard to the graphic illustration, it displays a narrative representation of the phenomenon of antibiotic resistance. Within the red circle, there are three dominant cartoon characters which might be difficult to identify due to their unfamiliar appearance. Nevertheless, their facial expressions can be perceived as unfriendly, aggressive, or threatening which viewers may have acknowledged those expressive emotions either from their first-hand experience or typical representation of such kind of characters in popular media (Ekström, 2013). By reading the embedded texts written nearby the characters, viewers are likely to be able to identify that they represent antibiotic-resistant bugs and such definition may also suggest their characteristic that can resist the opposing action of antibiotics. Therefore, from the perception of their facial expression and name, viewers can generally understand that antibiotic-resistant bugs are undesirable. Moreover, the different appearances of those represented bacteria probably imply that there are several types of them.

In addition, the graphics also metaphorically depict the occurrence of antibiotic resistance. The image of a capsule is embedded with the written texts allowing viewers to perceive that it specifically represents antibiotics. Although there is only one depicted capsule, the word "Antibiotics" denoting plurality may suggest that there are various types of antibiotics. Also, by resembling a familiar form of medicines, it can convey that antibiotics are medicines which might be already recognised by public audiences especially adults who have used or at least encountered them. Nevertheless, such general acknowledgement cannot guarantee the understanding that antibiotics are supposed to be taken particularly for treating bacteria-caused diseases (Department of Health, 2013; SAPG, 2017b).

The representation of antibiotics is integrated with the dashed line through their proximity which can introduce their connection whereby the line forms the motion path of the capsule

(Cohn & Maher, 2015). In other words, viewers potentially perceive that the capsule moves from the right side of the circle before reaching it and bouncing back to the right side again which reasonably corresponds to the actual bouncing movement usually happening under the Newtonian laws. Therefore, the whole graphic illustration may visually demonstrate the concept of antibiotic resistance in which antibiotics cannot overcome or have any effect on the resistant bugs. Such undermining of the effect of antibiotics may be figuratively underpinned by a visual representation regarding the greater number and relational size of the antibiotic-resistant bugs. Moreover, the red circle can also raise the notion of resistance since it is a visual element commonly used to denote prohibitive signs (GOV.UK, n.d.). Particularly, there is a restriction for antibiotics to penetrate the resistance of resistant bugs.

In terms of the poster headline: “Keep Antibiotics Working”, by including the tick mark, it can endorse that this imperative sentence is desirable. The message becomes clear that the right thing to do is to keep antibiotics being able to function efficiently. The red colour of the terms: “keep” and “working” may coherently underscore the determination and urgency of the prescribed action (Triedman, 2015). At the same time, the word “keep” can denote the demand for the preservation of such condition. This may also indirectly suggest that antibiotics are under a threat of being ineffective which is visually demonstrated through the graphic representation.

Coherently, such an undesirable state is literally denoted by the main statement under the headline which indicates that the unnecessary use of antibiotics is the cause of the issue. By reading the following paragraph of the written detail, although the texts do not literally identify particular inappropriate behaviour, viewers may be able to presume that it is imprudent to take antibiotics for treating common colds, coughs or sore throats which instead can be cured by plenty of fluids and rest. The following paragraph can further clarify the characteristics of common colds and mild symptoms regarding the possible duration of their persistence. It also suggests a practical way for viewers to consult a pharmacist or doctor for cases beyond the exemplified conditions. In addition, from the last sentence of the written texts, viewers might perceive that they have the potential to help and in particular to keep antibiotics working. By accessing the given URL online, they may discover how they can support the movement.

Furthermore, the logos featured at the bottom of the poster denote the context of the poster itself. As such, viewers can understand that the subject matter considered within the poster is likely to be relevant to healthcare and antibiotics. The name and visual representation of the Antibiotic Guardian’s logo may present the idea of protecting antibiotics which is congruent with the poster’s key message as explained earlier. In the same way, the logo of EAAD can also denote the occasion associated with the poster which may draw attention to antibiotics. In addition, the inclusion of the three authoritative institutions and the terms

“Scotland” and “European” potentially endorse the significance of the issue as a national as well as an international concern which several institutions collaboratively attempt to address.

7.1.4 Construction

The construction of meaning in the poster is arguably underpinned by the aspects of sustainability which is an ideological tool appropriated for fostering certain actions (Davidson, 2010). The notion of sustainability originally emerges within the realm of global environmental concerns particularly focusing on the sustainable consumption of natural resources. However, the ability to access equity between either intrageneration and intergeneration can be applicable to other types of resources beneficial to the survival of human beings (Brown, 2016; Mulligan, 2015). It is also the case for the poster of interest since it can be argued to appropriate messages about sustainability proposed by Mulligan (2015) including 1) the acknowledgement of interconnections and limitations of resources and their regeneration, and 2) its associating operations that incline toward the prevention of potential problems.

For the first aspect, it can be seen in the poster as shown in Fig. 7.1 that the concern of emerging antibiotic resistance can be presented primarily through the graphic representation and together with written texts. They formulate the connection between such concern and the use of antibiotics, namely the imprudent use of antibiotics can negatively lead to the increase of antibiotic resistance and inefficient antibiotics. In this context, the poster may replace the aspect of hyperconsumption underlying unsustainable behaviours usually considered in environmental issues with the unnecessary use of antibiotics described and exemplified primarily through the written texts (Mulligan, 2015). The written description also postulates that taking antibiotics inappropriately can limit their effectiveness to treat infections in the future. For the second aspect relevant to sustainability regarding the preventive operation, it is introduced by the poster's headline: “Keep Antibiotics Working” implying the action to be undertaken before antibiotics become ineffective. The statement is clarified further in terms of associating practical behaviours given in the subsequent textual description.

Since sustainability usually involves the future as one aspect of consideration, the advocacy of such a concept might be impeded by a difficulty regarding how future prediction can be portrayed in associated communication. Without an effective representation of the potential future challenges, the initiation of sustainability can become meaningless to audiences and may also introduce confusion instead of constructive practices (Brown, 2016). For this case, such a communication challenge might be mitigated by the appropriation of cartoon illustration to simultaneously represent the emerging antibiotic resistance as well as the potential outcome that could happen without sustainable behaviours. The poster benefits from the cartoon’s characteristic in terms of being accessible and yet able to contain

meaningful messages including knowledge or factual information (Labrecque, Coutu, Durand, Fassier, & Loisel, 2016). The cartoon's feature of make-believe representation, which does not necessarily follow the natural law or realistic representation, allows it to explain the concept of antibiotic resistance through the visual metaphor, namely antibiotics cannot penetrate the circle/resistance to tackle resistant bugs (Kulvicki, 2014). Moreover, the graphic design of the characters adopting the stereotypical representation of a villain regarding their triangle-shaped teeth can portray the hostility of the bugs and of antibiotic resistance which subsequently may elicit viewers' emotional responses (Ekström, 2013).

Corresponding to a general goal of sustainability promotion, the dimension of behavioural changes especially at the individual level is also implied in the poster (Mulligan, 2015). It potentially underpins all crucial facets suggested by the UK Department of Environment, Food & Rural Affairs (DEFRA) for any influencing policy including to encourage, enable, engage, and exemplify to implement a prescribed behaviour (DEFRA, 2011). Particularly, the poster may encourage the appropriate use of antibiotics by providing an incentive primarily through the poster's headline that, by following the given suggestion, antibiotics will function effectively. Moreover, the opposing outcome of antibiotic resistance constructed by the visual representation and the main statement written under the headline may discourage imprudent antibiotics use. The inclusion of both associating aspects is also congruent with some compliance-gaining strategies (Littlejohn, 2010; Marwell & Schmitt, 1967). In other words, it adopts socially acceptable techniques by showing either how good things or bad things will happen by respectively complying with a prescribed behaviour or not. In such context, the poster agency probably plays a role of an expert who has the relevant knowledge to suggest actions, and the poster may endorse such perception of expertise through the inclusion of authoritative institutions' logos.

Furthermore, the poster can ensure viewers have the ability to comply with the prescribed actions by giving clear details and instructions for treating common sicknesses without using antibiotics, as well as providing an ultimate solution in terms of contacting a doctor or pharmacist. It can be seen that the information featured in the poster is selectively tailored to public audiences. For example, instead of including the term: 'antibiotic resistance', its scientific mechanism, or technical terms of particular antibiotics which may be inaccessible and potentially cause confusion to viewers (Bowater & Yeoman, 2012; Brake & Weitkamp, 2010), the poster has general terms and situations relatable to the public. Regarding engaging with viewers, although the poster might not directly perform any form of engagement, by giving the URL of Antibiotic guardian (AG) campaign it can suggest an opportunity to actively take part in the associated movement. For the aspect of exemplification, the poster is argued to demonstrate the consistency of practice and the shared responsibility to tackle the proposed issue through the featured logos especially the

terms “Scotland” and “European” underlying the large scale of the movement as explained in the reception context.

7.2 Billboard campaign for alcohol-drinking abstinence during Buddhist Lent

This section features a printed large billboard created in 2017 by an operative advertising agency through the initiation of the Thai Health Promotion Foundation (ThaiHealth). The analysis of this individual case serves as another example of visual images used in a public campaign encouraging behavioural change. Although both cases aim at a similar primary learning outcome and are featured in the long-lasting campaigns, the relevant contexts (production, distribution, and reception) of this case are still different from those of case 7.1 explained above. The analysis of a case arranged in a different country may introduce some similar or different aspects of using visual image among different cultural contexts which may also broaden the understanding of the topic. The billboard was utilised as a part of media tools for campaigning for alcohol drinking abstinence in Thailand. The campaign is an annual event usually taking place during Buddhist Lent (a 3 month period around mid-July to mid-October). Throughout the whole event’s duration in 2017, the billboard was displayed to the public at significant points across regions in Thailand. The following analysis focuses on the actual billboard placed along the Praram II highway connecting the central area (Bangkok) with the southern part of the country. The design of the billboard is still available for downloading from ThaiHealth’s web page (ThaiHealth, n.d.).

7.2.1 Content

Subjects

The billboard as shown in Fig. 7.4(a) (ThaiHealth, n.d.) consists of three distinct visual elements: the representation of an adult man which seems to be the dominant subject of the visual image, a graphic representation of the liver and the logos of associated institutions. Regarding the billboard’s left section as shown in Fig. 7.4(b), the liver is graphically represented as part of the accompanying written texts. Inside the shape of the liver are the Thai written words: “ผัก” (pak) and “ตับ” (tab). In addition, at the bottom-left corner of the billboard, there are six logos respectively representing the movement to abstain from alcohol consumption throughout the duration of the Buddhist Lent, the Thailand’s Ministry of Public Health, the Stopdrink association, the association for the study of the liver, the Gastroenterological Association of Thailand (GAT), and the Thai Health Promotion Foundation (ThaiHealth).

In terms of the billboard’s right section as shown in Fig. 7.4(c), the man is presumably depicted as a boxer with the shirtless upper body and both hands wearing boxing gloves depicted in the form of the human liver. He is represented in three different conditions which show the transition of some attributes, namely his hairstyle, beard, facial expression, abdomen and the boxing gloves/liver. For the first stage on the left, the man is represented

with unruly hair, some beard, unhealthy face, abdominal fat, as well as rough surface and uneven coloured liver. Meanwhile, the third stage on the right side represents the man with nicely set hair, no beard, smiling face, firm abdomen, and plump, even-coloured liver. It can be seen that the man in the middle stage comprises attributes bridging the dichotomy between the first and the third conditions.

Fig. 7.4(a): The whole billboard for the alcohol abstinence campaign in Thailand, ThaiHealth [online image] Available at: https://www.socialmarketing.thaihealth.or.th/index.php/component/tvprogram/video/5683/AW&page=5 [accessed 19th March 2019]

Fig. 7.4(b): The enlarged left side of billboard for the alcohol abstinence campaign in Thailand

Fig. 7.4(c): The enlarged right side of the billboard for the alcohol abstinence campaign in Thailand

Composition

The billboard is horizontally composed of two sections corresponding to the distinct characteristics of the featured elements. In other words, there is textual information and

logos on the left and the visual representation on the right section as shown in Figs. 7.4(b-c). Both sections cover approximately a half area of the billboard. Such an overall composition may be congruent with the typical left-right composition potentially suggesting the relationship between both parts. The left side provides given or known information while the right side presents new or proposed information to be attended to or evaluated by viewers (Kress & Leeuwen, 2006).

By considering the composition of each side separately, the elements featured on the left side of the billboard might be perceived as being arranged in three horizontal lines comprising the first line of written texts, the second line of the combination of written texts and graphic representation of the liver and the third line is the associated logos. It can be seen in Fig. 7.4(b) that the composition of this section probably balances the visual weights of the elements between its left and right sides. Being different from the commonality of the written texts within each textual line regarding their identical font type and size, the larger size of the graphical liver in combination with its salient font type and size places a certain volume primarily on the right area. However, such visual weight might be levelled by the distinct forms and colours of the logos on the left side especially the first logo noticeably larger than the other logos (Bradley, 2014d).

Regarding the composition of the billboard's right section as shown in Fig. 7.4(c), the three stages of the representation of the man are placed along the horizontal line which also inclines towards the surface/viewers. There are some overlapping areas whereby the right side of a previous stage is partially covered by the left side of its following stage. In other words, the position of each stage from the first one on the left to the third one on the right corresponds to the farthest to the closest distance. The placement of three such stages not only endorses the continuation between the different conditions of the man, but it is also coherent with typical horizontal triptychs. As such, it is arguable that the given and the new information are usually displayed on the left and the right side of a triptych respectively while the element placed in the middle may function as the mediator between the two sides (Kress & Leeuwen, 2006). Particularly, in this case, the man represented in the middle stage notably bridges the transition between his old and new conditions.

Visual perspective

In this case, the sense of depth can be drawn from several attributes including the gradient background colour, the realistic images of the man as well as their different perceptual distances from the billboard's surface viewers. Although the photographic representations of the man's conditions are digitally separated from their backgrounds, they still capture some light and shadows in the three-dimensional space between his body and arms. In terms of their positions, it can be seen that the sizes of the photographs are varied corresponding to their perspectives which can also give the pictorial cue of depth and space. Such a relation

of the sizes and positions is congruent with the linear perspective principles resembling the perception of an actual scene consisting of elements at different distances in their relational sizes. In other words, it can be seen that the photographs recede toward the vanishing point on the left side of the billboard (Chandler & Munday, 2011). As such, it may engender audiences to view the visual representation of the man primarily toward the left vanishing point and subsequently be able to perceive that the man at the third stage on the right side is nearest to them. However, such viewing direction might not always be the case because the overall billboard places two primary groups of elements along the horizontal line which may also engender a viewer to view it in the left-right fashion. This is endorsed by the written texts on the left section which can encourage the familiar direction of reading Thai texts from left to right (Foulsham et al., 2013). Moreover, the composition of the triptych as explained earlier and the labels accompanying the man's conditions in the progressive order from the left and the right may overpower the consideration of the vanishing point (to view in a right to left fashion toward it) and promote the leftward viewing instead.

Tonality and colour

Because the billboard is a composite visual image, it is arguable that the gradient background is adopted to endorse the perceptual depth as mentioned in the previous subsection. The background colour in the yellow-orange tone may provide the overall context of the visual image whereby it potentially resembles the colour of the yellow robe of Buddhist monks and in Thailand, such colour tone is also used commonly in Buddhism-related events (Google Search, n.d.; Phawanawiriyakhun, 2000). In terms of the visual representations of the man, they are photographic images which display realistic light and shadows on the man's body as well as his natural skin tone and hair colour. Nevertheless, the depiction of boxing gloves in the form of the liver would be digitally enhanced regarding their colours and lighting. In this case, the different levels of the colour differentiation between yellow and red on the liver images are appropriated to illustrate the different conditions of the liver meaningfully.

Look and gesture

All three versions of the representation of the man are depicted with his eyes looking directly at the camera as if he was making contact with audiences and demanding attention or responses (Kress & Leeuwen, 2006). Throughout the three stages, they gradually display the changes in the man's facial expression and posture. From the first image on the left side to the third one on the right side, his face is argued to respectively transform from the unhappy face with the tired eyes and the dropped lower lip to the happiest face with the raised eyebrows, the eyes wide open, and the smiling mouth showing his teeth (Leppänen & Hietanen, 2007; Maher et al., 2014). Also, this corresponds to the positions of his elbows transforming from the most dropped elbows to become approximately perpendicular to his

body. In addition, the gesture of raising two fists in proximity or against each other in front of the chest potentially resemble the common postures of a boxer (Getty Images, n.d.-a).

Size relationships

In order to create a graphical perspective within the visual image, the sizes of the man's images reduce from the third image on the right side to the most receded one on the left side corresponding to the geographical perspective perceived in reality as explained above in the subsection of visual perspective. Meanwhile, the graphic representation of the liver on the billboard's left section noticeably covers a larger vertical space than the texts written on the same line. Moreover, the first logo featured at the bottom-left area of the billboard is notably bigger than the other five logos which are depicted with the identical height. The first logo might have a greater significance because it is the campaign's logo itself while the other logos represent its contributors. Also, it contains texts inside the circle which can be read/understood as an imperative sentence. By displaying the first logo in the large size, the billboard may promote the retention of the campaign and allow viewers to read the texts from afar and probably receive a relevant message delivered through the logo.

Accompanying written texts

From the left section of the billboard, the first line of the written texts is expressed in the form of a cascade equation: "พักดื่ม (pak-duem) = พักตับ (pak-tab) = ตับดีขึ้น (tab-dee-kun)" meaning "to abstain from drinking = to restore the liver = better liver". The first and the second phrases denote two distinct actions while the third phrase suggests the improvement of the liver condition. As such, the equal symbols (=) are potentially used to replace words stating the similarity or equality between such actions and condition (Cambridge English Dictionary, n.d.-a). For the the second line, although they are combined with the graphic representation of the liver, by considering particularly in terms of the written texts, they can be read "เข้าพรรษานี้ พักตับ พักยก" (kao-pan-sa-nee, pak-tab, pak-yok) literally meaning "this Buddhist lent, restore the liver, abstain from raising" whereby the phrase: "พักตับ พักยก" (pak-tab, pak-yok) is the campaign's name. It is notable for the term: "พักยก" (pak-yok) that it can be also used in the context of boxing to denote the rest interval between each round of the match (WMC, n.d.). Such denotation can associate with the visual representation of the boxer (the man) wearing boxing gloves on the billboard's right section. Therefore, the term: "พักยก" (pak-yok) is deployed to connect the recontextualisation of the message relevant to drinking abstinence to the context of boxing primarily depicted in the visual image.

Meanwhile, on the billboard's right section, there are written texts: "เดือนที่ 1" (duan-tee-nung), "เดือนที่ 2" (duan-tee-song), "เดือนที่ 3" (duan-tee-sam), respectively meaning "1st month", "2nd month", and "3rd month" labeling each stage of the representation of the man. Also, such a three-month period corresponds to the duration of the Buddhist Lent mentioned in the written texts on the billboard's left section. Subsequently, those labels may emphasise that the

transformation depicted in the visual image can happen within the Buddhist Lent period (three months). In addition, such a suggestion might also be endorsed by the first logo explained in the previous subsection. Whereby, the written texts featured in the logo can be read “งดเหล้าครบพรรษา” (ngod-lao-krob-pan-sa) meaning “abstain from alcohol consumption throughout the Buddhist Lent”. This can restate the time frame required to gain the transformational result depicted in the third stage of the man’s visual representation.

7.2.2 Size and space

A display of the visual image exemplified in this case can be shown in Fig. 7.5. It is printed as a large billboard with dimension 15 m (height) x 40 m (width) which is installed on a stand approximately 35 m (height) from the ground. It is supposed to be seen from afar especially by people travelling towards it on the road. Corresponding to its size, the majority of characters (texts) written on the billboard are height about 12 cm while the small ones are height around 5 cm. As such, the written texts can be read from a viewing distance within ~30-90 metres, although it should be noted that the reading ability and the amount of information read by an audience are also significantly affected by the speed of an automobile (Emoto, Kusakabe, & Sugawara, 2014; Dostal, Kristensson, & Quigley, 2014; Thibou, 2014). For example, for people travelling with a speed of 35 mph (56 km/h), they will have less than 6 seconds to read the texts in such size before passing them. Nevertheless, this might not be the case for viewing the visual representation of the man in three stages. Based on its average height (~12 metres), it might be seen from a viewing distance further away than that of the written texts. In addition, it can be seen from Fig. 7.5 that there are some power cables suspended along by the street. As a result, at certain viewing angles, they might be seen overlapping some part of the billboard which probably distracts viewers or hinders the reading of the written texts.

Fig. 7.5: The campaign’s billboard displayed along Thonburi – Paktor street, Thailand in 2017

7.2.3 Context

Production context

The billboard was created and used in the campaign encouraging alcohol drinking abstinence in Thailand. The campaign is argued to be an implementation corresponding to the recommendation of ongoing Thailand's 10 years (2011-2012) national strategy for regulating alcohol consumption especially in the aspect of changing attitudes toward alcohol drinking and discouraging such a habit (Saengow, Wijitkunakorn, & Assanangkornchai, 2016). The campaign is part of a long-lasting project delivered in the form of an annual alcohol abstinence occasion happening at the same time as an established cultural event such as Buddhist Lent. Therefore, it is generally known as "งดเหล้าเข้าพรรษา" (ngod-lao-kao-pan-sa) meaning the event encouraging people "to abstain from alcohol consumption during Buddhist Lent". Because it has been undertaken yearly in Thailand since 2003 through the cooperation of two primary institutions i.e. Thai Health Promotion Foundation (ThaiHealth) and the Centre for Alcohol Studies (CAS), it has become a familiar annual event alongside its associated religious festival (SAB, 2016).

It is notable that the implication of the movement is based on the annual practice of Buddhist monks during Buddhist Lent to meditate for three months at the temple during the rainy season. Some lay Buddhists may also deliberately observe the five precepts of Buddhism including giving up alcohol consumption (Dipananda, 2016). Although the majority of the Thai population are Buddhists, there are only about 11% of them adopting such ascetic practice during the Buddhist Lent. The alcohol abstinence movement attempts to target audiences who are alcohol drinking men between 25-40 years old, and the secondary audiences include teenagers and young adults between 15-24 years old, adults above 41 years old, as well as those close to someone who drinks (Stopdrink, 2006).

Each year the campaign engages audiences with a specific theme arguing for alcohol abstinence. Each year's theme may involve any dimension such as value or belief, health and wellbeing, economy, or other social aspects (SAB, 2016). For example, it initially promoted alcohol abstinence as a meritorious act, then as an effective way to address financial and mental problems in the family, as the expression of affection to family members, or as a prove of desirable persistence and endurance (Temsiri, 2017). For the year 2017, the campaign is named "พักตับ พักยก" (pak-tab-pak-yok) which mainly focuses on the liver condition in relation to alcohol intake corresponding to the tendency of more people in Thai society turning their interests toward health issues and wellbeing. It is developed on the basis of the knowledge suggesting that the liver is part of the body that is susceptible to alcohol consumption, and abstaining from alcohol intake for three months can significantly restore the liver condition (Bonkham, 2017; SanookHealth, 2017; Thaipost, 2016).

In accordance with this main theme, the visual image considered in this case is created along with a coordinating short video by an advertising agency (Advertorial, 2017). From the creative team's statement (KapookHealth, 2017), the billboard and video are produced to deliver the key message proposing that to abstain from alcohol intake is effective to restore the liver. This proposition is summarised as a short caption or slogan "พักดื่ม = พักตับ = ตับดีขึ้น" (pak-duem, pak-tab, tab-dee-khun) to be included in the campaign materials. In terms of the visual representation of the billboard, it aims to present the potential improvement of the liver condition as a result of alcohol abstinence. Particularly, a longer period of abstinence may provide a better result for the liver. Moreover, it utilises the context of boxing in order to metaphorically illustrate the idea of fighting and resting. In other words, the liver is working against and might be damaged by alcohol intake in the same fashion as a boxer is fighting against his opponent in a boxing match. Meanwhile, the abstinence of alcohol intake over a period of time to restore the liver can be compared to the resting interval between the boxing rounds when a boxer has a chance to regain his strength. Also, this leads to the campaign's name "พักตับ พักยก" (pak-tab-pak-yok) and in this context, it literally means "restore the liver, the resting interval" which may emphasise the analogy between the two parallel contexts. In addition, the irrational representation of the liver as boxing gloves not only endorses such recontextualisation but it also draws attention to the characteristic of the liver especially regarding its colour. The different conditions of the liver are digitally manipulated based on the possibility of actual liver improvement by alcohol abstinence and the accuracy of the representation is achieved through the collaboration between the creative team and a hepatologist.

Distribution context

It is notable that the visual image was distributed in 2017 which is the 15th year of the annual movement promoting alcohol abstinence during the Buddhist Lent in Thailand (Temsiri, 2017). Also, the campaign is commonly acknowledged by many members of the public which is evident in the increasing number of people joining the campaign approximately 12 million participants in the previous year and around one-third of them successfully abstained from alcohol intake throughout the three-month period of the festival (SAB, 2016). Such satisfactory awareness of the movement is argued to be the outcome of the efficient campaign promotion appropriating a variety of channels across the country. As a result, it can be seen that the visual image considered in this case is distributed through several associated approaches such as TV and radio broadcasting, publications and newspapers, online banners and social media, outdoor billboards, public engagement activities, and advertisements like those on buses or trains and around their stations (KapookHealth, 2017; SAB, 2016; Thaipost, 2016).

The statistics from the previous year shows that, among several types of campaign materials, the billboard is the second most often encountered by people which allows

members of the public to become aware of the campaign following the most accessed channel like the video advertisement broadcasted on TV (SAB, 2016). The campaign's billboards are usually displayed around significant and conspicuous locations along main streets and junctions in order to be primarily seen by people travelling on a vehicle. This is also applicable to the billboard's distribution context exemplified in this case as shown in Fig. 7.5. The large billboard is presented alone on Praram II or Thonburi – Paktor road which is the primary national highway number 35 connecting three regions including the central, western, and southern parts of Thailand (BHS, 2018). The Praram II highway is argued to be the main route for travelling between Bangkok (the central area) and the southern region either for general or logistic transportation and can support a high volume of traffic with three primary lanes on each way, or four lanes at some busier sections (Nakthong, 2017).

Particularly, in this case, the billboard is placed facing vehicles travelling away from the central region around the last section of the Praram II road, approximately 1km before its ending point at the main junction connecting the road with another primary national highway (Phet Kasem Road) which passes through the western and southern regions as shown in Fig. 7.6. Such duration of the Praram II highway is specifically called the Prak-Nam-Daeng to Wang-Ma-Nao section which is used by an average of more than 120 thousand vehicles a day (RoadNet, 2018). Therefore, with the accompanying spotlights above the billboard, the billboard is potentially seen by a large number of audiences especially those travelling from the central region to either the western or southern part of the country throughout the day and night time. Moreover, during holiday seasons including the Buddhist Lent, the traffic may increase significantly because people working in the central region tend to visit their hometowns or have a holiday trip as an approach to requesting tax redemption encouraged by the government (TAT, n.d.).

Furthermore, for some people, the reunion with family members or friends during holidays is an opportunity to drink alcohol for celebration or socialisation (SAB, 2016; Vichitkunakorn, 2017). Although on the occasion of Buddhist Lent festival, most people are likely to be aware of alcohol abstinence, by viewing the campaign's billboard before the holiday reunion might endorse such acknowledged notion suggesting the alcohol abstinence especially on the 'Khao Pansa' holiday which remarks the start of the Buddhist Lent (Dipananda, 2016). In addition, because the billboard is displayed throughout three months of the festival period, besides raising awareness of ceasing from alcohol intake, it may also function as the ongoing reminder for the campaign's participants to continue observing the alcohol abstinence until the end of the Buddhist Lent festival.

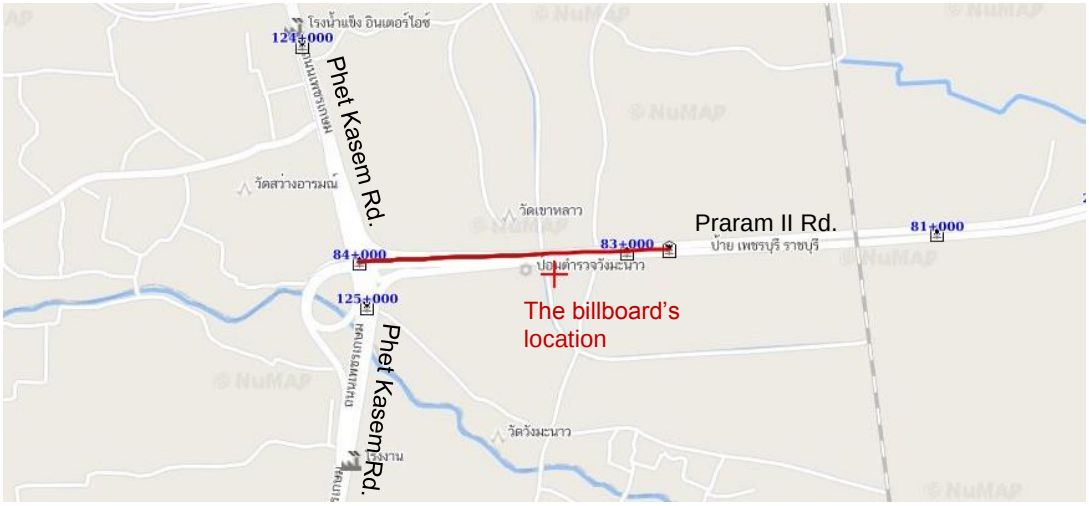


Fig. 7.6: The map displaying the position of the exemplified billboard for campaigning alcohol abstinence on the Praram II highway, Thailand, Longdo map [online image] Available at: http://roadnet.doh.go.th/ [accessed 30th May 2018]

Reception context

With regards to the accompanying texts written on the left side of the billboard, the first line is argued to be straightforward and accessible. It appropriates the equals symbol (=) which people commonly recognise in their daily lives in order to make the statement concise and can be perceived within a brief moment. By reading the first line of the written texts, audiences might be able to attain the main statement of the billboard proposing that to abstain from alcohol intake is equal to restore the liver resulting in a better liver condition. Although the phrase: "พักดื่ม" (pak-duem) literally meaning "to abstain from drinking" does not directly mention words relating to alcohol beverages, for Thai audiences, the word: "ดื่ม" (duem) meaning "to drink" or "drinking" can suggest particularly the drinking of alcohol rather than other types of drinks. This is congruent with a common Thai phrase: "นักดื่ม" (nak-duem) literally meaning "drinkers" generally used for denoting people who drink alcohol regularly (Longdo Dict, n.d.-a). Moreover, it is notable that the proposed equation is started with the phrase: "พักดื่ม" (pak-duem). Therefore, it potentially suggests such action as the prerequisite action required to obtain the associating outcome written in the last phrase of the equation.

The second line of the written texts begins with the phrase: "เข้าพรรษานี้" (kao-pan-sa-nee) meaning "this Buddhist Lent" which can coherently identify the aspect of time along with the actual billboard's display duration. On one hand, for people encountering the billboard prior to the festival time, it may be able to raise their attention to the campaigning and prompt them to participate in the approaching three-month abstinence. On the other hand, for audiences viewing it during the three month period of the festival, such a phrase may endorse that the movement is contemporary especially for participants observing alcohol abstinence and may encourage them to continue doing so until the end of the festival. Then, the phrase is followed with the campaign's name: "พักตับ พักยก" (pak-tab-pak-yok) as

explained earlier in the subsection of the accompanying written texts that the phrase: “พักยก” (pak-yok) can involve a noun naming the rest interval between rounds of a boxing match. In this aspect, it may connect the verbal statement primarily relevant to alcohol intake with the context of boxing visually represented on the billboard’s right section and endorse the notion of restoring the liver as similar to a boxer regaining his strength through such break time.

Meanwhile, it is arguable that the phrase: “พักยก” (pak-yok) might also describe the action of abstaining from alcohol intake itself. The words: “พัก” and “ยก” commonly denote the verbs “to rest” and “to raise”, respectively, and particularly in the context of alcohol drinking, the word: “ยก” (yok) is used as the shortened word associated with the phrase “ยกแก้ว” (yok-kaew) literally meaning “to raise a glass” connoting the action to give a toast (Longdo Dict, n.d.-e). Therefore, the phase combining the two words: “พักยก” (pak-yok) can mean “to rest/stop from raising up a glass, and potentially suggests audiences to withhold from such cebebration with alcohol drinking. From this perspective, the campaign’s name: “พักตับ พักยก” (pak-tab-pak-yok) proposes the same statement written in the first line explained above. In addition, it can be seen that the phrase “พักตับ” (pak-tab) especially the word: “ตับ” (tab) meaning the liver is embedded in the graphic representation of the liver. As a result, such a written word and the visual representation are argued to complement each other. While the word: “ตับ” (tab) labels such depiction as the liver, the graphic illustrates some liver’s physical features. As such, it can be conceived that the depiction of the boxing gloves on the right side of the billboard represents an image of the liver. In other words, despite lacking prior knowledge about the appearance of the liver viewers can ensure that such representation resembles the liver rather than any other body part.

Besides the liver-like boxing gloves, the perception of the depicted man as a boxer can also be suggested by his posture and his upper body without wearing a top may resemble the common appearance of a male boxer in Thailand especially in the context of Thai boxing (Google Image, n.d.). Furthermore, for audiences who have seen the billboard’s accompanying video (ThaiHealth, 2017) featuring the man fighting with bottles of alcoholic drinks in the boxing ring prior viewing the billboard, they might be able to recognise the man and acknowledge that he is represented as a boxer. Regarding the overall visual representation, it can be perceived as a pictorial chart displaying the changes of visual attributes along the axis of time spanning from the first to the third month labelling each stage of the representation. By depicting the man in approximately the same camera angle and postures throughout the three stages, such consistency might emphasise the differences of the focused attributes among those stages (Kennedy, 1985; Lester, 2010).

As such, viewers potentially perceive that there are transitions regarding the man’s hairstyle, beard, facial expression, liver condition, and abdomen especially the dichotomy between his conditions in the first and the third months. Although the notion of change is represented

through these accounts, within a brief viewing time, the most predominant elements potentially perceived by audiences might be the facial expression and the liver representation which seems to provide sufficient cues suggesting the transition. This might be because a human face is generally argued to be a focal point attended by people who are also able to read its expressive emotions (Adolphs, 2002; Bradley, 2015b). Moreover, the man is depicted looking directly at viewers which may present the demand for a response (Kress & Leeuwen, 2006). Regarding the liver depiction, it is conspicuous through its shape and colours dominant from the man's body which is also endorsed by the man's posture raising it up in the foreground closer to viewers, as well as the accompanying written texts mentioning the word: "ตับ" (tab) meaning the liver.

By viewing such visual attributes along the time scale, viewers may understand that within the three-month period, the depicted man becomes happier as shown through his facial expression (Calvo et al., 2014; Maher et al., 2014) and having a better liver condition coherently stated in the first line of the written texts. The liver depicted in the first stage on the left side can suggest the aspects of abnormality or disease. Such a representation is arguably recognisable by audiences since the liver's condition in terms of its colour and surface may resemble some characteristics of damaged organs which are represented on cigarette packets as warning pictures (Wateesatokkit, 2008). Meanwhile, the contrasting representation of the liver in the third stage may imply the liver condition opposing the defected one since the liver can be perceived as healthier due to the absence of cues indicating imperfection. It can be seen that the visual representation primarily suggests the transition over a period of time while the cause of such happening is proposed in the written texts as the act of alcohol abstinence.

Furthermore, although the idea of transition might be sufficiently perceivable through the visual representation of the first and the third stages, the man and the liver condition depicted in the middle stage can suggest that it is a continuing process gradually bringing the improvement as the result of persistently withholding from alcohol intake throughout the three-month duration. Also, such a concept is emphasised by the first logo featured at the bottom-left corner of the billboard literally encouraging the alcohol abstinence throughout Buddhist Lent in which Thai audiences generally acknowledge that it covers three month period (Dipananda, 2016). In addition, the adjusted depiction sizes of the three stages expanding toward the latter month may endorse not only the distinction between the stages but also the idea of growth or advancement of the man appearance and the liver condition which is coherent with the word "ดีขึ้น" (dee-khun) meaning "getting better" written in the last phrase of the first textual line written on the billboard's left side.

7.2.4 Construction

The visual image and the accompanying written texts considered in this case may construct aspects suggesting the notion of well-being. Although the understanding of the term well-being and its relevant agenda can be diverse in different contexts, several frameworks developed to measure either a national or a personal level of well-being usually involve the dimensions of economic, environmental, social, as well as subjective indicators (Bache, 2018; Spratt, 2017). For example, Rath (2010) particularly proposed five primary elements of an individual's well-being comprising the aspects of career, social, financial, physical and community well-being. This is also congruent with the emerging use of the term well-being intricately associating with the position of health defined by the World Health Organisation (WHO) which covers aspects beyond the absence of disease to the wellness of physical, mental, and social state of a person (Spratt, 2017). Subsequently, the goal to encourage desirable well-being may evolve from the fundamental paradigm of disease prevention exclusive to doctors and patients to become everybody's lifestyle or behaviours yielding to the quality of life. Moreover, such a perception of well-being can be observed in the account of public health movements raising awareness of health risks and promoting a healthy lifestyle (Searle, 2008).

From several dimensions contributing to a person's well-being, the construction of the billboard is argued to focus on the aspect of physical well-being which generally involves the concept of having good health and sufficient energy to sustain one's life on a daily basis (Rath, 2010). It can be seen that the billboard selectively presents alcohol intake as a risk leading to negative effects. Also, it proposes alcohol abstinence as an approach to improving physical well-being. The condition of the man and the liver at the first stage probably suggests that alcohol intake can negatively affect one's health which is represented through some accounts of negative physical well-being indicators such as the unhealthy outward appearance, the absence of happiness, and the damaged liver (Searle, 2008). It can underpin the audience's common acknowledgement of alcohol's negative effects especially being harmful to the liver (SAB, 2016).

Meanwhile, the composite visual representation of the three different stages may be appropriated to promote the prescribed behaviour which is primarily constructed through the accompanying written texts and the billboard's context suggesting the alcohol abstinence. The pictorial chart may construct a perceivable improvement of the depicted man's health between the two dichotomy conditions over a period of time. As such, it visually displays a measurable short-term incentive which may have the potential to encourage an individual to make a positive decision to comply with alcohol abstinence (Rath, 2010). The visual construction coordinates with the written texts stating the potential outcome particularly regarding the improvement of the liver condition. It also associates with the context of boxing which may emphasise the concept of enduring damage of the liver from alcohol intake which

can be restored through a period of alcohol abstinence in a comprehensible analogy. Furthermore, by depicting the man in the visual image, it may exemplify him as a relatable typical drinking person, as a member of the main target audiences who are susceptible to alcohol consumption and can attain well-being improvement by abstaining from alcohol. This may encourage audiences to observe the alcohol abstinence by promoting the perception toward their ability to accomplish the prescribed action (Sullivan, 2009).

The construction of the billboard in the aspect of stimulating a behavioural change might be congruent with a socially acceptable technique adopted to gain compliance with a suggested behaviour (Littlejohn, 2010; Marwell & Schmitt, 1967). In other words, the proposed health improvement potentially attained from alcohol abstinence, either in the forms of visual or verbal envisaging, can serve as a promising reward for viewers who could successfully abstain from alcohol intake over a period of time. Moreover, it can also be explained from the perspective of advertising techniques in which the billboard probably constructs a persuasive proposition through two distinct juxtaposition strategies. On the one hand, the enhanced photographs in combination with the written texts may suggest two coordinating causal relationships linking alcohol intake with the man's well-being. As such, the billboard proposes that either alcohol intake can lead to the man's negative health effects as depicted in the first stage of the visual representation; or alcohol abstinence can result in his health improvement visually depicted in terms of the transition of the liver condition and his appearance. The latter cause-effect juxtaposition is also asserted in the written texts in the simplified form using the equal symbol to denote such a relationship. On the other hand, the visual representation potentially illustrates the visual contrast among the sequences of the liver and the man representation. It may juxtapose the conditions presumably before and after the alcohol abstinence has been observed to emphasise its positive well-being effects as if it is a desirable action. Besides, the written texts labelling each depicted stage can suggest that the factor of time is also significant in attaining the claimed result.

In addition, it is notable that the billboard is familiar in terms of health promotion in Thailand that has also become an accompanying movement alongside the annual traditional Buddhist Lent, namely "งดเหล้าเข้าพรรษา" (ngod-lao-kao-pan-sa) as explained previously in the production context. It may present familiar emblems of the movement including the written texts mentioning its keywords such as "withhold drinking", or the name of the associated religious event which are endorsed by the background colour, and the logos of the project's leading institutions. Therefore, the billboard potentially serves as a stimulus evoking recognition and reaction toward such accustomed health-related movement. In other words, the billboard can construct the idea of the movement itself. As such, some viewers may also acknowledge its aim to promote alcohol abstinence and may already comply with such prescribed action as a common norm during the Buddhist Lent whether or not they are influenced by the proposition presented in the billboard.

7.3 Summary

The two cases analysed in this chapter associated with public campaigns to promote behavioural changes. The messages conveyed in cases 7.1 and 7.2 involve science-related worldview or proposition which arguably contain certain aspects of value or evaluation toward science (Hill & Helmers, 2004; Messaris, 1997). Namely, the science-based recommendations can be disseminated explicitly in cases 7.1 (poster 'Keep Antibiotics Working') and 7.2 (billboard championing alcohol abstinence) which are rationalised by scientific and statistic evidence.

To construct messages in both cases, they adopt some iconic signs such as the images of a capsule and probably the resemblance of microbes seen through a microscope in case 7.1, or the image of a male boxer in case 7.2 in combination with written texts. Some written texts may serve as an anchor to explain visual images such as the textual description embedded nearby the visual representation of antibiotic-resistant bugs in case 7.1. The inclusion of a suggestion nearby the visual representation in case 7.2 may also reinforce the association between the two pieces of information namely the idea of "พักตับ" (restoring the liver) involving alcohol abstinence in this context, and the liver which will be positively affected by this action. As such, it may also promote the retention and application of the idea in audiences' daily lives (IARE, 2003; Mayer & Sims, 1994).

On the other hand, the statements declared by written texts can be endorsed by visual representation. Namely, the visual representation of the occurrence of antibiotic resistance in case 7.1 and that of the improvement of the man's condition in case 7.2 may respectively promote the propositions "Keep Antibiotics Working", and "พักดื่ม (pak-duem) = พักตับ (pak-tab) = ตับดีขึ้น (tab-dee-kun)" meaning "to abstain from drinking = to restore the liver = better liver" (Anglin et al., 2004; Gregory, 1980; Lacey, 1998). In case 7.1, the reception of the intended message may also be promoted by a tension between competing elements. The desirable outcome suggested in the written main statement: 'Keep Antibiotics Working' can be emphasised by being contrasted with the undesirable or provocative antibiotic-resistant bugs represented in the visual image (i.e. regarding their character designs and facial expression).

Therefore, the encouragement of a desirable behaviour might be undertaken by two major approaches. It may be accomplished through written/verbal information with visual representation utilised as a complementary element. Alternatively, it may rely on the interdependent combination of visual and textual/ verbal information. For the first approach, the intended message associated with a prescribed behaviour is entirely perceivable through textual/verbal information. For example, the texts written in the poster 7.1 and the billboard 7.2 are considerably conspicuous, regarding font type, size, and colour, and subsequently may be capable of drawing one's attention to read them as a result of these features. By reading such written texts alone, an audience may be able to attain the intended messages,

respectively arguing for using antibiotics prudently and alcohol abstinence. Meanwhile, the visual images in these cases seem to support such primary construction by visually representing a potential outcome of either complying with or ignoring the suggested practice. The appropriation of these supportive visual images can be beneficial to the events at least in two respects. The visual representation can raise emotional responses towards the proposition which may subsequently reinforce the decision to follow the prescribed behaviour. Also, by coherently presenting information in both modalities (verbal and visual), it not only makes the events engaging to audiences with different learning styles but also enhances the information processing and acquisition (Littlejohn, 2010; Marwell & Schmitt, 1967).

The visual representation of a predicted or plausible scenario may rely on a pretence system like cartoon illustration in case 7.1 or a composite visual image in case 7.2. It can be notable that the desired interpretation may be endorsed by the adoption of a recognisable visual metaphor. In other words, the graphic illustration of the poster 7.1 and the billboard 7.2 may respectively associate with the familiar bouncing of an object after being resisted by its target, or the pictorial chart comparing the different measurable quantity or observable conditions of something over a period of time. In addition, there is also the inclusion of institutions' logos which, similar to the primary visual representation, potentially serve as the visual element endorsing the written proposition, especially regarding its authority and reliability.

Chapter 8
Discussion

This research focuses on the investigation of visual images utilised in science communication events which are encountered by public audiences casually in their daily life contexts. Visual images are less likely to be used solely as a single modality for communication within an event but are usually deployed with other modes of information such as written texts or verbal conversation. Hence, the study considers the collaborative mechanism between visual images and such accompanying elements of communication in relation to the construction of an intended message and the fulfilment of the event's objectives.

8.1 The recapitulation of individual case analyses

The analyses of individual cases in Chapters 4-7 show that the utilisation of visual images for a casually encountered science communication event can be an approach that can reach out to a range of audiences and gives members of the public an opportunity to encounter science in their daily life context. Science communication can involve different facets of science besides scientific facts, such as information about scientific practice, scientific community or about scientists themselves, science-related ideas or worldviews (Bennett & Jennings, 2011; Brake, 2010; Burns, O'Connor, & Stocklmayer, 2003; Gregory, 2015; Hohenberg, 2017; The Office of Science and Technology and the Wellcome Trust, 2000). The case studies featured in this research demonstrate that a combination of visual representation and other accompanying components, for example in the forms of written texts or verbal conversation, can construct an intended message that is either directly or peripherally associated with science (Chandler & Munday, 2011; Lacey, 1998). They can involve different facets of science such as in terms of scientific knowledge, scientific enterprise and purpose, cultural aspects of science, or science and society. Hence, the use of visual images could potentially enhance the communication of science with the public.

The case studies provide a variety of specific examples of how visual images can be utilised in science communication events. Such contribution primarily postulates some answers to the research questions RQ1: How is the message constructed by a visual image and accompanying information in a science communication context? and RQ2: How is the discourse of an ideology or concept realised in different science communication contexts using a visual image(s)? Such two research questions respectively focus on the investigation of cases' potential intended messages, and the discourse or concept underpinned by the appropriation of visual images and accompanying elements. It demonstrates that a variety of messages/content can be conveyed in image-based science communication events in which

the approaches of representation through the collaboration of visual/verbal elements within a context may encourage certain versions of audience perception and response.

The investigation of the events based on the discourse analysis framework (Kenney, 2009) as explained in Chapters 4-7 shows that visual images used in combination with accompanying written texts can be a useful tool for communicating intended messages including particular social ideologies. From the sections explaining the construction of meanings in those individual cases (sections 4.1.4, 4.2.4, 5.1.4, 5.2.4, 6.2.4, 6.3.4, 7.1.4, and 7.2.4), the social ideologies or concepts associated with those exemplified cases can be summarised in Table 8.1.

Table 8.1: The summary of the concept or ideology potentially constructed in the exemplified cases

Case	Concept or ideology	
	Endorsement	**Opposition**
4.1 'Let The World Keep Turning' exhibition	Diversity, multiculturalism, and collaboration	The stereotypical image of a scientist
4.2 'Enjoy Science Careers' exhibition	Professionalism regarding biomedical engineering	The stereotypical image of a scientist
5.1 Mural 'Seeing red'	Environmentalism and sustainability	Industrialism and overconsumption
5.2 Mural 'We are the same blood'	Environmentalism, romanticism	n/a
6.2 Panel 'X-ray kissing'	Authenticity	Capitalism
6.3 Panel 'Chocolate shells'	Industrialism	n/a
7.1 Poster antibiotic resistance	Sustainability	Antibiotic resistant bacteria
7.2 Billboard alcohol drinking abstinence	Personal wellbeing	Overindulgence of alcohol

Meanwhile, the construction of meanings as previously explained in those chapters can be considered into two interrelating accounts including through visual representation and through the combination of multiple modalities.

Visual representation

The case studies show that visual images can convey information which contributes to an overall interpretation of the intended message. Whereby, their depicted contents may suggest some meanings on their own accounts. A visual image might be articulated with a series of visual signs either in terms of iconic, symbolic, or indexical representation (Lacey, 1998). By merely viewing a visual image, the determination of a depicted subject and its

properties relies on one's prior knowledge stored in the mental schemata that can be congruent with the representation in its relevant context (Winn, 2014).

An iconic sign represents a subject by resembling some of its significant features. These visual images arguably provide some structural and spatial information of the depicted subjects in relation to their surrounding elements (composition) to an audience which then is used for matching with some appropriate preexisting schema (IARE, 2003; Winn, 2014). Namely, the recognition of a depicted subject may occur when it contains some familiar attributes. For the cases in which the matching process cannot be achieved straightforwardly, they may raise an audience engagement or contemplation by provoking one's mind to resolve the challenge of visual search (Rumelhart & Norman, 1981; Winn, 2014; Wolfe, 1988).

Some cases also contain a symbol to suggest a relevant subject. It can be seen that a symbol is arbitrarily created to represent a thing including an abstract concept and conventionally used and acknowledged within a particular society which can be a small one such as a family or a global one (Lacey, 1998). Similar to the case of iconic representation, the determination of a symbol is based on prior knowledge stored in one's mental schemata, namely the structural memory outlining the relationship between a symbol and its interconnected facts or idea (Winn, 2014). Nevertheless, such learnt knowledge required for accurately perceiving a symbolic representation might not be accessible to a broad range of audiences but exclusive to one culture.

The recognition or identification of individual depicted subjects may occur within a very short time after attending to a visual image or occasionally may require some conscious negotiation. Nevertheless, it can be seen that in the actual perception of visual images, one's mind rather attempts to draw an overall meaningful message from the contribution of several given cues based on their personal experience and prior knowledge despite the omission of some featured elements or the presence of certain unrecognisable subjects (Anglin et al., 2004; Gordon, 1997; Gregory, 1980; Lacey, 1998; Lester, 2010). In order to do so, besides visual representation, one may also attend to other available information, especially the accompanying written texts.

The contribution of multiple modalities (visual representation and accompanying elements)

The cases considered in this research can affirm the notion that visual images are usually accompanied by textual or verbal information to deliver an intended message (Kenney, 2009; Lacey, 1998). By coupling two modes of representation aimed at the communication of an associated message, the material can activate both representational systems: visual and verbal in the brain to be activated to provide cognitive resources for information processing

which potentially results in an efficient learning experience regarding the understanding, integration and retention of the relevant message (Adcock, 2000; IARE, 2003; Paivio, 1990).

The contribution between a visual image and its accompanying elements such as written texts observable in the case studies can be considered in several dimensions with respect to their relationships utilised to convey an intended message or to achieve a communicative function. Those relationships are summarised at the end of each chapter (Chapters 4-7). Some plausible dimensions are drawn from the observation of visual-textual relationships emerged in the exemplified cases, and to increase the validity of the findings, they are compared with the findings proposed in other previous studies (Unsworth & Cleirigh, 2009; Hunt, Lomas, Corris & Adler, 2010). The comparison of research findings subsequently shows that the approaches of using visual images with accompanying elements observable in this study are also congruent with the existing literature. As such, the combination of modalities can be generally encapsulated into four distinct, though occasionally overlapping, dimensions, namely identification, expansion, implication, and reinforcement (Unsworth & Cleirigh, 2009; Hunt, Lomas, Corris & Adler, 2010).

For identification, written texts may be deployed as an anchor to explain visual representation, especially in cases depicting unfamiliar or unknown subjects. The written texts utilised in this manner are usually a short name or phrase placed nearby or embedded in a visual representation. By simultaneously presenting two forms of coherent information in integration, it may reduce the effect of split-attention which can support learning by reserving cognitive resource for further processing the overall materials (Mousavi et al., 1995; Sweller, 2016; Sweller, Chandler et al., 1990). In terms of expansion, written texts may provide additional information relevant to a visual image. They not only describe the content of the image but may also introduce further information not included in the visual image. In the case of implication, accompanying written texts may not explicitly give literal information relevant to a visual image, but they rather suggest a context or manner for perceiving the visual representation. And for the last dimension, written texts may be designed to reinforce a perception or concept obtained from a visual image.

The following sections provide a further understanding of these phenomena by ‘stepping back’ from the particular details to obtain a broader overview of the exemplified cases. It draws together the key generic observations which emerged in those specific cases which may be applicable to the practice of using visual images in science communication. They explain how the featured visual images, as well as accompanying elements, can facilitate a science communication experience. Namely, they may provide some answers associated with the research questions RQ3: How can visual images perform their function regarding the capturing and maintaining of audience attention? and RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements

corresponding to the fulfilment of Generic Learning Outcomes (GLOs)? As a result, they consider the events through the dual lenses of science communication on the one hand and the mechanisms of how learning may occur in these cases of visual images and their accompanying elements on the other. The results and findings associating with elements considered in such two research questions (RQ3 and RQ4) are presented in three dimensions including:

- the potential of a visual image-based science communication event to gain attention or make a passer-by stop and visit the event regarding its presence and invitation (section 8.2), then
- to maintain such attention when an audience may participate in the event (section 8.3); and
- the experience transformation or learning mechanism that may occur in such an event, and the enabler of the event's objectives respecting to the Generic Learning Outcomes (GLOs) framework (section 8.4).

Each dimension of results and findings is endorsed by examples drawn from the case studies either provided here along with the explanation or cross-referenced to previous chapters or the Appendix D. The dimensions of findings are also explained in relation to relevant theoretical perspectives and examples found in other domains of communication.

8.2 Presence and invitation

Since the exemplified cases are encountered science communication, it is arguable that these events are supposed to be significant enough to draw people's attention even in a nuanced environment. Displaying a visual image and its accompanying text in a public space can generate curiosity and interest in the event. The featured materials need to be distinct from the surrounding environment thus enabling a passer-by to become aware of the installation which simultaneously acts as an invitation for a viewing (Arcand & Watzke, 2010; Kennedy, 1985; Naylor & Keogh, 1999). Based on the dual coding principle (Paivio, 1990), the utilisation of a visual image and written texts in the exemplified installations can serve as a stimulus which is able to activate the representation systems in the memory through visual stimulus. Namely, it can intensify the suggestion that there is some information intentionally presented for attention, and subsequently prompts the mind for processing the information. This section explains some characteristics of visual images or events drawn from exemplified cases which potentially capture attention, as well as to promote the events' presence and invite people to make a visit. As such, it may partially answer the research question RQ3: How can visual images perform their function regarding the capturing and maintaining of audience attention?

The event's attractiveness can be underpinned by several attributes encouraging passers-by to stop or pay attention to them. Such processes may involve two primary aspects of visual

perception including the sensing of and attending to a visual image whereby a visual element may influence such behavioural responses either emotionally or cognitively (Bruce et al., 2003). Some characteristics observable in the exemplified cases include the accessibility and informality of an event, a visual image's physical dimension and occupied space, different aspects of recognition perceived from visual content, and the perceptible coherence of an overall event. Each dimension can be explained and endorsed by examples from the case studies as follows.

8.2.1 Accessibility and informality

From certain proximity, a passer-by may be able to discern the event's overall format which can also generally advise some expectation regarding the exploration of the event. Such initial presumption about the event may be utilised in combination with some personal factors such as their interest or availability to decide whether to stop and deliberately consider a visual image (Anglin et al., Anglin, 2004; Falk, Storksdieck, & Dierking, 2007; Guler, 2015). From the case studies, the accessibility and informality of the events suggesting the likelihood of enjoyment attained from viewing striking visual images may ease such process of decision making (Bultitude & Sardo, 2012; Jensen & Buckley, 2014; Sardo & Grand, 2016). The event's setting and location might endorse the convenience of participation where passers-by can spontaneously access the event and presume that the featured visual images were publicly presented for anybody who would wish to view them including the passers-by themselves. For each case study, the visual images were accessible by public audiences, and in some cases, they were also selected intentionally to accentuate the relevance to particular groups of people (Bowater & Yeoman, 2012; Stocklmayer & Bryant, 2001). For example, the banners of case 4.1 were arranged in a hospital, they endorsed their association with healthcare or medicine which is relevant to the majority of the passers-by such as patients and their visitors, or members of the medical staff.

Furthermore, the arrangement of visual images may also roughly suggest the event's viewing manner such as in terms of its viewing space, viewing path or circulation, as well as entrance, backtracking or exit (Guler, 2015). The flexibility of the viewing paths observable in the 'Light Works' exhibition, as explained in Chapter 6, may encourage an exploration in which a viewer could selectively view the panels in the exhibition without any restricted order. This might also be the case for the murals 5.1 and 5.2 in which audiences could freely explore the murals displayed on the wall along the pavement as they pleased. In addition, the majority of the cases considered in this research were displayed in a stand-alone fashion (i.e. without facilitators) which may convince passers-by that they would be comfortable making a casual visit. Nevertheless, by seeing facilitators prompting at the exhibits in cases 4.1 and 4.2, the subsequent perception of a demand to interact with them may arise and occasionally becomes off-putting to some potential audiences (Kamolpattana et al., 2015).

8.2.2 Size and occupied space

It can be seen that all the visual images were displayed in a substantial size within their context which could make them noticeable within a public space or the nuances of the surrounding environment (Kennedy, 1985). Since there is a limited amount of optic array, namely the spatial and temporal pattern generated by the light with respect to the environment layout that an eye can perceive at a time (Bruce et al., 2003; Gordon, 1997), the presentation of a visual image in a large size comparing to its surrounding objects may promote its capacity for viewing. As a result, it may increase the chance when passers-by could be aware of its presence and significance.

The existence of a visual image may be endorsed by the number of its associated visual images (Bradley, 2014; Lester, 2010). This might be evident in cases 4.1, 4.2, 6.1 and 6.2 since each visual image is part of an overall exhibition that occupies a prominent area within a public space. In some cases, such presence may also be reinforced by the number of visual images and their arrangement. For example, the large number (50) of visual images in the 'Light Works' exhibition explained in Chapter 6 create an overall conspicuous size. Moreover, the form of the customised panels and their arrangement may also increase the exhibit volume in the optic array as well as make the exhibition noticeable from afar.

The size of a visual image may generally be related to the perception of detail clarity. Namely, a larger visual image seems to require less effort for viewing or identifying the portrayed subject compared to a smaller one resulting in a better chance to get attention (Codispoti & De Cesarei, 2007). Based on such consideration, besides the factor of visual image dimension, the perceptible accessibility of its detail may also play a significant role in encouraging a person to look at it. Therefore, a visual image used in an event encountered unexpectedly is not always a huge one as long as it can conspicuously present the depicted content in relation to its size and the amount of information it is trying to convey. For instance, the size of the billboard 7.2 is specifically designed to be large enough to allow people travelling on the street at a certain speed to see the visual representation and read the written texts properly.

Meanwhile, the poster 7.1 was mainly presented to pedestrians who may stop and view the visual image at certain proximity, the A1 size seems to be sufficient and appropriate for displaying on a shop window in such viewing context. Otherwise, if the poster 7.1 was too large that a person can partly see the visual image and cannot draw an initial perception about its meaning within the viewing distance allowed by the pavement area, it might be generally perceived as part of the background element without predominance and ignored by the passers-by. Moreover, despite the smaller size, the poster is clearly able to display the detail of its main content especially the simple visual illustration and the sizeable written headline which sufficiently make it salient within such environment.

The physical features of some visual images might also be affected by the venue characteristics. Although the science communication events considered in this research generally occur in public spaces, their locations might be selected corresponding to the accessibility of the target audience especially in their daily life context. For example, the size and format of the billboard in case 7.2 might be the deciding factor with respect to attracting the target audience i.e. the people travelling on the road from the central area toward the southern part of the country. This may be also the case for the size of the murals 5.1 and 5.2 which are probably also influenced by the available space allocated on the walls.

Although the factor of visual image size may be less significant in relation to the identification or classification of a perceptible depicted subject, a larger size is more efficient in spontaneously eliciting an audience emotional response compared to its smaller sizes which still able to display the same recognisable features of a subject (Arnheim, 2004; Codispoti & De Cesarei, 2007). The banner sizes in cases 4.1 and 4.2 may exemplify this consideration when they represent persons in approximately their real-life size and may endorse the perception of the emotion through the depicted facial expression as well as the social relationship and virtual interaction between the subjects and a viewer better than their smaller versions. This potential result may also apply to the size of the mural 5.1 that may support its role to generate an emotional response better than its smaller ones when a viewer can perceive the large red element (approximately a square shape) coherently suggested by the texts “SEEINGREDMURAL” written in capital letters. As a result, such characteristics of the visual image and the written text may reinforce the accentuation of the conveyed message.

8.2.3 The appropriation of colour and brightness

The initial perception of a visual image when it is an element encountered in people’s everyday life may be emphasised by its colour(s) and relative brightnesses of elements which can be demonstrated in all exemplified cases. Such effects might be underpinned by either the neurophysiological and psychological aspects of visual perception. The retina of the human eye that possesses three different types of cones enabling colour vision may physically support the readiness for colour perception in human beings (Barry, 1997; Bruce et al., 2003). Therefore, a visual image containing colours potentially triggers the visual system specialised to detect light wavelengths or colours to notice such sensory information.

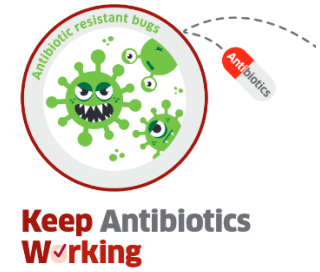
Also, from the psychological aspect particularly the consideration of Gestalt theory (Gordon, 1997; Lester, 2010), the colours contained in a visual image may make it distinct from the surrounding environment and stimulate an audience spontaneous response resulting in a higher possibility to get attention. Nevertheless, this effect may be less significant when a visual image is surrounded by other colourful elements like the mural 5.2 or the poster 7.1 presented along with several bright and colourful visual materials as shown in Figs. 8.1 and

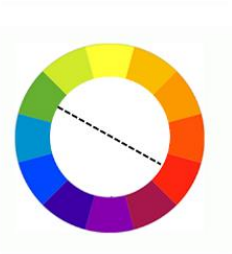
8.2. In such a case, the predominance of a visual image may rely on other distinctive features such as its composition, or featured content. The choices of colour and brightness of visual images examined in this research seem to be carefully considered and less likely to be merely the amorphous inclusion of different visual elements. Instead, they present harmony regarding their colour and contrast which potentially brings an aesthetically pleasing effect to the viewing. It can be seen that several visual images contain colours which comply with schemes of complementary colours, as well as the balancing interaction of colour contrast (Arnheim, 2004; Triedman, 2015).

The configuration of colour contrast may be performed either through the use of the same hue with different brightness or in the same brightness with different hues in juxtaposition. For example, the utilisation of the duo complementary colours like red and green in the poster 7.1 or green-yellow and purple in picture 8 (See Appendix D) as shown in Fig. 8.3(a). Also, the group of three split-complementary colours between the greenish-yellowish, pinkish-purplish, and bluish in the mural 5.2 and picture 37 (See Appendix D) as shown in Fig. 8.3(b); or the analogous colours, namely a group of colours which are next to each other on the colour wheel. The analogous colours ranging from yellowish to red can be seen in the billboard featured in case 7.2 and the X-ray kiss image featured in Chapter 6 as shown in Fig. 8.3(c). These appropriated colour schemes notably bring the perception of harmony to a visual image making it pleasing to the eye. Moreover, other visual images contain effective colour contrast such as in case 4.1 in which black and white presupposed to be the achromatic colours respectively having the lowest and highest value of brightness counterbalance each other to present a unified visual image (Triedman, 2015). In case 4.2 and the mural 5.1, red is adopted in juxtaposition to such two achromatic colours while the photograph of case 6.3 contrast colours between black with yellowish or orangish colour.

Fig. 8.1: The mural ‘We are the same blood’ featured in case 5.2 was painted beside several murals on the same wall

Fig. 8.2: The poster ‘Keep Antibiotics Working’ featured in case 7.1 was placed along with other colourful visual materials





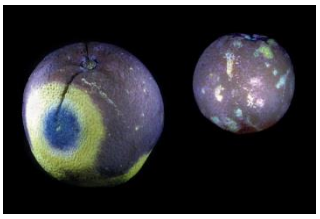


Fig. 8.3(a): The examples of complementary colours used in visual images

Fig. 8.3(b): The examples of triadic split-complementary colours used in visual images

Fig. 8.3(c): The examples of analogous colours used in visual images

Furthermore, the composition of colour and brightness within a visual image may generate certain viewing effects such as suggesting the visual salience of a depicted subject (Fuchs, Ansorge, Redies, & Leder, 2011; Kress & Leeuwen, 2006). This applies to the banners of case 4.1, as some examples illustrated in Fig. 8.4, in which the central area is brighter than the surrounding area (black area). As a result, such interaction of colour and brightness perceptually brings the central area (a scientist holding a piece of paper) closer to a viewer and may encourage a viewer to pay attention to such distinct area.

Fig. 8.4: An example of viewing effect caused by the composition of colour and brightness taken from the exhibition ‘Let The World Keep Turning’ featured in case 4.1

Besides raising the salience of a visual image, the case studies also show that tonality and colour occasionally suggest aspects of meaning or interpretation (Kress & Leeuwen, 2006). The depiction of tonality may advise the perception of a visual image regarding its authenticity. For example, the appearance of light and shadow in photograph 6.3: ‘Chocolate Shell’ image or the billboard 7.2 (photographs of the man) may endorse that the visual representations are captured from actual scenarios. Meanwhile, the absence of tonality in the murals 5.1 and 5.2 may suggest their characteristics of meaning such as complying with the make-believe construction or representing a conceptual message rather than a realistic one. This is also the case for the use of colour. For example, as one feature determining a subject’s physical appearance within the context of a visual image which does not

necessarily resemble its natural colour seen in reality. For instance, the colour of some animals in the mural 5.2, or the antibiotic-resistant bugs in poster 7.1.

8.2.4 Recognisable visual content

It is arguable that human visual system is constantly activated by visual stimuli in a surrounding event. Also, one of its primary functions is to determine what is seen by the eye and subsequently react to such visual information. Based on the concept of constructivism, such visual interpretation involves the inference of the given visual cues that primarily relies on one's prior knowledge (Gregory, 1980). Among several plausible interpretations of visual information, the facilitation of selecting one particular interpretation as the preferred interpretation might be underpinned by the principle of simplicity. Namely, people tend to presume the identification of visual cues given in a particular context based on the simplest approach or explanation the mind can address (Chater, 1996; Feldman, 2016; Hatfield & Epstein, 1985). As a result, some aspects of visual information might be recognised if they contain properties congruent with a certain familiar thing although such resemblance might be partial and not completely identical. For example, a simple interpretation might occur when an audience classifies several visual elements as the same thing/group (or the symmetry/regularity of two parts) through their dominant similarity despite the presence of their small variations. It is also the case for the rough approximation of a complicated or incomplete shape to a common geometric shape (Arnheim, 2004; Boselie & Wouterlood, 1989; Koffka, 1935).

Visual images considered in this research contain at least one recognisable (for the audience) facet although some of the images, regardless of the familiarity level of the depicted content, may simultaneously present several recognisable attributes. The recognition which potentially relies on the principle of simplicity may provide a better chance to get attention since object recognition is a primary task of the visual system and the mind tends to selectively attend to an identifiable object (Yantis, 1998). As such, it may also bring a certain level of initial viewing satisfaction since it potentially alleviates the task of the mind to resolve the encountered visual challenge which seems to require less effort for further interpretation (Arnheim, 2004; Kirschner, 2002; Sweller, 2016). Furthermore, the visual representational system in the brain relevant to such a recognisable element can be activated and prompted to process information presented in a visual image (Anderson et al., 1977; IARE, 2003; Mayer & Sims, 1994). Otherwise, passers-by tend to ignore a visual image perceived as irrelevant or inaccessible to them which may also result in completely discarding its associated information (Pashler & Pashler, 1998; Rigutto, 2017). Some recognisable aspects observable in the exemplified cases comprise the perception of a familiar depicted subject, shape, classification, pattern as well as symmetry which can be explained as follows.

Depicted subject

All visual images analysed in the research case studies contain at least one familiar represented subject which is also applicable to many photographs featured in the 'Light Works' exhibition including pictures 4, 5, 13, 15, 19, 25, 28, 30, 31, 32, 35, 36, 47 and 49 (See Appendix D). The recognition of a depicted subject involves the ability to identify or name what is represented in a visual image. It relies heavily on the properties of visual representation to resemble certain appearance features such as shape, colour, or attributes of an object; as well as the audience's prior knowledge to associate such visual cues with the intended subject (Hopkins, 1998; Hyman, 2006).

The recognition of components represented in a visual image can be partial and probably serves as the entry point to the image contemplation. In other words, an audience might recognise some individual depicted subjects while the others remain unknown; or only determine a subject's general type or category instead of its specific name. For instance, despite being depicted in different forms and levels of given visual cues as shown in Figs. 8.4 and 8.5, human beings could be recognisable in the interpretation although an audience might not be able to identify their identities precisely. Similarly, the representation of the Mars rover in picture 15 (See Appendix D) can be recognised broadly as a machine due to its respective physical characteristics. Although the determination of a depicted subject might not be always complete or accurate according to what intended by the image creator, and the extent of the subject's recognisability may have a better potential to engage an audience.

Genre

Besides identifying the general category or type of a depicted subject, some audiences might be able to discern the classification or genre of the overall visual image. This relies on observable structural properties of a visual image which are systematically or conventionally adopted for representation, such as composition, colour scheme, featured attributes, or the nature of meaning construction as well as an individual's prior knowledge (Kulvicki, 2014; Messaris, 1997). For example, some audiences might be able to recognise some visual images featured in the 'Light Works' exhibition as certain types of scientific images, for example, an astronomy image for pictures 9, 20, 22, 29, 33, 43, 50 (See Appendix D), an X-ray or scan image for pictures 12, 34, 45, 49, a map or satellite image for pictures 11,14, 39, 40, 41, 42; or a microscopic image for pictures 7 and 27.

An audience's ability to recognise the types of scientific image mentioned above might be supported by prior experience of seeing scientific images in everyday life such as through informal science outreach activities, or different channels of mass media and become aware of their variety (Rigutto, 2017; Smith et al., 2014). A pertinent example can be seen in the case of X-ray images which is familiar to people since they are commonly used in medical practice or ubiquitously displayed in media with which people are familiar (Aichinger et al.,

2012; Pasveer, 2006). The ability to recognise an image classification particularly for a visual image containing unfamiliar content may encourage a passer-by to pay attention to the visual images. Some scientific images may be able to initiate audience exploration due to their recognisability which might be further understood through their accompanying descriptions (Kress & Leeuwen, 2006; Lacey, 1998; Manghani, 2013).

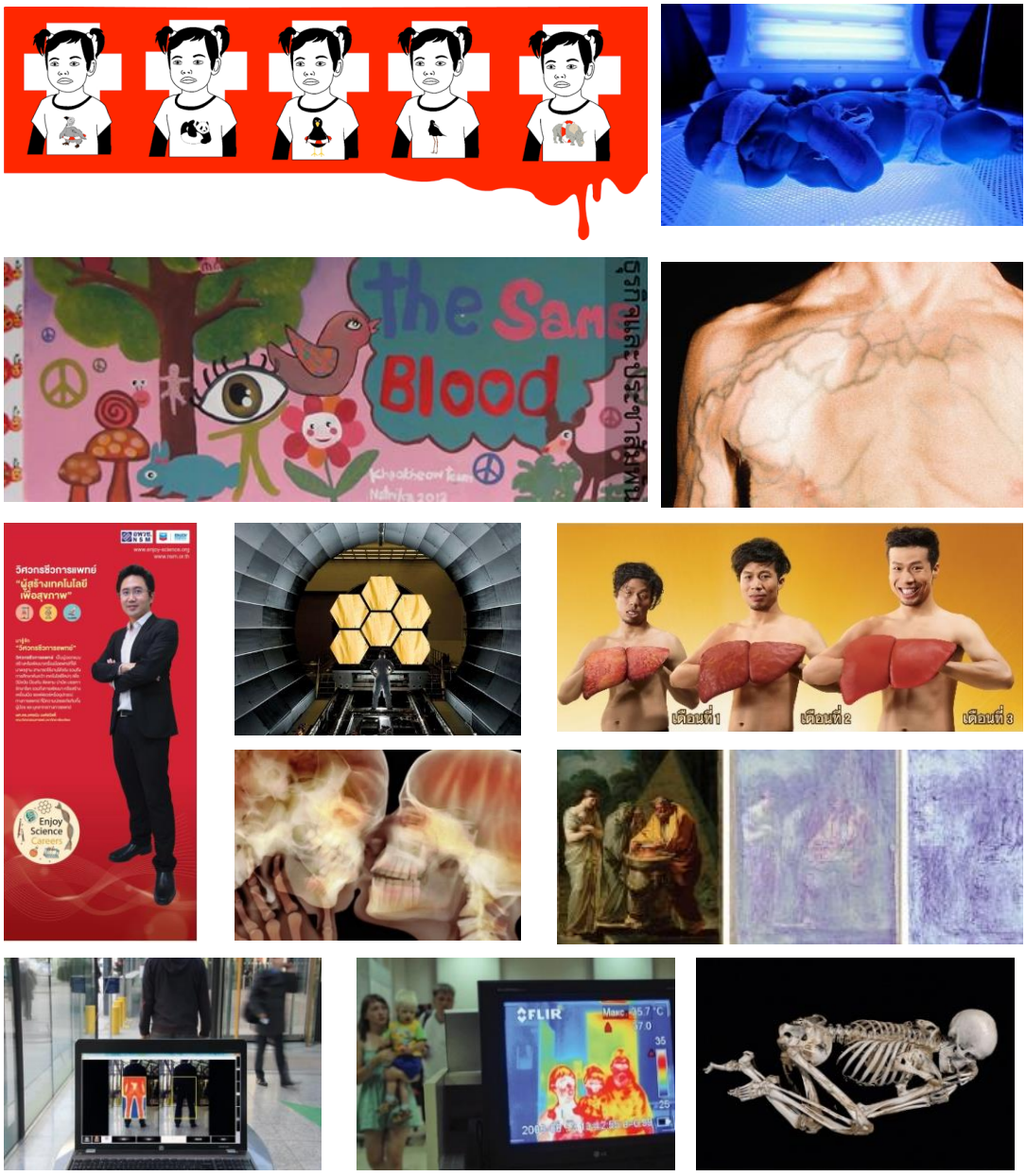


Fig. 8.5: The examples of different forms and levels of given information to demonstrate that they can provide sufficient visual cues for an audience to determine the representation relevant to human beings

Shape

The recognition of a shape can be significant in the perception of a visual image depicting unfamiliar content such as can be seen in some scientific images. The inference of shapes in

an audience's mind usually leans toward the patterns of familiar shapes such as geometric ones albeit the visual cues presented in a visual image might be incomplete or not exactly corresponding to the properties of those shapes (Arnheim, 2004; Bloomer, 1976). Some examples can be illustrated in Fig. 8.6 when both represented shapes might be simply perceived as a circle. In the same way, the perception of a recognisable shape inferred from unfamiliar visual content may occur in several visual images featured in the 'Light Works' exhibition such as exemplified in Table 8.2. Although, the depicted subjects are unknown or cannot be identified by a non-expert audience, the familiar perceptible shape within those visual images may increase its salience by serving as engaging or accessible content, and potentially motivate the exploration of their meanings (Haber, 1980). For example, the triangular shape present around the upper-right corner of the visual image exemplified in the column Triangular of Table 8.2 which is caused by tidal surges may allow such a visual image to become more familiar to audiences.

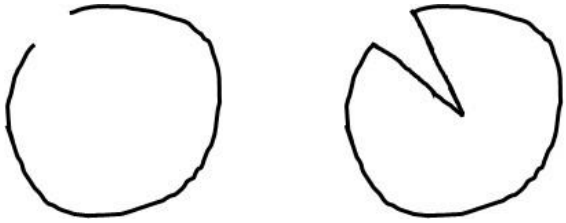


Fig. 8.6: Examples of shape inference based on the simplicity principle (adapted from Bloomer,1976, p. 15)

Table 8.2: Some examples of unfamiliar visual images presenting a recognisable shape to make them more salient and engaging to audiences

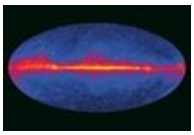
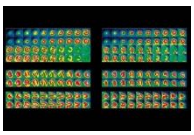
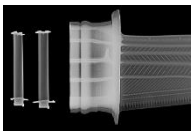
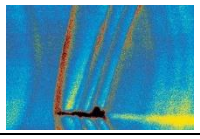
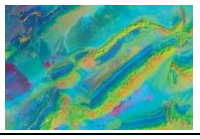
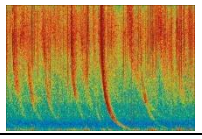
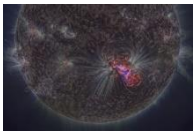
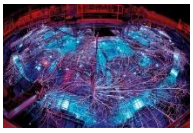
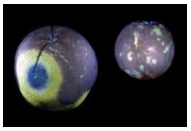
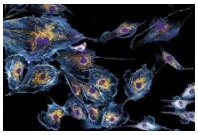
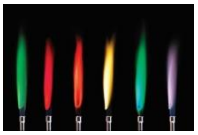
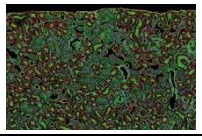
Perceivable familiar shapes				
Circular	Oval	Rectangular	Triangular	Mixture
				
				
				
				

Table 8.3: The examples of different forms of pattern perceivable in visual images

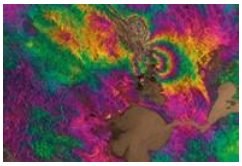
Forms of pattern	Exemplified visual images from the 'Light Works' exhibition
Spirals	  
Meanders	   
Explosion	
Branches	
Packing, spreading	   
Mosaic	 

From Table 8.3, the spiral pattern displays perceptible a smooth continuous line forming a vortex that occupies visual image space. Meanwhile, in the meander or zigzag pattern, there are switches of direction which occur periodically and create types of noticeable twist, ripple, or wavy surface. Regarding the pattern of the explosion, it contains perceptible paths radiating outward from approximately the same area or point. On the other hand, the distribution of flows in a branch pattern may start from a set of different initial points within a visual image. The packing or spreading pattern respectively involves the inclusion or the stretching of elements containing certain common features to fill a visual image space. Notwithstanding, the similarity of individual parts might be partial and not necessarily to be identical in all constituent properties. In other words, there might be some difference between them such as the variation of their size, shape, or colour that does not significantly alter their perceivable unification. For the mosaic pattern, it consists of individual elements joined together with distinct boundaries and varying degrees of contrast between them to form an observable network or hierarchical structure of constituents.

There are some visual images in which several kinds of patterns might be perceivable such as illustrated in Figs. 8.7(a-g). It is observable in Figs. 8.7(a-c) that there are some fractal patterns or small-scale meander/zigzag patterns of the ripple ground surfaces. For Figs. 8.7(a-b), the forms of the rivers also present some branch patterns. Meanwhile, Figs. 8.7(b-c) also contain some spreading patterns constituted by the actual spreading of land use in London over years and land deformation caused by an earthquake, respectively. The simultaneous presence of the meander/zigzag and branch patterns are also observable in Fig. 8.7(d), or the coexistence of the branching pattern of the river and the packing pattern of the buildings in Fig. 8.7(e). In the same way, both Figs. 8.7(f-g) display the explosion patterns of surrounding parts from the central areas which are contributed by mosaic patterns of elements.

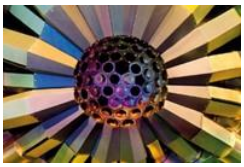

(a): Las Vegas and Lake Mead


(b): London


(c): Earthquake movement


(d): Manufacture by Melting


(e): Dubai seen from Space


(f): Gamma sphere


(g): Space Telescope Mirror Test

Fig. 8.7: The exemplified visual images from the ‘Light Works’ exhibition that contain several aspects of patterns

Besides visual images featured in the ‘Light Works’ exhibition including the perceivable packing pattern in the chocolate shells image (case 6.3), some other visual images analysed in the research also adopt such aspect of pattern intentionally constituted by the image creators. For example, the repetitive elements in case 4.1 (the four banners are displayed together), or the multiple groups of the approximately similar visual attributes in the ‘Seeing red’ mural 5.1. This is also the case for the inclusion of several represented antibiotic-resistant bugs containing some common features in poster 7.1, and the organisation of the man’s triple conditions in the billboard 7.2.

Another recognisable aspect of elements featured in some visual images is their symmetrical property which can be comparatively explained by the same principle of packing pattern. One symmetrical element can be perceived either as the pattern of two approximately identical parts facing each other or the repetition of such two parts that potentially construct the sense of harmony and balance between them (Arnheim, 2004; Feldman, 2016). Both

aspects of symmetry can be demonstrated with some exemplified visual images as shown in Figs. 8.8(a-b), respectively.

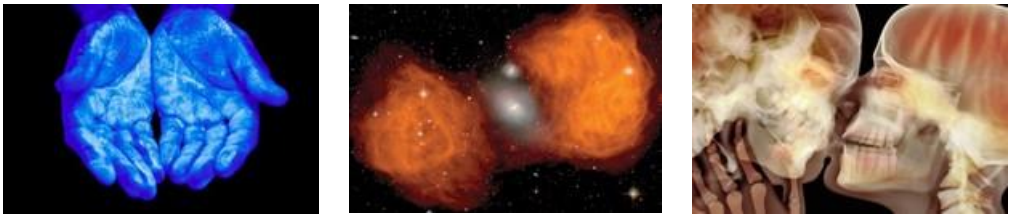


Fig. 8.8(a): Exemplified visual images containing symmetry constituted by two identical parts facing each other

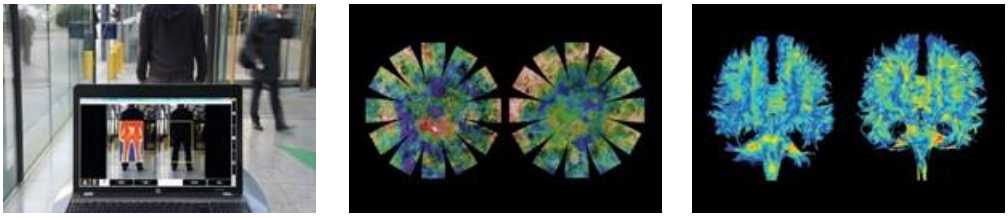


Fig. 8.8(b): Exemplified visual images containing symmetry constituted by the repetition of two identical parts

Similar to other recognisable properties, by containing a familiar pattern or symmetry of elements, a visual image potentially become more accessible to audiences. The perception of patterns is objective since most people can identify them in a common determination regardless of their cultural values or beliefs (Bell, 2012). Therefore, they might be adopted as a hook in science communication events effectively for a wide range of public audiences. Furthermore, pattern and symmetry of visual elements can be aesthetically pleasurable making a visual image become attractive and able to draw people's attention (Bowater & Yeoman, 2012; Rigutto, 2017). The appreciation of and familiarity with pattern and symmetry can also be evident in the broad range of design and appropriation of patterns or motifs for decoration, as well as the endeavour to explain them with design or art principles. Whereby, their properties such as regarding composition, balance, or rhythm comply with the notion of being well-designed or aesthetic (Arnheim, 2004; Bell, 2012; Cole, 2015; Schmidt, Tietenberg, & Wollheim, 2007).

8.2.5 Coherence or unification between visual images

Besides a pattern of elements within a visual image, an audience may also perceive a pattern in the exhibition constituted by recurring features among several visual images. Such pattern recognised in a broader level is evident in all exemplified events that have multiple visual images such as case 4.1: 'Let The World Keep Turning exhibition', case 4.2: 'Enjoy Science Careers' exhibition, and cases 6.2 and 6.3 featured in 'Light Works' exhibition. The pattern of visual images utilised in these events might manifest differently such as the visual images' coherence either regarding their display format, arrangement, or featured content. It

should be noted that those aspects may not always coexist although at least one form of the overall pattern can be observable in every case mentioned above.

The unification within the display format can be observed, for example, in the form of the identical size and material of each individual exhibit, or the form of visual tool appropriated to render visual information. For example, all visual images in cases 4.1 are notably presented through the similar extractable banners of identical standard size. In the same way, the type of printing material and size of the panels introducing biomedical engineer in case 4.2 is common to the other science-related careers featured in the exhibition. This is also the case for the 'Light Works' exhibition in which all featured visual images are printed on the same kind of panels that are realised with the similar production technique and materials.

In regard to the overall pattern formulated from the arrangement or organisation of visual images, it might rely on their proximity and continuation within an exhibition (Bell, 2012; Kennedy, 1985). This can be seen in all different arrangements of the banners in the 'Let The World Keep Turning' exhibition as shown in Figs. 4.2-4.4 that there are always at least a couple of equal intervals between the banners and also the organisation of the panels in the 'Light Works' exhibition as exemplified in Figs. 6.1 and 6.3 placing them with the same interval between panels. To conveniently refer to those arrangements, those pictures are also replicated here as shown in Figs 8.9(a-c) and 8.10(a-b), respectively. As such, the overall events might be perceived by a passer-by as the periodically recurring of visual elements. The perceptible repetition regarding the arrangement of visual images in their display format can be recognisable as a form of intentionally created pattern particularly the packing type as exemplified in Table 8.3. As a result, the exhibition may be attractive to an audience by offering a preferred presumable well-organised or uncomplicated environmental setting for exploration (Arnheim, 2004; Bell, 2012).

Regarding the coherence of the depicted content between several visual images, it might be observed in several extents and aspects. For example, the coherence of the content illustrated in the banners of case 4.1 is explicit and can be perceived effortlessly in terms of their identical genre (portrait photography), featured attributes, as well as composition, and theme colour. Meanwhile, the perception of content unification for the 'Enjoy Science Careers' exhibition (case 4.2) or the 'Light Works' exhibition (cases 6.3 and 6.3) may occur at a lesser scale. They present the coherence of the content in a broader level such as with respect to the composition between each career's banners or with the subject matter of light application. It is notable that passers-by might not be able to perceive this aspect of unification from afar or by partially viewing visual elements contained in a few visual images. The potentiality of such perception might also depend on the degree of their conjuncture. Nevertheless, the contingent perception of overall coherence can endorse the recognition of patterns leading to affective effects on gaining attention as explained in section 8.2.4.

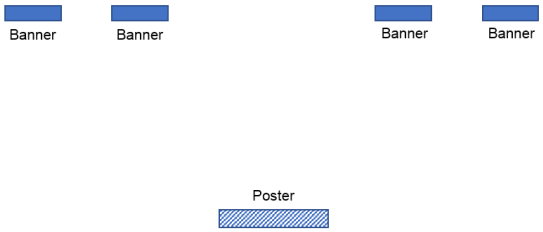


Fig. 8.9(a): The exhibition ‘Let The World Keep Turning’ arranged at the corridor in the hospital

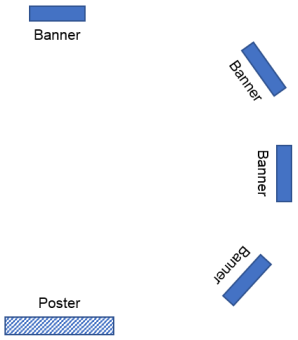


Fig. 8.9(b): The exhibition ‘Let The World Keep Turning’ arranged in the foyer of a university building

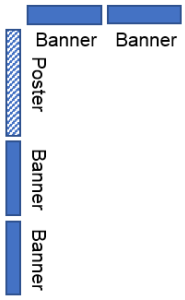


Fig. 8.9(c): The exhibition ‘Let The World Keep Turning’ arranged at the hallway in a shopping centre

Fig. 8.10(a): The Light Works exhibition being displayed with an identical interval between panels in the courtyard at Burlington House, London. Credit: Keith Smith/RAS. https://www.ras.org.uk/news-and-press/news-archive/259-news-2015/2582-light-works-exhibition-now-open

Fig. 8.10(b): The arrangement of the 'Light Works' exhibition with an approximately identical interval between panels in Edinburgh

This section (8.2) of the findings presents some visual image features observable in the exemplified case studies that may allow them to be a potential science communication tool to capture attention. This is particularly relevant in a public space where there might be a number of events going on and people in such environment are often bombarded with several kinds and modes of information. Attention involves the adaptive reiteration of prioritising encountered sensory information in order to selectively engage with the most important one (Watzl, 2017). At a particular moment including prior to coming across a science communication event, passers-by already assign their attention based on a certain prioritised structure of things/events. Based on such consideration, the visual image and event characteristics suggested in this section are argued to have the potential to activate the process of re-prioritization in one's mind. Namely, they may serve two primary roles in the mechanism of priority structure alteration: to present perceptual information or visual cues to be unintentionally noticed or seen by a passer-by and to contain aspects of

psychological salience in order to be prioritised in the mind and subsequently be attended. Such stimulus-driven attention may successfully influence a passer-by to become an audience who may stop and actively view a visual image for a period of time unless that person is passing it with a particular prioritised goal or task in mind which the encountered visual image or event cannot override (Yantis, 1998).

Several features of visual images proposed in this section create the appearance of a distinct science communication event in a nuanced environment through size and arrangement, creating initial spatial cues for pre-attentive processing. Meanwhile, the other features are coherent with some accounts of imperative visual features or visual salience in terms of colour and brightness, pattern, coherence, as well as other recognisable aspects of content. As such, they contribute psychological salience to a visual image and event and may influence one's attention toward them especially in an unexpected circumstance. From this state when one's attention might be involuntarily captured, the next section explains some characteristics of a visual image and science communication event that may be capable of stretching such initial attention or maintaining the priority of the visual image against other incoming perceptual information. Namely, such characteristics may encourage an audience to stay and keep engaging with the visual image or event.

8.3 Characteristics to maintain attention

The fact that mind-wandering can happen to human beings might affect a casually encountered science communication event utilising visual images in two primary ways (Schooler et al., 2011). On the one hand, the tendency of mind wandering allows the opportunity for a passer-by to passively attend or notice the given visual cues and subsequently may lead to the unintentional event exploration or participation even though the person may already have a prioritised goal or task to attend in their mind as described in the previous section. However, by the same cause, a person attending to a visual image or science communication can also be distracted by other perceptual information which has potential to evolve the priority structure and may deviate one' s attention from the event.

Since the involuntary attention, which is initially driven by a visual image performing as an exogenous stimulus, may happen instantly and last only for a brief moment unless such visual stimulus is consciously perceived to be pertinent and prioritised to successfully maintain one's attention (Buehler, 2014; Watzl, 2017). Together with the previous section (section 8.2) explained above, this section also partially answers the research question RQ3: How can visual images perform their function regarding the capturing and maintaining of audience attention? It explains four primary characteristics observable in the exemplified cases that have potential to maintain attention including being part of a series or continuation, displaying relevance, resonating with emotions, and being intriguing or challenging interpretation. However, some visual images such as the billboard 7.2 may

facilitate its functions both getting attention and delivering information within a short moment whereby a passer-by is less likely to stop and contemplate on it. As a result, the given visual image characteristics in relation to maintaining attention might be less significant in such circumstance.

8.3.1 Being part of a series or continuation

This characteristic of visual images may apply to a science communication event containing several visual images with a particular aspect of coherence between them as explained earlier in section 8.2.5. In regard to the physical property, the continuation of visual images arranged in such event may promote a perceptual line connecting them together which is also capable of direct one's eye and attention along with those visual images. Consequently, it may lengthen the duration people spend for overviewing or perceiving visual cues or elements presented in the exhibition (Kennedy, 1985; Lester, 2010; Wolfe, 1988). Since the perception of elements' locations in the visual field is probably combined with the brief register of their features, then a person viewing the coherent visual images may be able to perceive the conjunctions of visual features among them. For example, the conjunction regarding overall shape, colour, orientation/composition, and approximate sizes of depicted elements between visual images in case 4.1, or that of shape and background colour among the banners utilised in case 4.2. The appropriation of coherent visual images in this fashion not only makes the exhibition more conspicuous especially in the nuance or non-homogenous background or surrounding environment, but it may also influence the attention of viewers. Whereby, from one visual image, people tend to naturally continue perceiving another visual image if it presents some intersection of feature(s) found in the previous or nearby one, even though the focus of attention may be based on only one dimension of common features (Treisman, 1994; Wolfe, 1994).

For visual images with less apparent conjunctions, despite associating with the same main topic as the case of 'Light Works' exhibition, their difference or the change of visual information within such series of visual images may lead to a guided stretch of attention. Namely, one's attention is passively maintained along with one visual image to the next (Watanabe, 2011; Watzl, 2017). On the other hand, prolonging attention may also operate voluntarily by subjective attention guidance. For instance, if a single visual image cannot deliver a complete meaning or concept of the overall exhibition, such as the proposition of various light applications in this exemplified context and a viewer is interested in discovering it. In other words, the search for meaning becomes a goal-driven control of attention. As such, the person's attention toward the exhibition or visual images is maintained, and the active engagement may have a higher potential to withstand other competitive distracting perceptual information from the surrounding environment. Alternatively, if one visual image within a series may be discarded or its priority may be declined, and people tend to direct their attention to other things, the nearby visual images may serve as the next abrupt

encountered information (Watzl, 2017; Wolfe, 1994). As a result, it can re-alter the priority structure in the mind and may bring another opportunity to retain attention to the exhibition.

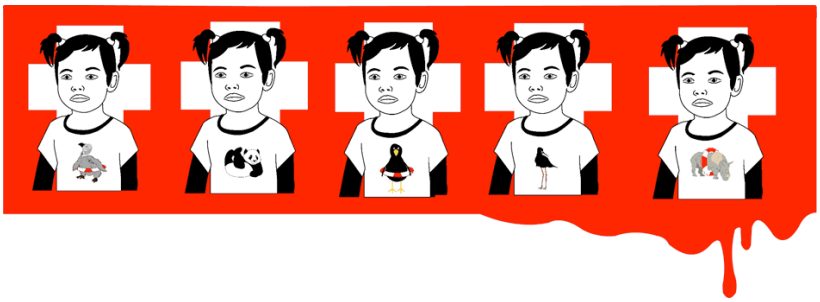
8.3.2 Displaying relevance or applicability

The property regarding the relevance or applicability of given information involves the consideration of visual image content and accompanying written texts. It may support the proposition about the attention mechanism. Namely, the propensity of one's voluntary attention is influenced not only by the psychological salience of a visual stimulus but also by his/her subjective perception of the portrayed content. The piece of information a person regards as pertinent tends to be selectively prioritised and actively processed (Duncan, 1993; Kitchen, Kerr, Schultz, Mccoll, & Pals, 2014; Watzl, 2017). By mainly focusing on the visual images themselves, this section explains some characteristics observed from the exemplified cases which promote a level of information relevance. This entails aspects of visual image content potentially pertinent to an audience either in the social or cognitive perspectives respectively explained in terms of the portrayed demanding gaze or gesture, and overall subject matter as follows.

Demanding gaze or gesture

The majority of visual images considered in the case studies in the previous chapters notably feature a form of character namely the representation of human beings in cases 4.1, 4.2, 5.1, 5.2, 6.2, and 7.2, animals in cases 5.1 and 5.2, or that of microbes in case 7.1. The social relationship between such visual elements and an audience, which may perceptually endorse the personal relevance of a visual image, seems to rely on their represented gaze or gesture that resembles a type of social interaction, either verbal or nonverbal (Gombrich, 2002; Wollheim, 1973).

An example can be demonstrated in Figs. 8.11(a-b) comparing the depictions of gaze and gesture of characters in murals 5.1 and 5.2. Both visual images feature a human being and animals. However, regarding the sense of social interaction, the characters in mural 5.2: Fig. 8.11(b) are considerably more socially engaged with a viewer especially through their direct gazes and facial expression. As such, they can be perceived as an attempt to demand response or make contact with an audience leading to the establishment of a virtual interaction (Kress & Leeuwen, 2006; Kulvicki, 2014; Messaris, 1997). Besides endorsing the visual image relevance, it may also suggest that the message portrayed in the visual image is addressed to the viewer which may also promote the information processing. Meanwhile, the absence of engaging gaze or gesture in mural 5.1: Fig. 8.11(a) may diminish the sense of engagement or personal relationship between the depicted character and a viewer although the relevance of the mural may be perceived from other aspects such as the subject matter described below.



(a): The design of the visual image to be pained as the ‘Seeing red’ mural (featured in case 5.2)

(b): The mural ‘We are the same blood’ featured in case 5.2

Fig. 8.11: The exemplified comparison of different gazes and gestures resembling the different degrees of social relationship

Subject matter

The perception of a visual image’s subject matter may rely on one’s initial assumption of what the visual image is about which is articulated from the given cues and context, as well as the person’s prior knowledge and experience applied to perceive them (Gregory, 1980; Lacey, 1998; O’Sullivan, 2003). Whereby, such initial determination of a visual image subsequently affects one’s motivation whether to continue pursuing further information and it potentially becomes the case if the person finds it to be important, beneficial, or associated with dimensions of interest (Bowater & Yeoman, 2012; Watzl, 2017). The given cues and context in this respect can be gathered either from the content of visual representation and the accompanying written texts especially the image title or a short caption people can understand in a brief moment. Also, the perception of subject matter and the respective degree of relevance can be subjective and vary from person to person.

The exemplified cases provide some examples suggesting their subject matter explicitly through the depiction of recognisable elements and short written texts such as the poster in case 7.1 and the billboard in case 7.2. In such cases, viewers probably can perceive their topics and may also regard them as a pertinent subject matter that can affect their life either in a harmful or beneficial way. Also, the subject matter of a science-related career

(biomedical engineer) presented in case 4.2 to which may be attended as one area of interest for the target audience: high school students who are considering pursuing their education and career path. Nevertheless, in some cases, the relevance of a visual image can be perceived primarily from visual elements. This may be applicable to the mural in case 5.1 as shown in Fig. 8.11(a) in which the recognition of the cross behind the represented girl and lifebelts depicted on the body of some featured animals may encourage the perception of a visual alarm suggesting danger, urgency, or a life-threatening situation. If people tend to regard these messages as relevant to them at the moment of perceiving visual images, they may also be able to prompt a responsive behaviour by default (Broadbent, Baddeley, & Weiskrantz, 1993).

Meanwhile, in the case of unfamiliar visual images that a viewer is less likely to recognise or be certain of its depicted subject, the relevance of such visual image seems to be significantly promoted through a relatable title or short caption. An example can be given from a visual image featured in the 'Light Works' exhibition as shown in Fig. 8.12. Although the visual content depicting the landscape and the rover might seem to be inaccessible or irrelevant to a layperson, the title 'Mars Rover Selfie' especially the word 'Selfie' is arguably relatable and probably increase the level of the visual image relevance as being associated with the ongoing social behaviour concerned in society (Loveless et al., 2016; Patti, 2014; Patty, 2018).

Fig. 8.12: Mars Rover Selfie, an example of an image title 'Mars Rover Selfie' promoting the relevance of its unfamiliar visual content

8.3.3 Resonating with emotions

Another visual image property that may increase its pertinence to an audience is notably the inclusion of elements to potentially elicit emotional responses which can be seen in the majority of the visual images considered in this research. This factor to influence one's attention relies on the capability of visual images and written texts to reproduce emotions to

which people are already sensitive and readily attend to in real-world interactions (Messaris, 1997; Richards & Blanchette, 2004). There might be various devices appropriated to construct an emotional stimulus. Although this is by no means a comprehensive list of potential approaches, this section expands on some elements either in the visual or textual mode, that was likely to have featured in the exemplified cases, for such emotion-eliciting purpose. These elements include facial expressions, some semiotic elements that may connote meanings associating with emotions and the aesthetic features of a visual image.

Facial expression

An apparent facial expression represented in a visual image might be perceived generally between the dichotomic emotions: pleasurable and unpleasurable states. The first group of emotions might be evident in the portrayal of the scientists in cases 4.1 and 4.2 which can be argued to express positive emotional states such as happiness primarily through their smiling faces as shown in Fig. 8.4. This is also the case for the depiction of several animals in the mural 5.2: Fig. 8.11(b), and the third condition of the man in the billboard 7.2: Fig. 8.13. On the other hand, some unpleasurable emotions can be observed from the representation of the antibiotic-resistant bugs in case 7.1 or the initial condition of the man represented in the billboard 7.2 as respectively shown in Figs. 8.13 and 8.14. By containing the salient emotional information depicted through facial expression, these visual images are argued to be able to prolong the engagement compared to a neutral one, as well as promote the perceiving and processing of the relevant features and information associating to such perceptible emotion (Hillmann, Kempkensteffen, & Lincoln, 2015; Maratos, 2011).

Fig. 8.13: The unhappy face of the man in his initial stage depicted in the billboard featured in case 7.2

Fig. 8.14: The provoking faces of antibiotic-resistant bugs in the poster featured in case 7.1

Connotation associating with emotion

Besides facial expression, some visual images appropriate other elements especially relying on their cultural semiotic meanings associating with a particular emotion. Subsequently, for a viewer who can discern emotional meanings communicated from such cues, it might lead to an emotional resonance for the viewer. As described in the previous chapters, some visual images and written texts that may elicit an emotional response can be drawn from cases 4.1, 5.1, and 5.2. Regarding case 4.1, the written translation of the positive attitudes toward science and Edinburgh may resonate some pleasurable emotions in audiences. On the other hand, the overall style of the visual representation resembling some significant features of a mug shot or the expression of social movement may evoke a variety of emotions a viewer can associate to the perception of such meanings. In the same way, the discursive construction of visual and textual cues in the murals 5.1 and 5.2 may resonate different feelings in an audience such as empathy, compassion, anger, or radicalism in case 5.1; or affection, sympathy, or kinship in case 5.2.

Furthermore, for case 6.2, the potential connotation of the visual representation of kissing and the written title ‘X-ray kiss’ may not only evoke emotions associating with affection or personal relationship, but it might be also perceived as a sexual appearance and possibly elicit an emotional response and gain some special attention from some viewers (Bloomfield & Doolin, 2012; Messaris, 1997; Palmer-Hague et al., 2017). The latter emotion-eliciting effect may also occur in the perception of some visual images presenting certain extents of nudity such as some pictures featured in the ‘Light Works’ exhibition as shown in Figs. 8.15(a-b) respectively containing the unclothed upper body of a man, or the transparent lower body the man standing in front of a scan unit. Although the perception of emotional meanings of some visual images might differ from their intended message, their capability of raising the initial emotional engagement may encourage further exploration or critical interpretation of the visual images as well as the overall event (Chebat, Vercollier, & Gélinas-Chebat, 2003).

(a): Blood supply under the skin

(b): Security Scanning

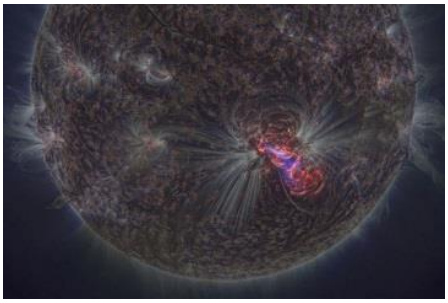
Fig. 8.15: The exemplified visual images from the 'Light Works' exhibition presenting a certain extent of nudity occasionally eliciting an emotional response

Aesthetic features

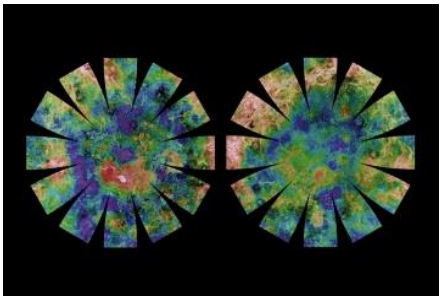
Some audiences might contemplate on a visual image because they find it beautiful or aesthetically pleasurable (Reid, 1973; Watzl, 2017). Viewing a visual image in this fashion may be comparable to the appreciation of art which is a form of active perceptual engagement with the visual material. Subsequently, the elicited emotion or sensation toward the visual image due to its mesmerising quality can occasionally lead to the further interest of its relevant meaning (Smith et al., 2011). The perception of beauty or aesthetics can be subjective and culturally specific although an aesthetically pleasurable visual image might be objectively explained by some aesthetic features based on the consideration of visual art such as balanced composition, simplicity, harmonious colour and brightness, and dynamics (Arnheim, 2004). Besides visual images analysed in the case studies, this section provides some examples of visual images displaying aesthetic features drawn from the 'Light Works' exhibition as shown in Figs. 8.16(a-f).

From Fig. 8.16, regarding balanced composition, it can be seen that all visual images depict their objects at either a restful or a particular point explicitly leaning toward any direction which balances visual elements regarding their visual weight and direction (Arnheim, 2004; Bradley, 2014d). In other words, there is a sense of repose between the perceptual forces directing toward the centre and the four corners of the visual image's rectangular frame. Nevertheless, although the visual images demonstrate the stability of visual elements, they also contain some dynamics: the perceptible tension of elements such as between perceptual forces pulling toward opposite directions or the spatial arrangement of an object that differs from the regular horizontal or vertical line like the depiction in Fig. 8.16(a) for example. In that image, the volume and the direction of the circular shape perceivably leaning toward the top part of the visual image can be counterbalanced by the active bright and colourful spots in the bottom part especially the biggest one approximately at the bottom-right corner. As such, the visual image contains the dynamics of visual elements while preserving its balanced composition.

For simplicity, visual images may display this property through the optimal inclusion of visual content which is necessary to articulate an intended representation without redundancy. Also, they present the harmony of colours and brightness arguably congruent with proper colour schemes that could promote the exhibition's pleasurable viewing experience. For example, Figs. 8.16(a-f) respectively illustrate visual objects with approximate (a) analogous colour scheme ranging from red to purple; (b) rectangle colour scheme of purple, orange, yellow and green; (c) complementary colours between orange-yellow and purple-pink; (d) rectangle colour scheme of orange-yellow, purple-pink, green and blue; (e) the contrast between orange-yellow and black; and (f) the split complementary colour scheme between yellow, red-violet, and blue-violet. Although these visual images depict unfamiliar visual information, they may potentially engage with a viewer primarily through their aesthetic properties. In addition, besides examples given in Figs. 8.16(a-f), visual images contain a form of pattern or repetition may bring the same viewing effect since they also contain aesthetic features as previously explained in section 8.2.4.

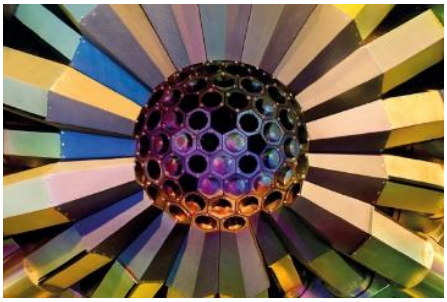


(a): Solar Flare

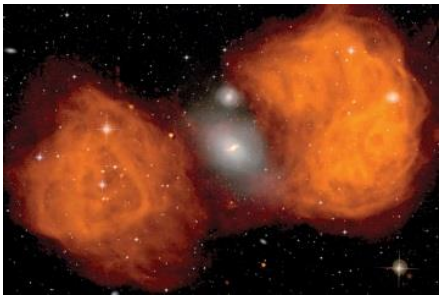


(b): Surface of Venus

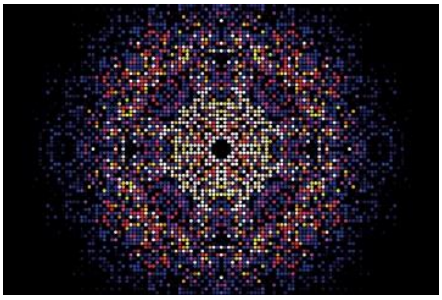
(c): Andromeda Galaxy, M31



(d): Gamma sphere



(e): Fornax Radio Lobes



(f): Fighting Sleeping Sickness

Fig. 8.16: Some examples of unfamiliar visual images featured in the 'Light Works' exhibition that contains some aesthetic properties

8.3.4 Being intriguing or challenging the viewer

Visual images which contain different forms of intriguing elements may cognitively challenge a viewer to resolve the relevant meaning voluntarily. This might be because a visual search is one primary task of the visual system and further than identifying individual perceived object for what it is, as the mechanism of understanding the surrounding world, the mind endeavours to meaningfully associate such information with the structural memory of prior knowledge and experience (Mandler, 1984; Winn, 2014; Wolfe, 1988). An intriguing visual element might involve visual information which the mind partly acknowledges since it may be able to activate relevant memory. However, the given information might not be apparently organised into any structure of prior knowledge, or some uncertainty of the interpretation might still remain. This section explains some aspects of intriguing visual elements observable in the exemplified cases regarding the ambiguity of a depicted subject, event or overall meaning, the comparison between visual elements, as well as the obscurity of a certain part or element within a visual image.

Ambiguity of content

The ambiguity of depicted content that is not entirely insolvable or does not resemble a recognisable object tends to encourage contemplation of the visual image's meaning (Bloomer, 1976; Gregory, 1980). For instance, the representation of a human being in mural 5.2, or the X-ray image of kissing in case 6.2 which deviates from their familiar or usual representation may provoke the mind to pay special attention to them in order to organise and address such discrepancy in relation to some pre-existing memory (Halkias & Kokkinaki, 2014; Messaris, 1997; Yantis, 1998; Zschocke, 2005). This may also be the case for viewing a depicted event or action as well as recognisable subjects combined in a conceptual way that might not be seen in the reality such as the mural featured in case 5.1. Without an explicit description, the mural may consequently initiate the enquiry of further information or discussion that may allow one to articulate potential meanings from the given cues in order to understand the situation and the relevant message (Anglin et al., 2004; Lacey, 1998; Lester, 2010; Rumelhart & Norman, 1981).

Comparison of visual elements

Furthermore, the comparison or contrast of visual elements can be found in several visual images such as the combination of banners in case 4.1: Fig. 8.4, the groups of visual elements in the mural 5.1: Fig. 8.11(a), or the three conditions of the man represented in the billboard 7.2: Fig. 8.14. Based on the Gestalt principles such as in terms of proximity, similarity or continuation of elements (Bradley, 2014c; Kennedy, 1985; Lester, 2010), the depiction of these visual images can promote the perception of grouping or classification of visual elements. As a result, such property potentially directs one's attention to the search for the differences in contrast to their similarities. Namely, a viewer may be encouraged to specially attend to the different physical appearances and written languages in case 4.1, the

variety of animals illustrated on the girl's T-shirt in case 5.1, or the improvement of the man's conditions from the initial to the latest stages in case 7.2.

Obscurity of visual elements

In addition, there might be some noticeable obscurity or a marked visual element within a visual image that can draw the eye to attend to the masked area and may also stimulate the active perceptual search of the concealed information (Ansorge, Horstmann, & Worschech, 2010; Scharlau & Neumann, 2003). A pertinent example can be drawn from the 'Light Works' exhibition as shown in Fig. 8.17. In such a visual image, it includes three frames of the same picture captured/scanned with different techniques. As such, the image may encourage the consideration of the difference and similarity between the three constituent images, and the obscurity also serves as the spatial cues guiding one's attention to shift toward the right side of the visual image to scrutinise the visual element hidden in the first frame. By being prioritised and intriguing, they may evolve a viewer's attention from being passively influenced by the exogenous visual stimulus to become the goal-driven active control directing the attention toward the visual image (Watzl, 2017; Yantis, 1998).

Fig. 8.17: Forensics in Art, an exemplified visual image featured in the 'Light Works' exhibition which contains obscurity or marked visual content as also shown in Appendix D: number 35. The first frame on the left side is the visible light image in which an audience cannot see the signature of the artist at the bottom-right corner. Meanwhile, the third frame on the right was scanned by terahertz radiation to reveal the artist's signature, and the frame in the middle is the merged image of the first and the third frames.

8.4 The mechanism of experiential learning

The characteristics of visual images and events explained in the previous sections may be sufficient to affirm that a visual image can be utilised in a science communication event for reaching out to broader audiences in their daily life context due to its accessibility and capacity to get and maintain attention (Arcand & Watzke, 2011; Mirzoeff, 1999; Naylor & Keogh, 1999; Watzl, 2017). Nevertheless, as seen in all exemplified cases, a visual image is less likely to be used in isolation. Instead, for each science communication event, there is usually the cooperation between visual images and some other facets of communication such as accompanying written texts, facilitators or other materials. Such deployment of communication tools is aimed at achieving the event's expected outcomes further than

allowing people to be aware of the event, getting their attention or inviting for a visit. This section considers three aspects associated with the learning process that may occur in the exemplified cases. It explains the capacity of events utilising visual images with other accompanying modes of communication to cater for different learning styles and preferences; how meanings can be constructed and perceived through those modes of communication; and through which element(s) each potential learning outcome with respect to the Generic Learning Outcomes framework (GLOs) could be achieved.

8.4.1 Catering for different learning styles and preferences

From all cases examined in this study, a visual image is less likely to be deployed solely in isolation but usually accompanied by other modes of communication. A science communication event delivered in such fashion not only enables different levels of audience participation but, by being multimodal communication, it is also potentially engaging to a range of audiences regardless of their preferences of learning modalities. A pertinent example can be seen in case 5.2 (‘Enjoy Science Careers’ exhibition) which comprises visual images, written texts, a video, a facilitator and actual equipment used by a biomedical engineer as shown in Fig. 8.18. Therefore, based on Fleming’s model of VARK modal preferences (Fleming, 2012), the exhibition may be able to appeal, engage or motivate audiences for learning regardless of their different learning preferences through its components that provide multiple learning approaches as postulated in Table 8.4 (Bultitude, 2010; Hamilton, 2013).

Fig. 8.18: The exhibition ‘Enjoy Science Careers’ in case 5.2 comprising multiple modes of communication

Table 8.4: The potential of the exhibition in case 5.2 to cater for different modal preferences

Preferred modality	Channels of communication
Visual (V)	Visual images, video
Aural (A)	Conversation among audiences or with the facilitator
Read/write (R)	Written texts
Kinaesthetic (K)	Hands-on activities such as trying provided equipment
Mixture of preferences	Different combinations between the available modalities

For the 'Light Works' exhibition, despite being a stand-alone event and absent of any demonstration or hands-on activity, it may better support an audience preferring kinaesthetic modal by adopting the arrangement of the featured panels as guidance for exploration. Namely, the progressive orders of visual images along the viewing path could be assigned as corresponding to their associated light wavelengths along the electromagnetic spectrum such as from the shortest wavelength (Gamma rays) to the longest one (Radio waves) instead of a random distribution. As such, it may endorse a concrete experience of learning by providing an explorative journey for encountering different kinds of light along with the range of the electromagnetic spectrum (Fleming, 2012).

Furthermore, the case studies demonstrate that visual images and accompanying modes of communication can operate the experiential learning process suggested by Kolb (1984) resulting in certain types of knowledge acquisition. Events displaying visual images offer an audience an experience to be grasped either via apprehension or comprehension, namely the interpretation or conceptualisation of the potential meaning drawn from the given cues. Such experience may be further processed through either reflection or experimentation to gain knowledge. Hence, knowledge may be attained in all studied cases for audiences who can interpret the meaning of visual images, though not always accurately, and reflect or integrate such message to their prior knowledge. Meanwhile, some audiences may be keen to prove the validity of the proposed message via an actual practice such as by following the behaviours prescribed in cases 7.1 (poster 'Keep Antibiotics Working') and 7.2 (billboard campaigning alcohol abstinence).

Besides mentally comprehending the given cues, in some cases, audiences may be able to grasp an offered experience through a concrete experience or by being involved in such an experience themselves. For example, from exploring the 'Light Works' exhibition in an orderly manner, an audience might be able to attain additional knowledge about light by connecting the lengthening of the viewing path with the increasing of wavelengths with respect to different kinds of light; or an accommodative knowledge by applying such understanding to consider or classify the light encountered on a daily basis. Although a static

visual image may not directly provide physical actions, it can potentially stimulate a concrete experience by provoking emotions or bringing a certain experience with which people are already familiar into the mind that also leads to learning about the associated subject matter (Lester, 2010; Messaris, 1997). An instance can be explained from case 5.2 (mural 'We are the same blood') in which the representation of the mural may remind one of experience or emotion relevant to a desirable family relationship which subsequently can contribute to the reflective perception or active practice toward conservation. In the same way, case 5.1 (mural 'Seeing red') may lead to a similar effect by provoking a prior experience of urgency, compassion or a need for aiding/rescuing.

Based on such potential to generate different approaches to learning, a science communication event using visual images can be devised to flexibly support different patterns or styles people adopt for learning. Besides being able to encourage learning in different types of learner as proposed in the respective Kolb's learning style inventory (LSI) (Kolb, 1984) including diverger, converger, assimilator and accommodator corresponding the adaptive transaction taken at a particular learning situation, the argumentation for this kind of events to cater for all learners can also be reinforced by its arguable capacity in relation to another comparative frame of consideration: Honey & Mumford's model of learning styles (Honey, 1986). From the examined cases, a learning condition may be promoted by several factors suitable for different learning styles which can be exemplified in Table 8.5.

It can be seen in several examples that although a visual image may not be the primary element required by some learners to attain knowledge, it still serves as a significant springboard for learning by attracting attention and drawing people to a receptive state conducive to further exploration. Case 5.1 (mural 'Seeing red') can be given as an example in which the mural itself may have a learning impact on 'reflectors' (Honey, 1986) though this might not be the case for other groups of audiences. However, its salience such as in terms of conspicuous size, colours and contrast, or striking visual content can generally engage people for viewing. Then, they have a greater chance to discover the accompanying QR code, URL, and hashtag which may serve as a learning initiator for those with other learning styles.

Table 8.5: The potential of a visual image-based science communication event to cater for different learning styles suggested by Honey & Mumford (Honey, 1986)

Learning style	Provided condition proper for learning
Activist	A chance for actively engaging with the event such as through conversation with a facilitator in cases 4.1 and 4.2; accompanying hands-on activity in case 4.2; prompted access of online discussion or website in case 5.1; a potential explorative journey in 'Light Works' exhibition; or antibiotic guardian scheme for participation in case 7.1
Reflector	Convenient access and friendly viewing space and condition where audiences can freely deliberate visual images in their own paces. This can occur in all cases arranged in a generic venue
Theorist	Containing written texts giving information to support the determination of the intended message such as seen in case 4.2, the 'Light Works' exhibition, case 5.1 (available online), case 7.1, and case 7.2; or a chance for conversation or discussion for interrogation about the associated subject matter.
Pragmatist	Containing practical suggestion or implication such as the scientific applications featured in case 4.1 or the 'Light Works' exhibition, the potential future career or education path in case 4.2, or the prescribed behaviours in cases 7.1 and 7.2.

Note: case 4.1: 'Let The World Keep Turning' exhibition, case 4.2: 'Enjoy Science Careers' exhibition, case 5.1: mural 'Seeing red', case 7.1: poster 'Keep Antibiotics Working', case 7.2: billboard campaigning alcohol abstinence, the 'Light Works' exhibition associated with the case analysis provided in Chapter 6.

8.4.2 The enabler of potential learning outcomes

In general, a visual image adopted in combination with other modalities such as textual or verbal information is arguably beneficial for experiential learning regardless of individuals' learning styles or preferences as explained in section 8.4.1. Moreover, a visual image can be polysemic suggesting various meanings which occasionally becomes problematic for interpretation. Whereas one approach to clarifying the message can be through combination with linguistic content such as through accompanying written texts or verbal conversation (Barthes, 1977; Manghani, 2013). This section recaps the summary sections of Chapters 4-7 to answer the research question RQ4: How can learning occur in a science communication event featuring visual images and accompanying elements corresponding to the fulfilment of Generic Learning Outcomes (GLOs)? As such, it summarises some communication approaches or devices among those modalities that significantly enable the fulfilment of a science communication event's objectives based on some or all of the dimensions contained in the Generic Learning Outcomes framework (GLOs) including an understanding of information, having a change of attitude or value toward things, performing certain behaviours, enjoyment and inspiration, as well as the development of skills (Arts Council England, n.d.). It should be noted that, in reality, each science communication event may involve several learning outcomes rather than one. The findings can be encapsulated in

Table 8.6 which provides some consideration for utilising a visual image with an accompanying communication approach with respect to intended goals in other similar events.

Table 8.6: The summary of approaches for using a visual image with accompanying modes of communication in relation to expected learning outcomes emerged in exemplified cases

Primary generic learning outcome	Combination of a visual image and textual/verbal information
Understanding of information	Mainly through written texts or verbal conversation, while a visual image(s) plays a supportive role
Attitude/value	Interdependent construction of the message between both modalities
Behaviour	Textual/verbal information with a supportive visual image, or the interdependent construction of the message between both modalities
Enjoyment/inspiration	Potentially relying on a visual image, particularly a conceptual or ambiguous one for an inspiring purpose

Regarding another generic learning outcome: improvement of skills, which is not particularly considered in Chapters 4-7, all case studies can demonstrate that the use of visual images in a science communication event may provide a chance to practice the skills relevant to the visual image viewing (Arts Council England, n.d.; Hooper-Greenhill, 2004). As such, a visual image may enable such a learning outcome by serving as a practical exercise for experiential learning within the daily life context. An audience who visits an exhibit or exhibition and perceives a visual material may have a chance to perform various levels and aspects of skills regardless of the combinations between a visual image and written/verbal information, or the clarification of the intended message. In terms of intellectual skills, through the process of interpretation, a viewer is argued to demonstrate the ability to acquire information from the provided cues either visual or textual/verbal ones. It may advance beyond acknowledging the denotation of a visual sign or word to the formation of a concept from available cues which also relates to the dimension of visual thinking skills (Arnheim, 1970; Simons, 2008). Moreover, it may also involve emotional skills since a visual image can portray affective content like emotions. Therefore, by viewing a visual image, an audience may practise not only the sensitivity of perceiving and understanding expressed emotions but also reflectively responding to such emotions appropriately in the given context (Hall, 2005) and as a result, develop those skills.

In summary, this chapter explains several dimensions associated with science communication events that use visual images and accompanying elements either written texts or verbal conversation based on the exemplified case studies. The consideration of results and findings corresponds to the four main facilitations potentially expected in a science communication that is to convey an aspect(s) of science, to get attention, to maintain

attention, and to fulfil the objectives and outcomes of the science communication experience. It may provide sufficient evidence to affirm that a visual image can be utilised in a science communication event for reaching out to passing audiences in their informal familiar surroundings. Several characteristics of visual images and events can be intentionally adopted to facilitate particular functions. The combination of visual images and other modes of communication makes an event capable of catering for different learning styles or preferences. The dynamic construction of meanings between those communicative elements can provide a broad range of the extent and clarification of information to be given in an event with respect to the intended goals. To enable some aspects of potential outcomes, a visual image may serve as a primary element conveying some information and facilitating learning on its own account, or as an initiator conductive to learning by getting and maintaining audience attention. As such, visual images can promote informal learning of science in an environment. It suggests that such events may engender various learning outcomes at the level of attainment with which an audience is comfortable. Namely, the events provide multiple learning approaches and levels of engagement which offer an audience not only the experience and enjoyment of viewing or interpreting the meaning of visual images but also facts or certain aspects of science, personal inspiration, or motivation for a behavioural change. Such informal and pleasurable learning conditions contributed by these visual image-based events may underpin their potential to engage science with public audiences including those having no interest in science.

Chapter 9
Summary and Conclusions

9.1 Summary of research

This study attempts to gain a better understanding of how a visual image can be used purposefully in a science communication event especially one encountered by an audience unexpectedly within a generic space. The results drawn from the analyses of a selection of exemplified visual images are applied to articulate implications for strategic consideration, particularly for a science communicator to consciously make decisions regarding the appropriation of a visual image in a given science communication context. With respect to the research questions, the research mainly considers several overarching aspects relevant to a science communication event featuring a visual image(s) and accompanying modes of communication to achieve its objectives. Namely, it examines what and how a message or concept/ideology can be constructed; how or what characteristics of a visual image can perform its functionalities in terms of getting and maintaining attention; and how the event's objectives regarding potential learning outcomes might be fulfilled in such an event.

To answer the research questions, the multiple-case study approach based on qualitative methods was utilised to investigate exemplified visual images and their accompanying written or verbal texts. Each individual case study enables the research to focus on the particularity of actual science communication contexts and to acquire in-depth information associated with each exemplified case. Meanwhile, the multiple-case study approach supports the exploration of significant relationships or features of visual images and accompanying information across the cases. Although we are not able to generalise the findings drawn from a few case studies to formulate a holistic principle applicable to all situations, the findings may provide some ideas for consideration for using a visual image in association with the dynamic of science communication contexts and objectives. Each case considered in this study involves a unit of a static visual image(s) and accompanying modes of communication used in a science communication event that potentially contains meanings associated with a social aspect besides factual or scientific information. The examined events are all casually encountered science communication held either in the UK, USA, or Thailand between the years 2015 and 2018.

There are eight cases selected for this investigation in which each couple of the cases are placed together in each chapter (between Chapters 4 and 7) based on their commonality regarding the expected learning outcomes. Chapter 4 analyses two cases featuring photographs of scientists, namely the exhibitions "Let The World Keep Turning" (case 4.1) and "Enjoy Science Careers" (case 4.2) which primarily aimed at positive attitude toward science. Then, Chapter 5 features two examples of murals appropriated in science

communication including “Seeing red” (case 5.1) and “We are the same blood” (case 5.2). Both murals represent the subject matters that may encourage the consideration of environmental issues and conservation. In Chapter 6, the two examined visual images are obtained from the same photographic exhibition: ‘Light Works’. From all 50 panels of the exhibition, the two cases are sampled with the main criteria that they may be created originally for other purposes though deployed for science communication, and potentially suggest a social aspect besides scientific facts. Regardless of their initial purposes, it should be noted that in the exhibition context, both chosen visual images (cases 6.2: ‘X-ray Kiss’ and 6.3: ‘Chocolate shells’) are presented as the examples of the light application along with their relevant details. The last two cases are featured in Chapter 7 each of which was appropriated in a health-related public campaign. They include the poster “Keep Antibiotics Working” (case 7.1) encouraging the prudent use of antibiotic medication, and the billboard promoting the alcohol drinking abstinence (case 7.2) especially over the Buddhist lent period in Thailand.

Several forms of data relevant to the exemplified cases were gathered through some available approaches either from the primary or secondary resources. They involve copies of the examined visual images, photographs of the actual events, field notes recorded from the visit of some accessible events, transcriptions of interviews with event facilitators, internal reports documented by the event facilitators, or information retrieved from online published articles or news about each case. It is notable that the accessibility of each case data can be different, namely, besides the copy of the case’s visual image(s), certain forms of data are omitted from some cases’ supporting evidence. Furthermore, since the primary data is contained in the visual mode, in the qualitative case analysis, it is transformed into textual information based on the framework for examining the potential message or intention underpinning the representation of each case (Kenney, 2009).

The framework (Kenney, 2009) was adopted as the guideline for the preliminary analysis and building an explanation of a visual image particularly in relation to its potential intended message. It considers several aspects of each exemplified case including its featured content/subject matter; physical size and occupied space; contexts of production, distribution, and reception, as well as the construction of meanings through the elements presented within such relevant contexts. The pieces of case data mentioned above are deployed in conjunction with the researcher’s critical analysis to construct the descriptive explanation of the individual cases. For example, a transcript of an interview with a facilitator of case 4.1 as exemplified in Appendix C provides a considerable amount of information about its contexts of production, distribution, as well as expected/potential reception and construction of meanings.

Meanwhile, the featured content is investigated in terms of the depicted subject and characteristics of a visual image, and its relationship with the accompanying modes of communication. Whereby, the visual image's characteristics comprise the aspects of image composition, visual perspective, tonality and colour, look and gesture that are applicable to the representation of a person or character, and the size relationship between the image's elements. The extensive analyses of the exemplified cases articulated through the application of such a discourse analysis framework are provided throughout Chapters 4-7. Those case studies may provide sufficient evidence to affirm that visual images have the potential to be adopted to convey meanings besides to serve as an auxiliary element. Together with accompanying components either written or verbal text, they can selectively construct various aspects of messages ranging from straightforward facts or scientific information to complex concepts or social ideologies.

From those case studies, the research findings are subsequently drawn in relation to visual image characteristics that may support their functionalities in visual science communication events as explained in Chapter 8. They are structured into four dimensions in which the first section suggests that visual image-based science communication could enable public members to encounter different facets of science in their daily lives. Some specific topics emerged from the case studies include the presentation of scientific facts/knowledge, scientific enterprise and purpose, cultural aspects of science, as well as the relationship between science and society. Then, the subsequent two sections entail the explanations of how or what characteristics of visual images may allow them to get and maintain audience attention. The final dimension of the findings explains the exemplified cases' potential to cater a variety of audiences regardless of their preferred learning styles, and different ways of a message representation through either visual depiction, or the collaboration between visual images and accompanying elements. This last section also considers the cases' featured components that play a significant role in enabling each aspect of Generic Learning Outcomes (GLOs).

Regarding the role of visual images to capture attention, it involves visual image capacity to offer unexpected perceptual information to people within their surrounding environment. Several properties of visual images potentially promote the significance of such extraneous stimuli for getting initial attention which may subsequently lead to the further exploration of the event. By examining the exemplified cases, such attributes can be considered in terms of their accessibility and informality, physical size or occupied space, the appropriation of colour and brightness, the recognition of aspects of content, and the coherence or unification between several visual images.

The study demonstrates that the size of a visual image or an event constituted by a number of visual images seems to be relatively large enough to make them conspicuous within their

particular distribution setting (Bruce, Green, & Georgeson, 2003; Gordon, 1997; Kennedy, 1985). Also, various examples of visual images can attest the careful utilisation of colour and brightness by showing their compliance with some colour schemes (Arnheim, 2004; Triedman, 2015). Meanwhile, the recognition of content's aspects is associated with the consideration of visual search as a primary task of the visual system (Wolfe, 1988; Yantis, 1998). The capability to identify what the eye perceives, though may occur partially, is argued to be psychologically satisfactory and consequently encourage further interpretation or consideration of the event's intended message (Anderson, Reynolds, Schallert, & Goetz, 1977; Arnheim, 2004; IARE, 2003; Kirschner, 2002; Mayer & Sims, 1994; Sweller, 2016). The findings present several recognisable components of visual images such as depicted subjects, genres, shapes of depicted elements, or forms of perceptible pattern or symmetry (Arnheim, 2004; Bell, 2012; Schiller & Tehovnik, 2015). Furthermore, the coherence of visual images can be endorsed by their collaborative presentation of a perceptible pattern either in terms of their depicted contents or their physical properties and arrangement. As such, the exemplified cases suggest that the unification or pattern of several visual images featured in a science communication event might be articulated through different accounts of similarity such as regarding their identical size, material, or the display format, as well as their periodically recurring arrangement.

In regard to the visual image's capacity to maintain audience attention, the relevant explanation is based on the principle of mind-wandering or attention declination (Buehler, 2014; Watzl, 2017). From such perspective that considers the continuing reiteration of prioritising pieces of incoming perceptual information, some visual image characteristics arguably endorse the priority or salience of a visual image to overpower other distracting or competitive stimuli and prolong audience participation with the associated event. Some relevant consideration drawn from the exemplified cases explains such a potential visual image as being part of a series or continuation, displaying pertinent information, resonating with emotions, or being intriguing or challenging interpretation.

The continuation of visual images within a science communication event may maintain attention at least in two dimensions: by forming a perceptual directional line drawing the eyes along their physical arrangement, or motivating the search of the conveyed overall message or story that cannot be completed unless a series of visual images are perceived (Kennedy, 1985; Lester, 2010; Watanabe, 2011; Wolfe, 1988). The level of relevance of information or a message may be affected by the associated subject matter (Bowater & Yeoman, 2012; Watzl, 2017), as well as the inclusion of demanding gaze or gesture which potentially promote event participation as if an audience could interact with a depicted subject (Kress & Leeuwen, 2006; Kulvicki, 2014; Messaris, 1997). It should be noted that a presented subject matter may promote the relevance of a visual image in different extents depending on audiences' cultural backgrounds. For example, in case 5.2 (the mural 'We are the same

blood'), the courtesy associated with family relationship which is esteemed in Thai culture may have less significance for audiences from other cultures.

Moreover, the salience of a visual image can also be endorsed by various emotional stimuli such as through the depiction of facial expression or visual cues suggesting meanings that may relate to particular emotions, or the inclusion of aesthetic features inviting the contemplation of a visual image simply for the sake of its beauty (Hillmann, Kempkensteffen, & Lincoln, 2015; Maratos, 2011; Reid, 1973; Smith et al., 2011; Watzl, 2017). Last but not least, the intriguing property of a visual image, based on the presumption of visual perception as the determination of a suitable hypothesis (Gregory, 1980), is argued to have potential to activate goal-driven attention regarding the endeavour to solve visual image's meanings. Some attributes articulating the challenge of visual perception might be observable in terms of ambiguous, compared/contrasted, or obscured visual elements (Ansorge, Horstmann, & Worschech, 2010; Bloomer, 1976; Messaris, 1997; Scharlau & Neumann, 2003; Yantis, 1998; Zschocke, 2005).

The last section of the findings demonstrates various approaches leading to experiential learning in the exemplified cases. It entails the observation of the event's components in terms of visual images, written texts, or verbal conversation with a facilitator that seem to be the significant enabler of potential learning outcomes. The findings are explained respecting to each aspect of the Generic Learning Outcomes (GLOs) framework (Arts Council England, n.d.) based on dynamic relationships between visual and textual/verbal modalities for facilitating different communicative purposes (McCloud, 1994). The exemplified cases, especially in Chapter 6 featuring visual images drawn from the 'Light Works' exhibition, suggest that in order to achieve the audience understanding of relevant information, the construction of a message like factual information may rely on written texts or verbal conversation. They arguably provide a more definite interpretation than visual representation which may be adopted as an additional element in this context.

Meanwhile, the endorsement of an attitude or value, especially toward science or scientific community as seen in Chapter 4, seems to require the interdependent construction between visual representation and textual/verbal information. As such, the necessity of both modalities for such learning outcome might be supported by the implication of the elaboration likelihood model (ELM) whereby they may influence the reception of a proposition either cognitively or emotionally (Kitchen, Kerr, Schultz, Mccoll, & Pals, 2014; Lacey, 1998; Messaris, 1997; Petty, Cacioppo, & Schumann, 1983). This is also the case for enabling the expected outcome as encouraging a certain behaviour, such as the cases included in Chapter 7, which can be underpinned by the compliance-gaining strategies (Littlejohn, 2010; Marwell & Schmitt, 1967). It is observable in those cases that, to fulfil this learning outcome, textual/verbal information is usually provided to specifically inform a

prescribed action while visual representation collaboratively envisages a potential consequence of either complying with or ignoring the suggested behaviour.

For the learning outcome as the enjoyment attained from participating in an event, it may be achieved through the viewing of a visual image on its own account. The experience associated with such a viewing process can be satisfactory or aesthetically pleasurable (Arnheim, 2004; Reid, 1973; Watzl, 2017; Wolfe, 1988). At the same time, some visual images like the murals explained in Chapter 5 may also inspire an audience. Such a learning outcome may rely on its polysemic nature and capability to represent a conceptual message not necessarily seen in reality or complying with realistic features which can give a chance for imagination or creativity (Bloomer, 1976; Gardner, 1982; Kulvicki, 2014; Spearman, 1930). In addition, the utilisation of a visual image in science communication is also beneficial for gaining the learning outcome regarding the indirect improvement of skills especially ones relevant to the visual system (Arts Council England, n.d.; Hooper-Greenhill, 2004). It provides an opportunity for audiences to perceive visual representation that requires the demonstration of intellectual and emotional skills (Arnheim, 1970; Hall, 2005; Simons, 2008).

9.2 Implication of the findings

Based on the research opportunities relevant to visual science communication suggested by Trumbo (1999) as explained in Table 2.6, this research primarily focuses on the nature of visual images in relation to science communication contexts and purposes. The case studies demonstrate several ways and potential of appropriating visual image properties in combination with written/verbal texts to construct an intended message. The findings drawn from the cross-case synthesis may be applied to the process of visual image production which is a significant aspect of visual science communication. As such, the research may contribute to the practice of science communication in terms of suggesting a practical guideline for using visual images in relation to science communication objectives.

By adopting the discourse analysis framework in the analyses of individual cases, the research demonstrates that the framework could support the researcher to answer the research questions regarding visual images used in science communication. It also shows that the construction of meanings and the characteristics of visual images are underpinned by the intended message and functionality. It can be seen that the adopted framework considers several significant aspects associating with the appropriation of visual images which is also coherent with the dimensions covered in the framework for interpreting a visual image proposed by Rose (2016). For each site of investigation including the sites of image itself, production, circulation, and audiencing, Rose (2016) suggested a visual material interpreter to consider three components: technological, compositional and social modes. These frameworks are not only useful for the research study or analysis of a visual image

but they may be applied in the practice of science communication. Based on such two analysis frameworks (Kenney, 2009; Rose, 2016), a guideline, that may be helpful for a science communicator to select a visual image, associating the three modes considered in Rose's framework in conjunction with Kenney's framework can be explained as follows. Some probing questions are suggested to support the consideration of a visual image and its potential use. Respectively, some examples drawn from the investigated cases are also provided to further clarify the consideration in response to those questions.

9.2.1 Technological mode

This mode involves the consideration of visual image production and its effects which can be clarified by asking some relevant questions such as:

- what technologies were used in producing this image?
- what was made possible or not possible by the means of production?
- what are the expectations around the medium of production?

Apart from the decision for visual image's production techniques (i.e. photography, painting, illustration, or graphic design), a science communicator may subsequently evaluate their potential, limitation, and inherent implication. This can be exemplified by the cases investigated in this research. For cases 4.1 ('Let the World Keep Turning' exhibition) and 4.2 ('Enjoy Science Career' exhibition) in which adopted photography as the mean of production, it can be seen that the portraits featured in these cases could capture the appearance or physical characteristics of those scientists in detail as an actual eye would see. By taking such photographs in a studio it also allowed the image creators to set visual image components as intended such as regarding lighting, pose/gesture, or style of the depicted subjects. Moreover, since photographs are generally adopted as a proof of evidence, they may promote the truthfulness of the representation of the scientists and their associated aspects of science. Or by using X-ray technology in case 6.2 ('X-ray Kiss' image), the visual image can display the body's parts under the skin. Although it was originally a grayscale image, it was digitally colourised as part of the 'Xogram' image production technique which offers an alternative way to present an X-ray image as an artwork. As such, it may decontextualise the x-ray image as a scientific image to be a cultural mean accessible to the members of the public.

Meanwhile, for cases 5.1 ('Seeing red' mural) and 5.2 ('We are the same blood' mural), despite lacking the capability to convey realness, natural lighting or colours as a photograph could perform, the murals allowed the image creators to illustrate conceptual information which may not actually happen or be seen in reality. They could offer the audiences an opportunity to perceive and evaluate the proposed messages themselves. This is also the case for the poster 'Keep Antibiotics Working' (case 7.1) in which the graphic illustration allowed the characterisation of antibiotic-resistant bugs, or in the billboard campaigning

alcohol abstinence (case 7.2) when the digital editing technology provided tools to create such a composite visual image to metaphorically represent the intended message.

This technological mode may also consider the realisation of an actual visual image to be distributed to its audience. Particularly in an unexpectedly encountered event, this suggests the decision for a visual image's physical size and format respecting the potential audience's lifestyle and venue characteristics. For example, a visual image in such kind of event is supposed to be relatively conspicuous in such associated environment. Besides promoting the presence of a visual image, it may also involve the decision for achieving the event's accessibility (i.e. actual space/venue or via the Internet) and appropriate viewing condition that is convenient for an audience to perceive the conveyed information. The display format and the arrangement of several visual images might be also aimed at endorsing the coherence or unification of the overall event. Furthermore, the final distribution of a visual image may affect the consideration of this technological mode as seen in case 7.2: the billboard campaigning for alcohol abstinence in which the visual image was printed in a large site. As a result, it required digital technology to create a visual image with sufficient resolution and render the final billboard in good quality.

9.2.2 Compositional mode

The compositional mode mainly focuses on the site of a visual image itself (Rose, 2016) by considering its content/subject matter and how or in which fashion such content is portrayed. It may be useful to ask:

- what is this image about?
- what features of the image are most striking or salient, and what might this indicate?
- what is shown in this image, and what is absent or not shown?

It is evident in the analyses of individual cases that a visual image could be intentionally created to promote/suppress certain idea or interpretation as exemplified in Table 8.1. As such, the construction of an intended message might associate the selective depiction of content as well as look and gesture of a depicted character (if applicable), or the choices of visual characteristics such as the composition of visual elements and their size relationship, visual perspective, and tonality and colour. For example, it can be seen in case 5.2: 'We are the same blood mural' in which the content comprising a variety of plants, creatures and human being was depicted to illustrate the concept of biodiversity, and their facial expression and gesture may emphasise their common agreement to sustain each other. Or the billboard featured in case 7.2 intentionally presented the dramatic change or perceptible development of the representative's condition as the result of alcohol abstinence while probably omitting other opposing scenarios such as the variation in the effectiveness of practice or the improving rate.

Regarding visual image characteristics, some examples can also be seen in the examined cases. The oblique camera angle and visual perspective of the photograph featured in case 6.3: ‘Chocolate shells’ enabling the capture of numerous chocolate halves may emphasise the context of manufacturing and industrialism. The selective appropriation of tonality and colour can be exemplified in case 5.1: ‘Seeing red’ mural in which the striking colours (red, black, white) and their contrast may affect an audience perception of the image. Namely, the colours may promote the solemnity of the depicted subject matter. Also, the depiction of antibiotic-resistant bugs in sizes larger than that of the antibiotic capsule in case 7.1 could endorse their capability to hinder the effectiveness of antibiotics.

9.2.3 Social mode

This mode of consideration associates the site of ‘audiencing’ proposed by Rose (2016) which involves several social factors relevant to the perception and functionality of a visual image. Therefore, it may be helpful to narrow down such range of possibility in order to purposefully use a visual image by asking:

- how is this image being used?
- who is the image for? who is called upon to be the audience?
- what assumptions are implicit in the image?
- what is the image trying to "do"?

The research demonstrates that a visual image has the potential to be used in a science communication event more than simply being an auxiliary element. Besides getting and maintaining audience attention as mentioned above, a visual image may also perform a communicative function to a particular group of audience. For instance, the visual image featured in case 4.2: ‘Enjoy Science Career’ exhibition was not only attractive and engaging to high school student but it was also appropriated to present a desirable image of a biomedical engineer in the similar style of an entrepreneur. Such portrayal may encourage some positive assumptions about the career and may subsequently persuade some audiences (mainly students) to pursue such a career. In the same way, the visual image depicted in case 7.2 was created purposefully to encourage alcohol abstinence by illustrating its positive outcomes as an example especially to those drinking alcohol (mainly men in between 25-40 years old).

Moreover, to construct an intended message and perform a certain objective, a visual image is usually used in combination with other modes of communication such as written texts or verbal conversation. The accessibility of an intended message should be tailored for the target audience although all featured information is not necessarily to be straightforward or precisely interpreted by an audience, depending on the event’s expected learning outcome. As such, this social mode also involves the consideration of how a visual image may co-operate with its accompanying elements. The findings that emerged from the exemplified

cases suggest that there are several approaches of collaboration between visual images and accompanying elements. A variety of collaborations can be adopted to fulfil different Generic LearningOutcome (GLOs) as explained in section 8.4.2 and Table 8.6. Such findings also serve as the basis of the proposed guideline. For the learning outcome associating with the development or improving skills, this study does not provide a suggestion specific for developing a practical skill such as how to use a visual image as a visual instruction for doing something. Nevertheless, it shows that the utilisation of a visual image, regardless of its different functionalities, can peripherally improve participants' visual skills by default.

In summary, the consideration for selecting and using a visual image explained above in the sections 9.2.1 – 9.2.3 can be encapsulated into five dimensions as listed in Table 9.1. Table 9.1 also includes some helpful questions and examples emerged in the investigated cases which may support the consideration and provide some ideas of options relevant to each aspect of the guideline. The guideline may be beneficial to a science communicator to analyse potential visual images and make a conscious decision for using them. Although the suggested guideline and examples are particularly drawn from encountered science communication events, the proposed aspects of consideration can still serve as a basis applicable to other kinds of events regardless of how a visual image and accompanying elements would be delivered to audiences. For instance, whether visual images are to be posted on a social media platform or displayed in an exclusive science communication event, their nature in terms of production technique/type, format and size, content, properties, and collaboration with other modes of communication as mentioned in Table 9.1 are still significant to their contexts of utilisation. Meanwhile, the examples of realisation included in Table 9.1 might not be suitable for all cases, but would need to be adjusted as appropriate. Also, it should be noted that such guideline has never been adopted in an actual practice which may impose some limitation to the guideline in terms of its effectiveness and the extent it could actually support a science communicator to use a visual image.

Table 9.1: The guideline for selecting and using a visual image in a science communication event with some clarifying questions and examples of realisation drawn from the multiple-case study

Aspect of consideration	Clarifying question	Examples of realisation
1. Production technique or type of a visual image	• what technologies were used in producing this image? • what was made possible or not possible by the means of production? • what are the expectations around the medium of production?	photography, painting, graphic illustration, scientific image, Xogram
2. The actual format and size of a visual image based on the approach of distribution	• How this image is delivered to audiences? • In which location this image is to be displayed?	different sizes of banner, mural, poster, billboard, customised panel, or a digital file for online distribution
3. Subject matter or content to be featured in a visual image	• what is this image about? • what features of the image are most striking or salient, and what might this indicate? • what is shown in this image, and what is absent or not shown? • who is the image for? who is called upon to be the audience? • what assumptions are implicit in the image?	selective aspects of content, emphasising/obscuring a certain ideal, the accessibility of clarity of interpretation
4. Determination of some desirable image properties	• What characteristics of this image can get and maintain attention? • How this visual image can be used or arranged in combination with other visual images?	
• Aesthetic features		proper or harmonious colour scheme and brightness, balanced composition, dynamic and simplicity of visual elements
• Recognisable element		a depicted subject, a perceivable shape, a perceivable pattern of symmetry
• Engaging/relatable element		a direct gaze of a subject, a gesture asking for a response, a subject matter pertinent to audience
• Emotional stimulus		facial expression, visual cues resonating emotions such as through colour, character design

• Intriguing element		ambiguous representation, comparison of visual components, perceivable obscurity of a certain visual component
• Coherence or connection between visual images in the same event		the coherence or continuity of their content, their similar size and format, the continuity of their arrangement
5. The collaboration between a visual image and accompanying elements to fulfil intended generic learning outcomes	• how is this image being used? • what is the image trying to "do"?	mainly through written texts or verbal conversation and visual images play a supportive role, mainly through visual images, interdependent construction between modalities as exemplified in Table 8.6

9.3 Limitations and future research

The findings in this research might be subject to at least three limitations. First, the selection of the exemplified cases that is based on their accessibility within a limited duration can affect the extent of evidence to support the analysis. The present study has not been able to approach some visual images' creators or events' facilitators. As such, the analysis of visual image production context relied on secondary resources while some relevant information about the science communication context is absent such as regarding the event's objectives, the purpose of using visual images in the event, or the target audiences. Although the cases are deployed as the basis for suggesting the use of visual images in science communication, the study cannot establish the actual effectiveness of all cases to rationalise as if they were a good example to follow. Several cases were investigated without any form of an empirical evaluation or actual feedbacks from events' target audiences. Meanwhile, the evaluation results accompanying some other cases primarily focused on the overall event or general factors rather than considered the effect of the utilised visual image specifically.

Second, a potential source of bias for the study is the influence the researcher had on the analysis of visual images especially in the aspect of visual image reception context. For some cases, the research approached visual images with a cultural background different from that of their creators or audiences. Therefore, the potential interpretation of visual images articulated in the study is limited by the researcher's prior knowledge or experience to decipher them with all possibilities. For example, the researcher might not be able to recognise some cultural connotation conveyed in a visual image. Although the effect of such lacking resources for exhaustively considering the visual image construction of meanings might be mitigated by cooperating theoretical perspectives and peer review conducted by people from different cultural backgrounds and experience, the analysis of such dimension is

still inevitably influenced by the researcher's subjective factors. The interpretations of visual images explained in the study tend to be the researcher's prefered versions of potential meanings which can be different from those perceived by actual or target audiences.

Third, the way the research associates the dimensions of visual images with science communication contexts may hinder the findings comprehensiveness. Both components of the research are multidisciplinary themselves which entail several theoretical backgrounds and considerations. By selectively examining the nature of visual images in relation to the event's objectives based on Generic Learning Outcomes, the research might overlook some visual image characteristics particularly significant to other components of science communication. Such impediment might also be the result of assigning and respectively considering a couple of cases in relation to a particular aspect of commonality although such classification might have been based on other potential criteria. Moreover, the reliance on the discourse analysis framework primarily investigating visual images in companionship with written texts might overlook the consideration of an alternative construction caused by other coexisting modalities such as a verbal conversation with a facilitator, or an accompanying video.

Therefore, further research may usefully determine the applicability and effectiveness of the proposed guideline in actual science communication events based on the experience of science communicators using the guideline as well as audience perception toward the visual images corresponding to the guideline. By doing so, it might be able to establish the findings and their implication proposed by this research or some unnoticed consideration of using visual images in science communication may arise and further expand the suggested guideline. In regard to the understanding of visual images used in the context of science communication, it would be interesting to examine their characteristics in relation to other science communication factors besides potential learning outcomes such as a certain scientific topic/issue, or group of audiences. This may shed some light on a particular appropriation of visual images in those contexts. In addition, respecting to the increasing deployment of multimodal tools, it is suggested that the investigation of a visual image in combination with other different accompanying modes of communication omitted in this research such as video, demonstration, discussion, or interactive media would be of great help in such ongoing science communication practice. This would not only expand the understanding of the topic to different contexts not exclusive to encountered science communication events but may also suggest some innovative approaches of using multiple modalities in science communication.

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Appendix A: The self-audited research ethics application form

Social Research Ethics Group (SREG) in SBMS
(sub-group of
University of Edinburgh, School of Health in Social Science)

RESEARCH ETHICS APPLICATION (REA)

This form is required when seeking ethical approval for research involving Social Science research methods (both quantitative and qualitative) in SBMS. The sections you are required to complete will depend on the nature of your application. Please start to complete the form from the beginning and proceed as guided. On completion the ***entire*** document should be submitted electronically to your supervisor who will then send it to SREG (Social Research Ethics Group) for consideration.

FORM OVERVIEW

FORM	COMPLETION
Project registration form	: Compulsory for all applications
Document checklist	: Compulsory for all applications
Level 1 Self Audit form	: To be completed for all research studies that are not subject to review by an external UK based ethical committee.
Level 2 /3 ethical review form	: To be completed when indicated by responses on the Level 1 form.

PROJECT REGISTRATION FORM

This form is the first stage in applying for University ethical approval and should be completed prior to the commencement of any research project. Applications submitted without appropriate documentation will be returned.

Ethical approval is required for all projects by staff or students conducting research, or similar.

Applicants should familiarise themselves with the School's Research Ethics Policy prior to completion.

PR1**Name of Applicant: Kaewnapha Phothi**
PR2**Name of Supervisor[1]: Dr Andrew Hall, Dr Elizabeth Stevenson**
PR3**Project Title: The use of visual images in science communication**
PR4**Subject Area (section of school): Science Communication**

[1] Not applicable to staff members.

PR5**If student, type of assessed work that this application relates to: The dissertation for PhD**
PR6**Planned date of project submission: --**
PR7**Date ethics application submitted: xx September 2015**
PR8**(Date complete information submitted if different):--**
PR9**IRAS Approval Number if applicable:--**
The following to be completed by ethics administrator
PR10***Date of initial response to applicant:***
PR10***Date of final approval:***
PR11***Amendments Requested Date:***
PR12***Amendments Approved Date:***
PR13***Reviewer 1***
PR14***Reviewer 2*** *Level 2-3 only*

DOCUMENTATION CHECKLIST

1) DC1**Does your research project require extraction or collection of data abroad? (✓)**

✓	**No**	*If 'No' Skip to Q2*	
	Yes	Local Ethical review needed, please confirm (✓) electronic attachment of: Application to ethical review panel in country of data collection (in English) **+** copy of letter of approval	

2) DC2**For the purposes of this research study, will you access identifiable[2] information on any NHS patient? (✓)**

✓	**No**	*If 'No' Skip to Q3*		
	Yes	Please confirm (✓) electronic attachment of:	**Caldicott Guardian** approval for use of NHS data (or confirmation that it is not required)	

[2] 'Identifiable information' refers to information that would allow you to know, or be able to deduce, the identity of a patient. The most common examples of this would be accessing medical records or similar, or accessing a database that includes patients' names.

3) [DC3]**Does the project require ethical review by an external UK committee e.g. NHS REC or Social Work?**

✓	**No**	*If 'No' Skip to Q4*		
	Yes	Please confirm (✓) electronic attachment of:	NHS REC (IRAS) /other application form **+** copy of letter of approval	
		NOTE: You are ***not*** required to complete University ethical review forms. **Skip to Q6**		

4) [DC4]**Unless you answered 'yes' to 3, you must also obtain ethical approval through the University of Edinburgh process. Please submit a Level 1 form (with 'Methods' summary) and, if indicated, a level 2-3 form as well.**

	Forms: level		**Summary of 'Methods'**
SHSS Ethics paperwork	**1**	**2/3**	
Please indicate the SHSS Ethics forms completed herewith (✓):	✓		✓

5) [DC5]**If you have completed the Level 2/3 form please list any additional documentation provided in support of your application (E.g. Disclosure, consent form, participant information, GP letters etc.)**

Documentation Name These should reflect content	(✓)	**Documentation Name**	(✓)

6) Signatures

_Kaewnapha Phothi___ _Kaewnapha Phothi____ __xx/09/2015___

Applicant's Name | Applicant's Signature | Date signed

Dr. Elizabeth Stevenson _____ __xx/09/2015___

Supervisor[3] Name | Supervisor's Signature | Date signed

Please return an electronic copy of your UoE HSS Ethics Application Form (in its entirety) we will need to adapt the wording here to your Section's Ethics Tutor, I don't think we have ethics tutors. Supervisors could probably be listed instead, accompanied by electronic copies of additional documents indicated above. We do not accept paper documentation, is this the case for us too? I suggest that if

[3] Not required for staff applications.

we can store things electronically rather than in paper form we do so, following our 'parent' committee please scan all documents into electronic formats. Please keep a copy of all documentation for your records.

LEVEL 1 SELF AUDIT FORM

The audit is to be conducted by all staff and students conducting any type of empirical investigation, including research, audit or service evaluation.

The form should be completed by the principal investigator and, with the exception of staff, signed by a University supervisor.

SA1**Primary Research Question: How visual images are used in science communication?**

Please tick	What type of research are you planning to do?
	Study of a novel intervention or randomised clinical trial to compare interventions in clinical practice
✓	Study utilising questionnaires, interviews or measures, including auto-ethnographic.
	Study limited to working with routinely collected clinical data
	Meta-analysis or systematic review
	Research database containing non-identifiable information

SA2**Please provide a brief summary of your proposed study. Our interest is in areas of your methodology where ethical issues may arise so please focus your detail on areas such as recruitment, consent, describing your participants and the nature of their involvement, and data handling.**

Project Summary:

This ethics application form is submitted for conducting research on the use of visual images in science Communication. The methodology used in the research will be interview with participants. Research subjects could include science communicators, and others involving science communication practice. The participants will be recruited covering different landscapes of science communication, and in accord to their job duties, expertise, and interests. A consent form will be agreed with each participant prior taking part in the research. During the course of making agreement, a proposed consent form could be refined as appropriate. The participants will be the key informants contributing required data to the research. The interview will attempt to elicit participant's opinions, experiences, frameworks or practices of using visual images as a medium for communicating science, as well as their qualifications, trainings, or working experiences background in relation to science communication. All collected data, including subsequent transcriptions of interview data, will be kept confidential, removed names or identifiable details and destroyed in due course. The findings will be used in the dissertation for PhD and may be published within academia or public dissemination. In addition, those images referred in the research might be reproduced in the research outputs with owner's permission.

Please circle your answer as appropriate:

	ETHICAL ISSUES		
SA 3	Bringing the University into disrepute Is there any aspect of the proposed research which might bring the University into disrepute? For example, could any aspect of the research be considered controversial or prejudiced?	*No*	***YES***
SA 4	**Protection of research subject confidentiality** *Will you make every effort to protect research subject confidentiality by conforming to the University of Edinburgh's guidance on data security, protection and confidentiality as specified in: http://www.ed.ac.uk/schools-departments/information-services/services/research-support/data-library/research-data-mgmt/data-security* *For example, there are mutually understood agreements about:* (a) non-attribution of individual responses; (b) Individuals, and organisations where necessary, being anonymised in stored data, publications and presentations; (c) publication and feedback to participants and collaborators; (d) With respect to auto-ethnographic work it is recognised that the subject's anonymity cannot be maintained but the confidentiality of significant others must be addressed.	***NO***	*Yes*

SA 5	**Data protection and consent** *Will you make every effort to ensure the confidentiality of any data arising from the project by complying with* the University of Edinburgh's Data Protection procedures (see www.recordsmanagement.ed.ac.uk); For example (a) Ensuring any participants recruited give consent regarding data collection, storage, archiving and destruction as appropriate; (c) Identifying information[4], (e.g. consent forms) is held separately from data and is only accessible by the chief investigator and their supervisors; (e) There are no other special issues arising regarding confidentiality/consent. (f) That where NHS data is being accessed Caldicott Guardian approval has been obtained.	***NO***	*Yes*
SA 6	**Duty to disseminate research findings** Are there issues which will prevent all participants and relevant stakeholders having access to a clear, understandable and accurate summary of the research findings should they wish?	*No*	***YES***
SA 7	**Moral issues and Researcher/Institutional Conflicts of Interest** *Are there any SPECIAL MORAL ISSUES/CONFLICTS OF INTEREST?* **Examples include, but are not limited to:** **(a) Where the purposes of research are concealed;** **(b) Where respondents are unable to provide informed consent** **(c) Where there is financial or non-financial benefit for *anyone* involved in the research, or for their relative or friend.** **(d) Where research findings could impinge negatively or differentially upon participants or stakeholders (for example when selecting an unrepresentative sample of a larger population).** **(e) Where there is a dual relationship between the researcher and subject? E.g. Where the researcher is also the subject's practitioner or clinician.**	*No*	***YES***

[4] 'Identifiable information' refers to information that would allow you to know, or be able to deduce, the identity of a patient. The most common examples of this would be accessing medical records or similar, or accessing a database that includes patients' names.

SA 8	**Potential physical or psychological harm, discomfort or stress** Is there any foreseeable potential for: (a) significant psychological harm or stress for participants (b) Significant physical harm or discomfort for participants? (c) Significant risk to the researcher? Examples of issues/ topics that have the potential to cause psychological harm, discomfort or distress and should lead you to answer 'yes' to this question include, but are not limited to: *Relationship breakdown; bullying; bereavement; mental health difficulties; trauma / PTSD; Violence or sexual violence; physical, sexual or emotional abuse in either children or adults; feedback of results from the project's assessments.*	*No*	***YES***
SA 9	**Vulnerable participants** Will you be ***recruiting*** any participants or interviewees who could be considered vulnerable? Examples of vulnerable groups, the inclusion of which should lead you to answer yes to this question include, but are not limited to: Clients or patients of either the researcher OR the person recruiting subjects; Children & young people; people who are in custody or care for example, offenders, looked after children or nursing home resident; persons with mental health difficulties including those accessing self-help groups; auto-ethnographic researchers examining distressing topics.	*No*	***YES***

Assessment outcome:

SA10 **Have you circled any answers in <u>BOLD</u> typescript?** Please tick as appropriate

No ✓

(i) Your responses on the completed self-audit confirm the ABSENCE OF REASONABLY FORESEEABLE ETHICAL RISKS.
(ii) Please now read the guidance below and provide the required signatures.
(iii) You are NOT REQUIRED to complete a level 2/3 application form.
(iv) Please submit the UoE HSS Ethics Application Form electronic document (in its entirety) along with ALL additional required documentation, failure to do so will mean that your form is returned to you.

Yes ☐

(i) Your responses on the completed self-audit indicate that we require further information to consider your application.
(ii) Read the Guidance below and provide the required signatures.
(ii) You **ARE REQUIRED** to complete a level 2/3 application form.

(III) Please continue to page x of this document where you will find the level 2/3 form

Subsequent to submission of this form, any alterations in the proposed methodology of the project should be reviewed by both the applicant and their supervisor. If the change to methodology results in a change to any answer on the form, then a resubmission to the Ethics subgroup is required.
The principal investigator is responsible for ensuring compliance with any additional ethical requirements that might apply, and/or for compliance with any additional requirements for review by external bodies.

ALL forms should be submitted in electronic format. Digital signatures or scanned in originals are acceptable. The applicant should keep a copy of all forms for inclusion in their thesis.

_Kaewnapha Phothi___	_Kaewnapha Phothi____	__xx/09/2015___
Applicant's Name	Applicant's Signature	Date signed
Dr. Elizabeth Stevenson	_____	__xx/09/2015___
***Supervisor**[5] Name	Supervisor's Signature	Date signed

*NOTE to Supervisor: Ethical review will be based only on the information contained in this form. If countersigning this check-list as truly warranting all 'No' answers, you are taking responsibility, on behalf of the HSS and UoE, that the research proposed truly poses no ethical risks.

[5] Not required for staff applications.

Appendix B: The informed consent form for interview participants

Dear _*(Name of participant)*_,

I am writing to introduce myself: I am Kaewnapha Phothi and I am a PhD student at the University of Edinburgh. I would like to ask whether you would be prepared to take part in a research study that I am currently undertaking for my dissertation project as part of a PhD in Science Communication.

I am studying the use of visual images in science communication and, as a component of my research, I would like to collect data about using visual images in the different contexts of communicating science.

What this will mean for you.

I would like to arrange to conduct an interview with you of around 30-45 minutes about your opinions, experiences, frameworks or practices of using visual images as a medium for communicating science, as well as your qualification, training, or working experience background in relation to science communication.

Confidentiality

The interview will include the use of image-elicitation to simulate a scenario of selecting visual images for certain science communications in which some parts of your body, including hands and arms, will be filmed along with note-taking and audio recording.

The footage, notes, recording and the subsequent transcript will be kept confidential and only be available to myself and my supervisor and will be destroyed after 5 years.

Interviewee names will not be used in the research outputs and quotes will be anonymised.

Images referred in the research will be reproduced in the research outputs with your permission.

Consent

If you decide you no longer wish to take part in the study even after the interview has taken place, this wish will be respected.

Use of Results

Results will be used in my dissertation for PhD, may be published within academia and for public dissemination. They may be used in teaching and in research.

Please do not hesitate to contact me if you have further questions.

Kind regards,
Kaewnapha Phothi

Contact details:

Student:	Kaewnapha Phothi:	s1360759@sms.ed.ac.uk
Supervisor:	Dr. Elizabeth Stevenson:	e.stevenson@ed.ac.uk

I have read and understood the explanation provided to me. I have had all of my questions answered to my satisfaction and I agree to participate in the research.

I am willing to participate in this study in the terms set out in this letter

Signature: _____

Name: _____

Department/Affiliation: _____

Date: _____

Appendix C: An exemplified transcript of an interview with an event facilitator of ‘Let the World Keep Turning’ exhibition (case 4.1)

CS01 Let the world keep turning, 2015

Participant: CS01Pa01; Interviewer: Kaewnapha Phothi

Recorded: CS12Au01; Filename: CS01In01

Date of Interview: 28/04/2015

****

Transcription

Transcriber: Kaewnapha Phothi

I= Interviewer

R= Respondent

****

I: ...OK, I hope that you've looked through the consent form that I sent to you earlier.

R: Oh, yes but I forgot to fill it.

I: No worries, I just would like to know, do you any questions or any detail that you would like me to change or refine from that consent form?

R: No..no, not at the moment (00'30") I'm OK with it.

I: OK, that's great. So, today I'm going to interview you about your experiences on the exhibition 'Let the world keep turning' and the interview will be recorded and transcribed and then removed any identifiable details, so you can (01'00") give me any information or opinion freely, because at the end I will anonymise the data.

10R: OK

I: So, let's start the interview. So, for the first question, could you give me some general ideas or opinions about the exhibition itself? What do you think about it?

R: Yes, I think that (01'30") the exhibition was pretty cool and it's a pretty creative way of doing like science and art. And it's a quite new idea of like showing science on a photograph. So, I think..yes... I think that idea would pretty good and instead of letting people read all texts, we're giving them those images, so (02'00") people are... That makes it easier for them to understand what we are trying to say, but on the other hand when we tried to do this..um.. the sorts of.. you know...the artistic way of showing science sometimes makes people confused as well. So, it's also a pretty dilemma.

I: So, from your opinion that you told me that it can use the images to communicate (02'30"). Could you tell me, what do you think the benefits from using the images in the exhibition?

R: So, I think first of all image is quite straightforward, so you don't have to really read anything..like..some people might just walk by and take a peek. They probably have their own understanding of the exhibition, but it's always a kind of (03'00") a poster with text that people might have to stop and read through it very carefully and that takes much longer. The time is much shorter for them, so that make people more comfortable, and they feel like look at them. And..um...also I think pictures is general for people at all ages and people doing all kinds of occupation...like... (03'30") everyone can understand image, but like if you use a piece of text, people might have different understanding ability at the text, and kids might not

understand as well adults when reading text. So, I think the image is more general for everyone. And the third one is...yes..again...picture is a...like..people can have different opinions to (04'00") one single picture...like...when they're looking the picture, people have their own thought of it, they can think more creatively by themselves. While they're reading of text, people might think about the same thing.

I: But we saw in the exhibition let the world keep turning, (04'00") those images were displayed solely without description. Do you think by the image itself without description, do you think what are the benefits or drawbacks from showing pictures without any description? As you told me that if different people can interpret that image in different ways (05'00"). Could you tell me more about the drawbacks from that? because as I see I think the communication of the exhibition depended hugely on explainers. So from this matter, do you think what is the good points or the shortcomings of depending on the explainer? (05'30")

R: So, should I go first for whether do we have explainers or not?

I: Yes, OK

R: So, I'm..like..for our exhibition we didn't have any explanation for those pictures because we thought that was art, and you're not supposed to explain art...like...how art and pictures are. In a gallery they don't certainly have an explanation (06'00"), so we're trying to...kind of...um...like...do it in an artistic way. And there are drawbacks of this because there was one person in the Royal infirmity who have seen the exhibition and he thought we were kind of doing something to protest against racism. So, you know people have different opinions (06'30") and they might be like no way close to what we're trying to show. So, it is important to have like facilitators there to explain what we are trying to do, and there was another lady, who was from China, watch the exhibition and you know if we were just putting text, she would not be able to understand anything, but she would understand the pictures, and (07'00") I could actually explain to her in her own language. That makes it easier. If I wasn't there, she would still be able to understand because it's a picture, not text. The matter is probably it's more suitable for more people and the drawbacks are like people may have very strange interpretation like pretesting against racism or somethings (07'30").

I: So, could I say that to have explainer can bring the exhibition close to the audiences better...like...

R: Sorry I can't hear it properly.

I: Could I say that to have explainers can help us to bring the exhibition come closer to the audiences?

R: Yes, the facilitators helped the audiences to understand what the exhibition is about and what we are trying to say (08'00").

I: And from your point of view as an explainer. What information or key messages that you tried to give to those audiences?

R: So, first of all, we were doing this as a part of the [Name of the festival that the exhibition took part] we have to tell them why we actually doing this, and we have to explain a little about [The name of the scientific project] and what [The name of the scientific project] is doing...like detecting lung diseases and a little about (08'30") the technology, the sciences behind it, and tried to do a little advertise for [The name of the scientific project], and it's actually the people who're seeing the exhibition pay the tax which goes to the funding for [The name of the scientific project], and I think they have the right to know what we are actually doing. And apart from explaining these backgrounds (09'00"), we have to explain what the pictures try to say, a little about [The photographer] and his work, and why he wanted to do this...like...he wanted to kind of do a new thing, and explain a little about what each picture is about, the scientist on the picture, the scientific language on the background, and their feelings about Edinburgh, the card they were holding and the explanation. So that's pretty much what we were trying to explain (09'30"). But we tended to not explain too

much...like...kind of to block people's mind. We wanted them still to have their own thought as well as our explanation.

I: Did you give them any information about art aspects? (10'00") As we can see the picture used like black and white colour or balancing or something like that.

R: I actually didn't it, because I don't know quite well what to say about the art. Because I'm actually not a professional in art and I really don't know (10'30") about art as well as [The photographer]. And there was a pity that [The photographer] wasn't there to explain art. And there were actually some people came to the exhibition for the art, for [The photographer], so it's like not suitable for me to explain to them about something that I don't know well. I think it's much better to look into the science side and the project.

I: And what about the (11'00") different groups of audiences. How did they respond to those images? Like different people might respond to the images differently. So, if you can recall your memory, could you tell me how did they respond to those images differently?

R: So, at the Informatics for which most of them are academics, they were more interested in the science part (11'30") of the exhibition, because one of them.. the scientist [The name of the scientist who took part in those images] was working in the Informatics, and like a lot of people knew his text...the background, so like more people they were interested in the science and..like.. they were asking very strange questions (12'00"). I think that Informatics was like more people interested in science. And in the hospital...like..more people interested in health problems and kind of what [The name of the scientific project) is doing. But I think personally the hospital was not a really good place for the exhibition, because...like people had...they were like emergency was going on as well as like people (12'30") actually just passed by the hospital. They were a lot of people who really had very urgent thing to do, or they were badly ill. And because it's the hospital, most people were not in the mood for the exhibition there. So, less people responded actually to our exhibition, less people would stop and look. (13'00") And at the shopping mall, mostly...like...the general public and we kind of at the beginning of the day we were doing the same thing like stopping random people and introducing the whole things to them. But it was a shopping mall, most people would think that we actually tried to sell something, they would actually walk away. (13'30") They might stop and look, but if we go up to them, they might actually walk away. So after one hour, we stopped doing that and then we sat at the corner and just let people enjoy the exhibition themselves, and that was...yes...we have a better response, more people stopped and looked, and some people actually wanted to approach to us..like... to talk a little about it (14'00"). Most people just stopped and looked and took a flyer and then walked by. So, we have little communication with the audiences in the shopping mall.

I: So, from this point like the case in the shopping mall, it seems that it's quite difficult to have explainers at the exhibition. So, form your opinion, what do you think that could be used (14'30") to communicate with people instead of explainers, apart from the image itself? What tools or approaches that could be used for interacting with people to give them information or something like that?

R: So, at the shopping mall, we actually had a poster board with a poster about [The name of the scientific project] and the whole (15'00") exhibition thing, the whole project. Some people stopped and looked, but I think it would be better if we have kind of a screen with the kind of video rotating on it, with the person actually speaking telling people about the exhibition so a video...I think could do better than a poster in the shopping mall. And also, we should have (15'30") big logo, and [The name of one science communicator] suggested like telling people that this is just for free, don't have to pay for it. That's what people care about. People don't want to find that you actually sell stuffs in the end, so it would be better if we just told everyone that this is a free exhibition and you can enjoy it for free and you can look at the (?), look at the poster and the pictures (16'00"). So, I think it would be better that people know it's free.

I: Back to yourself as an explainer. Could you tell me about what tasks that you're supposed to do, apart from giving information to people, I think you have to do all of things as well. Could you tell me some tasks that you're supposed to do in that exhibition? (16'30")

R: So, of course! we have to set the things up, and pack them up at the end, set them up at the beginning. And we have to introduce these stuffs to people, and give out flyers, and we have to do evaluation on it, and there are actually a lot of preparation works before the exhibition. Am I supposed to say something about this? (17'00")

I: Yes, because I'm also going to ask you how you prepared yourself.

R: Yes, it is actually the preparation works that's much longer than the exhibition. So, we had to actually go with the scientists to do the photo shooting, and I have to write something about the day...kind of...put on the [The name of the scientific project]'s website. (17'30")

I: Yes, I read that one.

R: Yes, we have to do that. We also had to design the flyer and put them on places like everywhere around campus and around Edinburgh. We had to do that, and we were supposed to do like the..to make a T-shirt with the [The name of the scientific project]'s logo and the name of the exhibition on it (18'00"), but we didn't have enough funding, we don't have enough money for that...so...and time...so we just let that out, and we had to...me and [The name of a science communicator] had to make the banners, and that was actually quite a hard job for her (18'30") to make connection to the printing job, and to the banners and print out the flyers and stuffs. And before that [The name of one science communicator] had to make connection with [The photographer] and that's the most important thing. So that's pretty much everything.

I: So, you told me that you were there in the production process on the shooting day, right?

R: Yes

I: From that matter that you took part in that production process. How this matter can affect or (19'00") help you to know more about the project, or to know more about the things that you could give to people? How that participation helps you?

R: So, first of all, I knew where the pictures came from, and how they were made, and this is actually a very good point of (19'30") telling the audiences about how scientists can know more people, and they can have fun. And I can use the example of their behaviours on the photo shooting day, and yes I think about the [The name of the scientific project], I actually learned more of the information online and from [The name of a science communicator]. The photo shooting day was pretty much about...about the picture itself (20'00"), and how it would be made. So those kinds of helpful for me to explain when they're asking about [The photographer], and how the pictures came to be like that....(20'30")

I: So, when the exhibition, the banners have been prepared, ready to be set up to show to people. From your opinion, what part of the exhibition that you think is the most attractive? I mean, what part could draw people to the exhibition?

R: I think it the exhibition itself (21'00"). The way the exhibition has made is very creative, and you don't always see a banner with a scientist on it in that shopping mall. I think it's the exhibition itself. The idea that is creative is the most interesting to draw people's attention.

I: And could you tell me, how do you think that those images can impact the audiences (21'30") in any way? Like which way, it could impact audiences? , or what information or what detail or what thing that can impact those people?

R: I think it's more of the contrast between scientists and the audiences' minds, and the scientists on the pictures. Like people don't always think scientists as normal people (22'00") I don't offend but some people so think scientists just like very weird people and (?). And this kind of picture shows the different sides of scientists, and... yes I think that...

I: So, can I say that when people come to the exhibition, they could go back with something in their mind (22'30") about scientists?

R: Yes, we're trying to make people walk away with some sciences that they've learnt, about lung diseases, about [The name of the scientific project] things, but I mean people don't have to learn. They can just walk away with the impression in their minds, and that also very good (23'00)

I: Yes, that's great. Like they can come to get some entertainments that would be OK.

R: Yes...yes

I: I would like to know about the flyers of the leaflet. Could you tell me from your point of view, how could those flyer impact peoples? How it can draw people or how is it useful for people or audiences?

R: So, we've got two types of flyers. The first one is about an A4 paper (23'30") and that kind of like advertise for our project, for exhibition. That would be put-on all-over campus and around shopping mall and the hospital, and yes that was a flyer with the [The photographer]'s picture on it, and all the venues and times. So, I think [The photographer]'s picture was pretty attractive for people who know (24'00") him. And the other flyer that we got is the little one with [The name of a scientist]'s picture on it. That's for the explanation of the project, of the exhibition, and that got a little piece of text on it, explanation of the pictures and what we're trying to say there. So, that's like something people can walk away with after seeing the exhibition and remember (24'30") what they've seen.

I: Do you know that most people that come to the exhibition, how do they know about the exhibition? From flyer? From the internet, from Twitter or anything? Do you know how did they know about it?

R: We actually didn't (25'00") do about the evaluation about how people know about the exhibition. Like I think from people that I talked to, some people, actually most people were just people who passed by. Some of people actually have seen the flyers and saw the website, and some people knew about the [The name of the festival] festival and they came. Some people knew about [The photographer] and then they came. It's like very different reasons (25'30") for different audiences.

I: I heard that you might bring the exhibition to show in your country.

R: Yes.

I: Could you tell me what opportunities that you could see from the exhibition that the exhibition could bring to individuals or organisation? (26'00") From the exhibition, what opportunities that you think the exhibition could bring to individuals or organisation or your country or people in your country?

R: So, from my opinion, I'm trying to do this at my undergraduate institute that I've already made connection with my teachers and staffs in my chemistry department, (26'30") and they're very happy to have this project in my undergraduate institute. And so first of all, it's just a kind of a test of science communication, because the big number of people in China have never heard about science communication before. And most people are doing science just for science, and they're very kind of isolated from the public in their labs. (27'00") It's not only students or people who're doing master or PhD, but also some professors and most senior academics. So, I'm trying to do on the different levels of audiences, because we're able to manage like a whole class just for undergraduate, or just for master students, (27'30") or just for PhD students...like... we're able to manage that. And then secondly, for people who are chemistry students, and other majors students in my undergraduate institute, it is a very good opportunity for them to make a connection with [The name of the scientific project]..like..it's kind of recruiting students to do PhD there (28'00) every year. And it's actually a good opportunity for them to make contact with [The name of a science communicator] ,and other people in the [The name of the scientific project], the professors of

the [The name of the scientific project] for them who try to study in the UK in the future. And for the academics, it's so a very nice opportunity for them to make connection with [The name of the scientific project], and the [A university in the UK]. Like I've just heard that my undergraduate institute has some kind of collaboration with the [A university in the UK] and my chemistry department (28'30"). So, it's a very nice opportunity for them to make a stronger connection. And yes, it is. I think making people care more about scientists is actually the main point of doing this. And we'll actually be doing it around campus, and people like the lay public from outside of school can come to see the exhibition.(29'00")

I: So, I can say that this exhibition can be one example of science communication.

R: Yes. I'm thinking of like talking a little bit more about science communication as well as a topic actually. (29'30")

I: So, I think we come to the last question. For the last question, do you have any recommendation or comments on using visual image in science communication that you think it's important, but I didn't talk about? (30'00") Do you have any comment or recommendation?

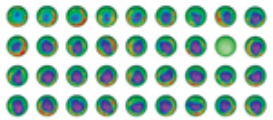
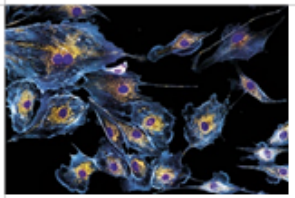
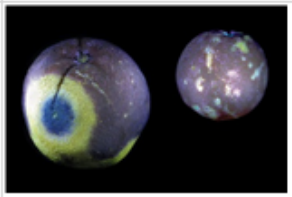
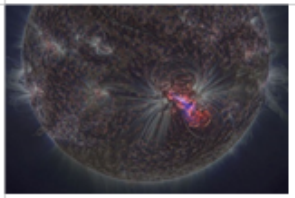
R: Yes, I think using visual image in science communication is a fantastic idea. It's very straightforward, and it's suitable for everyone. On the other hand, sometimes it could make confusion (30'30") as well.

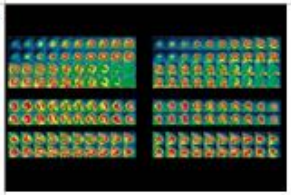
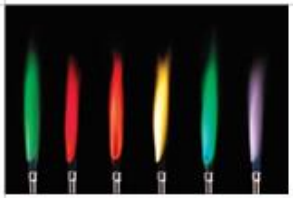
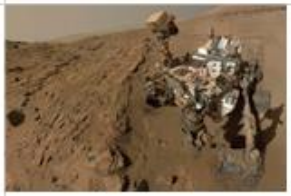
I: What your opinion about like most of science communicators, or in general, people usually think that image is used as an additional component in an exhibition, doesn't like this exhibition that used the images as the main element in the exhibition (31'00"), but most of science communication events or general ideas, they will accept images as for entertainment or for attractive point but not for the data. What is your opinion about this idea?

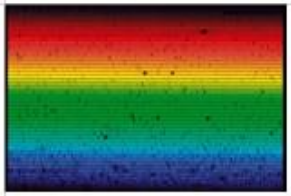
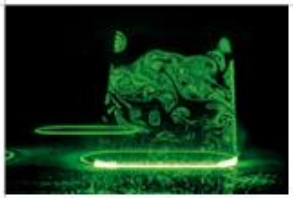
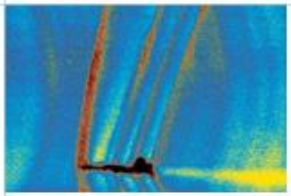
R: I think it depends on the actual science communication case...like (31'30") you can't use images to communicate science with the policy brief, or if we do that in the parliament, it would be not suitable to just use images. But if you do a science communication for school children or for kids, it will be much better to images as the main part of your communication work instead of talking or letting them read text. (32'00) So I think it actually depends on the case itself...like a narrow case...because we can't stop everyone and talk to them, then image is a very straightforward and very time-saving.

Appendix D: The inventory and classification of visuaimages featured in the ‘Light Works’ exhibition

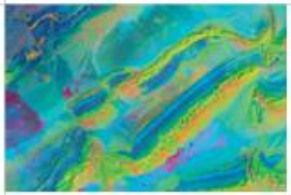
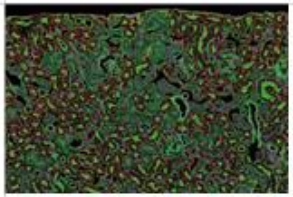
No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
1	The Gamma Ray Sky	gamma ray	astrophysics	Scientific research	Scientific image	Analytical process	Middle distance	Eye level, Frontal	
2	Z Machine Firing	x-ray	engineering, physics	Scientific research	Light application	Narrative process	Far distance	High angle, Frontal	
3	Rings of Saturn	UV ray	astrophysics	Scientific research	Scientific image	Analytical process	Close distance	Eye level, Frontal	
4	Bacteria on the Hands	UV ray	Technology	Health and medicine	Scientific image	Analytical process, Narrative process	Middle distance	High angle, Frontal	
5	Air Purification	UV ray	Technology	Health and medicine	Light application	Narrative process	Middle distance	Eye level, Frontal	

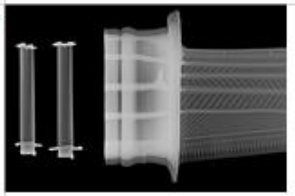
No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
6	Developing Ozone Hole	UV ray	Earth science	Environment	Scientific image	Analytical process	Far distance	Top-down	
7	Lung Cells	UV ray	Biology	Scientific research	Microscopic image	Analytical process	Middle distance	Top-down	
8	Food spoilage	UV ray	Technology	Agriculture (Post-cultivation)	Scientific image	Analytical process	Middle distance	High angle, Frontal	
9	Solar Flare	UV ray	Astrophysics	Scientific research	Scientific image	Analytical process	Middle distance	High angle, Frontal	
10	Martian Meteorite	Visible light	optical mineralogy	Scientific research	Microscopic image	Analytical process	Middle distance	Top-down	

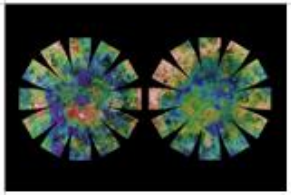
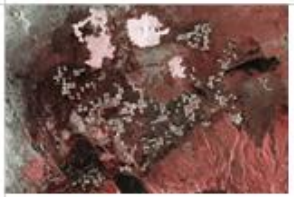
No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
11	Las Vegas and Lake Mead	Visible light	Earth Science, geoscience	Environment	Scientific image	Analytical process	Far distance	Top-down	
12	Heart Repair	Gammy ray	Technology	health and medicine	Medical imaging	Analytical process	Far distance	Top-down or Frontal	
13	Flame tests	Visible light	Chemistry	Entertainment (coloured fireworks), forensics and medicine	Scientific image	Classificational process	Middle distance	Eye level, Frontal	
14	Dubai seen from Space	Visible light	Engineering, Remote sensing	Environment, urban planning	Scientific image	Analytical process	Far distance	High angle, Oblique	
15	Mars Rover Selfie	Visible light and UV rays	Astrophysics	Scientific research	Scientific image	Analytical process, Narrative process	Middle distance	High angle, Oblique	

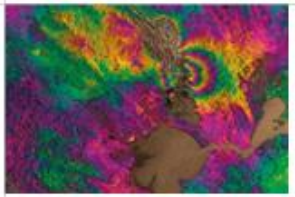
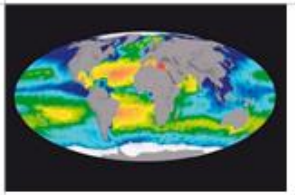
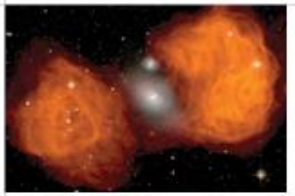
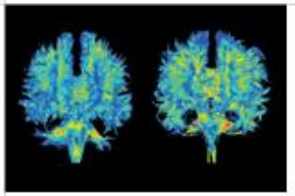
No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
16	Solar Spectrum	Visible light	Astrophysics, Astronomy	Scientific research	Scientific image	Analytical process	Middle distance	Eye level, Frontal	
17	Smartphone Screen Cutting	visible light	Engineering, technology	Manufacture	Light application	Narrative process	Middle distance	High angle, Frontal	
18	Sonic Boom Research	Visible light	Engineering	Scientific research	Scientific image	Narrative process	Far distance	High angle, Frontal	
19	Neonatal Phototherapy	UV ray	Technology	health and medicine	Light application	Narrative process	Middle distance	High angle, Frontal	
20	Andromeda Galaxy, M31	UV ray, visible light, and infrared	Astronomy	Scientific research	Scientific image	Analytical process	Far distance	High angle, Frontal	

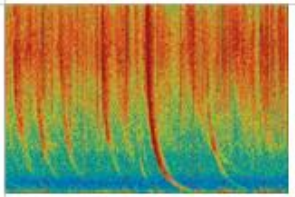
No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
21	Polycrystalline Solar Cell	Visible light	Engineering	Environment, energy	Light application	Analytical process	Middle distance	Top-down or Frontal	
22	Orion Nebula	UV ray, visible light, and infrared	Astrophysics	Scientific research	Scientific image	Analytical process	Far distance	Eye level, Frontal	
23	Gamma sphere	Gammy ray (invisible light)	Physics	Scientific research	Light application	Analytical process	Middle distance	Eye level, Frontal	
24	Manufacture by Melting	visible light	Engineering, technology	Manufacture, aerospace	Light application	Narrative process	Middle distance	High angle, Oblique	
25	Blood supply under the skin	Infrared	Engineering, technology	health and medicine	Scientific image	Analytical process	Close distance	Eye level, Frontal	

No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
26	Faulted Minerals	Infrared	Geoscience	scientific research	Scientific image	Analytical process	Far distance	Top-down	
27	Two-Photon Kidney Cells	Infrared	Biology	scientific research	Microscopic image	Analytical process	Middle distance	Top-down	
28	Space Telescope Mirror Test	Infrared	Astrophysics	scientific research	Light application	Analytical process	Far distance	Eye level, Frontal	
29	Centre of the Milky Way	Infrared	Astrophysics	scientific research	Scientific image	Analytical process	Far distance	Eye level, Frontal	
30	Domestic Heat Loss	Infrared	Engineer, technology	Well-being, Architecture	Scientific image	narrative process, Analytical process	Middle distance	Eye level, Frontal	

No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
31	Airport Fever Scanning	Infrared	Engineer, technology	health and medicine	Scientific image	narrative process, Analytical process	Middle distance	Eye level, Frontal	
32	Chocolate Shells	Infrared	Engineer, technology	Manufacture: Food/confectionary manufacture	Light application	Narrative process	Middle distance	Eye level, Oblique	
33	Star Formation	Terahertz light	Astrophysics	Scientific research	Scientific image	Analytical process	Far distance	Eye level, Frontal	
34	Non-Destructive Testing	X-ray	Engineer, technology	Manufacture: casting quality control	Scientific image	Analytical process	Middle distance	Top-down or Frontal	
35	Forensics in Art	Terahertz light	Technology	Art, archeology	Scientific image	Classificational process, Analytical process	Middle distance	Eye level, Frontal	

No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
36	Security Scanning	Terahertz light	Technology	Health and safety	Scientific image	Narrative process	Middle distance	High angle, Frontal	
37	Cosmic Microwave Background	Microwave	Astronomy, astrophysics	Scientific research	Scientific image	Analytical process	Middle distance	High angle, Oblique	
38	Surface of Venus	Microwave	Astronomy, astrophysics	Scientific research	Scientific image	Analytical process	Middle distance	Top-down	
39	London	Radio wave	Engineering, Remote sensing	Environment, urban planning	Scientific image	Analytical process	Far distance	Top-down	
40	Agriculture in Oregon	Microwave	Engineering, Remote sensing	Agriculture	Scientific image	Analytical process	Far distance	Top-down	

No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
41	Earthquake movement	Microwave	Engineering, Remote sensing	Environment, Earth observation	Scientific image	Narrative process	Far distance	Top-down	
42	Salty Seas	Microwave	Engineering, Remote sensing	Environment, ocean surface observation	Scientific image	Analytical process	Middle distance	Eye level, Frontal	
43	Fornax Radio Lobes	Radio wave	Astronomy	Scientific research	Scientific image	Analytical process	Far distance	Eye level, Frontal	
44	Seeing Concussion	Radio wave	Technology, biology	health and medicine	Medical imaging	Analytical process	Middle distance	Eye level, Frontal	
45	X-ray Kiss	X-ray	Technology	Art	Light application	Narrative process	Close distance	Eye level, Frontal	

No.	Name	Featured light	Scientific subject	Usage area	Image category	Representation	Size of frame	Point of view	Visual image
46	Lightning Sferics	Radio wave	Engineering	Scientific research	Scientific image	Narrative process	Middle distance	Eye level, Frontal	
47	Mummy Skeleton	X-ray	Technology	Informal education	Scientific image	Analytical process	Middle distance	Eye level, Frontal	
48	Fighting Sleeping Sickness	X-ray	biology, health and medicine	Scientific research	Scientific image	Analytical process	Middle distance	Top-down	
49	Lizard, Micro-CT	X-ray	Biology	scientific research	Scientific image	Analytical process	Middle distance	Eye level, Frontal	
50	Centaurus A Galaxy	Visible light & X-ray	Astronomy	scientific research	Scientific image	Analytical process	Far distance	Eye level, Frontal