Using Argumentation to Evaluate Concept Blends in Combinatorial Creativity

Roberto Confalonieri[1], Joseph Corneli[2], Alison Pease[3], Enric Plaza[1] and Marco Schorlemmer[1]

[1]Artificial Intelligence Research Institute, IIIA-CSIC, Spain
[2]Computational Creativity Research Group, Department of Computing, Goldsmiths, University of London, UK
[3]Centre for Argument Technology, School of Computing, University of Dundee, UK

Abstract

This paper motivates the use of computational argumentation for evaluating 'concept blends' and other forms of combinatorial creativity. We exemplify our approach in the domain of computer icon design, where icons are understood as creative artefacts generated through concept blending. We present a semiotic system for representing icons, showing how they can be described in terms of interpretations and how they are related by sign patterns. The interpretation of a sign pattern conveys an intended meaning for an icon. This intended meaning is subjective, and depends on the way concept blending for creating the icon is realised. We show how the intended meaning of icons can be discussed in an explicit and social argumentation process modeled as a dialogue game, and show examples of these following the style of Lakatos (1976). In this way, we are able to evaluate concept blends through an open-ended and dynamic discussion in which concept blends can be improved and the reasons behind a specific evaluation are made explicit. In the closing section, we explore argumentation and the potential roles that can play at different stages of the concept blending process.

Introduction

A proposal by (Fauconnier and Turner, 1998) called *concept blending* has reinvigorated studies trying to unravel the general cognitive principles operating during creative thought. According to (Fauconnier and Turner, 1998), concept blending is a cognitive process that serves a variety of cognitive purposes, including creativity. In this way of thinking, human creativity can be modeled as a blending process that takes different mental spaces as input and blends them into a new mental space called a *blend*. This is a form of *combinatorial creativity*, one of the three forms of creativity identified by Boden (2003). A blend is constructed by taking the existing commonalities among the input mental spaces (called the generic space) into account, and by projecting the structure of the input spaces in a selective way. In general the outcome can have an emergent structure arising from a non-trivial combination of the projected parts. Different projections lead to different blends and different generic spaces constrain the possible projections.

This poses challenges from a computational perspective: large number of possible combinations exhibiting vastly different properties can be constructed by choosing different input spaces, using different ways to compute the generic space, and selecting projections. Within the Concept Invention Theory project[1] (COINVENT), we are currently developing a computational account of concept blending based on insights from psychology, Artificial Intelligence (AI), and cognitive modelling (Schorlemmer et al., 2014). One of our goals is to address this combinatorial nature. One potential outcome of this work is a deeper understanding of the way combinatorial creativity works in general.

The formal and computational model for concept blending under development in COINVENT (Bou et al., 2014) is closely related to the notion of *amalgam* (Ontañón and Plaza, 2010). Amalgamation has its root in case-based reasoning and focuses on the issue of combining solutions coming from multiple cases. Assuming the solution space can be characterised as a generalisation space, the amalgam operation combines input solutions into a new solution that contains as much information from the two inputs solutions as possible. When input solutions cannot be combined, amalgamation generalises them by dropping some of their properties. This process of generalisation and combination can be expensive from a computational point of view, depending on the search space to be explored.

The amalgam-based approach for computing blends makes explicit the combinatorial nature of concept blending, which raises the issue of evaluating and selecting novel and valuable blends as opposed to those combinations that lack interest or significance. Although Fauconnier and Turner (1998) suggest a number of qualitative criteria that can be used for evaluating concept blends, it is not straightforward to chararacterise them in a computational model.

In this paper, we propose to explore an argumentative approach to understanding and evaluating the meaning, interest, and significance of concept blends. Specifically, we propose to view evaluating blends as a process of *argumentation*, in which the specifics of a blend are pinpointed and opened up as issues of discussion. Our intuition is that in the context of new ideas, proposals, or artworks, people use critical discussion and argumentation to understand, absorb and evaluate. We also consider the constructive roles that argumentation can play in concept blending.

Computational argumentation models have recently appeared in AI applications (Bench-Capon and Dunne, 2007;

[1]See `http://www.coinvent-project.eu` for details.

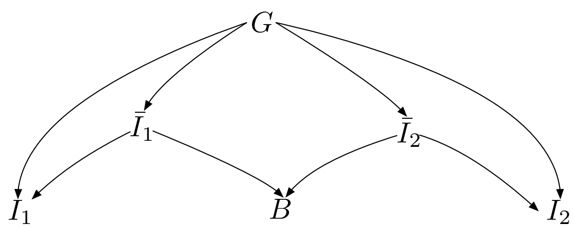


Figure 1: An amalgam diagram with inputs I_1 and I_2 and blend B obtained by combining $\bar{I}_1$ and $\bar{I}_2$. The arrows indicate generalisation.

Rahwan and Simari, 2009), and we believe that incorporating argumentation can foster the development of a fuller computational account of combinatorial creativity. The current paper develops these themes at the level of (meta-) design; implementation is saved for future work.

Roles of Argumentation in Concept Blending

Consider the *amalgam* diagram modeling the concept blending process (Figure 1): two input spaces I_1, I_2, two of their possible generalisations $\bar{I}_1$, $\bar{I}_2$, which have a generic space G and blend B. When two input spaces cannot be combined because they do not satisfy certain criteria, the inputs have to be generalised for omitting some of their specifics. The combination of each specific pair $\bar{I}_1$, $\bar{I}_2$ yields a blend.

Informally, we can imagine argumentation taking place at various points in the amalgam diagram. In general this would happen in response to indeterminacy, that is, when some features of the diagram are underdetermined. We foresee that argumentation can be used:

a. to express opinions or points of view that can be used for guiding the selection/omission of specific parts of the input spaces; in particular, to select a specific pair of generalisation $\bar{I}_1$, $\bar{I}_2$ of the input spaces in the blending process;

b. to provide a computational setting for modeling discussions around the quality of a creative artefact, with the aim of evaluating and refining the generated blends.

In the first case, arguments would be about generalisation, i.e. which features should be preserved from I_1 and which features should be preserved from I_2. More complex inferences could be involved, for example in a case where I_1 is fixed, and constraints and various optimality criteria on the blend are imposed, which then yield various constraints on what the other input I_2 should be. We return to this point in the discussion section, and we focus for the most part on the second case.

In the second case, argumentation would be used to evaluate a range of blends, and the evaluation is carried out *post hoc*, by a variation of try-it-and-see. A range of blends are trialled, each one bringing out different (un)intended meanings. The evaluation is modeled as an argument, or dialogue in which the specifics of a blend are pinpointed and opened up as issues of discussion. This dialogue can be considered as an introspective evaluation, although it usually takes place among several parties as a means for the social development and understanding of creative artefacts. In this paper, we focus on this role.

Our Approach

To exemplify our approach, we take the domain of computer icons into account. We assume that concept blending is the implicit process which governs the creative behavior of icon designers who *create* new icons by blending existing icons and signs. To this end, we propose a simple semiotic system for modeling computer icons. We consider computer icons as combinations of signs (e.g. document, magnifying glass, arrow etc.) that are described in terms of *interpretations*. Interpretations convey *actions-in-the-world* or *concepts* and are associated with shapes. Signs are related by sign-patterns modeled as qualitative spatial relations such as *above*, *behind*, etc. Since sign-patterns are used to combine signs, and each sign can have multiple interpretations, a sign-pattern used to generate a computer icon can convey multiple intended meanings to the icon. These are subjective interpretations of designers when they have to decide what is the best interpretation an icon can have in the real world. In this paper, we show how the intended meaning of new designed (blended) icons can be evaluated and refined by means of Lakatosian reasoning.

Background

Computational argumentation

Computational argumentation in AI aims at modeling the constitutive elements of argumentation, that are i) arguments, ii) attack relations modeling conflicts, and iii) acceptibility semantics for selecting valid arguments (Bench-Capon and Dunne, 2007; Rahwan and Simari, 2009).

The most well-known computational argumentation framework is due to Dung (1995). Dung defines an abstract framework to represent arguments and binary attack relations, modeling conflicts, by means of a graph. He defines different acceptibility semantics to decide which arguments are valid and, consequently, how conflicts can be resolved (Figure 2).

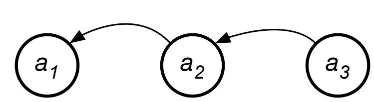


Figure 2: Dung framework example: Nodes represent arguments and edges (binary) attack relations. Argument a_1 is attacked by a_2 which is attacked by a_3. Thus, a_2 is defeated and a_1 can be accepted. a_3 is also accepted.

Abstract argumentation frameworks do not deal with how arguments are generated and exchanged. They merely focus on attack relations between arguments and acceptibility semantics. However, the intrinsic dialectical nature of argumentation is fully explored when an explicit argumentation process is considered. Then, the purpose of a dialogue becomes essential to determine how arguments should be generated and exchanged, and how a dialogue should be structured (Walton and Krabbe, 1995).

Lakatosian argument and dialogue

Lakatos (1976) was a philosopher of mathematics who developed a model of argument, presented as a dialogue, to

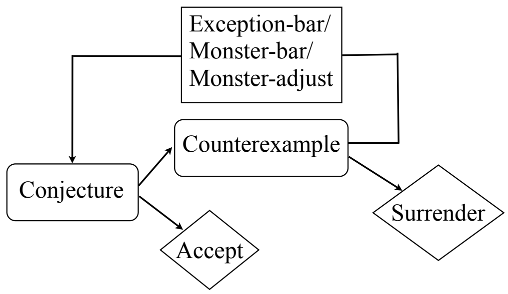


Figure 3: Our interpretation of Lakatos's game patterns.

describe ways in which mathematicians explore and develop new areas of mathematics. In particular, he looked at the role that conflict plays in such explorations, presenting a rational reconstruction of a dialogue in which claims are made and counterexamples are presented and responded to in various different ways. His resulting model describes conceptual continuity and change in the growth of knowledge, and contains dialogue moves, or methods, which suggest ways in which concepts, conjectures and proofs are fluid and open to negotiation, and gradually evolve via an organic process of interaction and argument between mathematicians. These dialogue moves are:

Surrender consists of abandoning a conjecture in the light of a counterexample.

Piecemeal exclusion is an exception-barring method that deals with exceptions by excluding a class of counterexamples, i.e., by generalising from a counterexample to a class of counterexamples which have certain properties.

Strategic withdrawal is an exception-barring method that uses positive examples of a conjecture and generalises from these to a class of object, and then limits the domain of the conjecture to this class.

Monster-barring/monster-adjusting is a way of excluding an unwanted counterexample. This method starts with the argument that a 'counterexample' can be ignored because it is *not* a counterexample, as it is not within the claimed concept definition. Rather, the object is seen as a monster which should not be allowed to disrupt a harmonious conjecture. Using this method, the original conjecture is unchanged, but the meaning of the terms in it may change. Monster-adjusting is similar, in that one reinterprets an object in such a way that it is no longer a counterexample, although in this case the object is still seen as belonging to the domain of the conjecture.

The moves above are not independent processes; much of Lakatos's work stressed the interdependence of creation and justification. These moves describe the evolution of both arguments and conclusions in mathematics, and as such constitute argument patterns, or schemes. However, they are a rational representation of exchanges between mathematicians and describe dynamic, rather than static arguments, presented as a dialogue. Thus, they also have temporal structure, and can be seen as a dialogue game, in which at any point various dialogue moves are applicable (see (Pease et al., 2014) for a description of Lakatos's methods in these terms). The fact that we include negotiations over definitions and changes in the conclusions being argued means that it is difficult to apply traditional abstract argumentation frameworks, which assume that such aspects are stable. However, we can see some of the moves in terms of Dung's framework: for instance if an initial argument for a conjecture forms a_1 in Figure 2, then a_2 might be a counterexample to the conjecture, and a_3 might be the monster-barring move.

The Lakatosian way of conceiving the reasoning as an open-ended discussion about a problem suggests that we can exploit Lakatos's moves for structuring dialogues for the evaluation of creative artefacts. Evaluation in creativity is not a static and rigid process, and the discussion should flow in a dynamic way. As such, in this paper, we propose to use Lakatosian reasoning to model the negotiation about the intended meaning of generated blends (icons). Figure 3 shows the dialogue game we will adopt to model these dialogues. For another formal framework of dialogue games for argumentation see (Prakken, 2005).

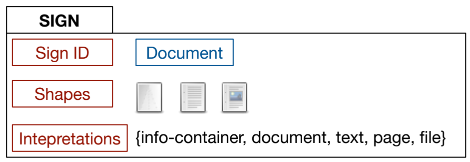
Icons and Signs

We follow a semiotic approach to specify the intended meaning of computer icons. Semiotics is a transdisciplinary approach that studies meaning-making with signs and symbols (Chandler, 2004). Although it is clearly related to linguistics, semiotics also studies other forms of non-linguistic sign systems and how they may convey meaning; this includes not only designation, but also analogy, and metaphor. Although some people may regard Peirce's Sign Theory as the origin of semiotics, Saussure founded his semiotics (semiology) in the social sciences. Currently, cognitive semiotics and computational semiotics take their own perspectives on the relation between sign and meaning-making. In this paper, we take a semiotic approach to describe computer icons in the sense that icons, as a spatial pattern of shapes, are viewed as signs, and compositions of signs are interpreted to convey a meaning, as when we say 'this icon means the download is still active'.

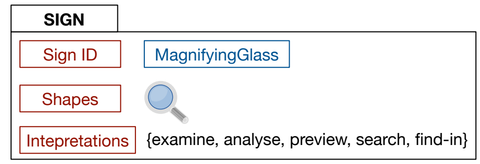
The shapes recurrently used in icons are interpreted as *signs*; screens, magnifying glasses and folders are examples of signs. A magnifying glass sign can be used in different icons in such a way that its meaning is *context-dependent*, that is, it depends on other signs related to it in different icons. We associate to each sign a set of *interpretations*, that encode the kinds of intended meaning associated to that sign as *actions-in-the-world* or *concepts*.

An icon is represented as a pattern defined by a collection of signs and qualitative spatial relations like *above*, *behind*, etc. We can find patterns of meaning that are shared among different icons by analysing recurrent patterns of signs and their spatial relation. We call them *sign patterns*. A sign pattern has an associated collection of *interpretations* that encode the intended meanings associated to that sign pattern.

Signs, sign patterns, and interpretations, which we will use in the paper, can be built by analysing and annotating existing libraries of computer icons. As we shall see, the inherent polysemy of signs, sign patterns and icons opens the way to use arguments for evaluating the quality or adequacy of new icons created by concept blending.

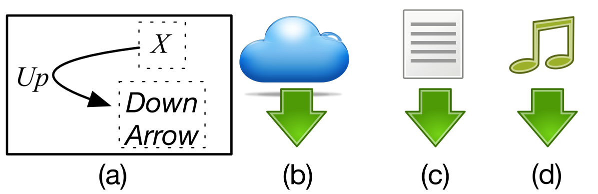


(I) The structure of the Document sign, including associated shapes and interpretations.

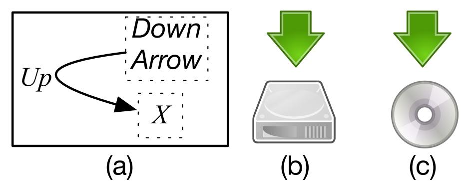


(II) The structure of the MagnifyingGlass sign, including associated shapes and interpretations.

Figure 4: Example of signs



(I) (a) the sign pattern From-DownArrow with three examples of the pattern where X is a sign for (b) cloud content, (c) document content, and (d) audio content.



(II) (a) the sign pattern DownArrow-Toward with two examples of the pattern where X is a sign for (b) a hard disk storage, and (c) an optical disk storage.

Figure 5: Example of different sign patterns used with the same sign DownArrow

A semiotic system for icons

In this section, we will formalise the notions presented above. A *sign* S is a tuple $\langle id, \mathcal{F}, \mathcal{A} \rangle$ where id is a sign identifier, $\mathcal{F}$ is a set of shapes embodying the sign S and $\mathcal{A}$ is a set of interpretations. We use $\mathcal{S}$ to denote the available set of signs. Figure 4 provides two examples. Figure 4I shows the structure of the Document sign, with several shapes embodying the sign, and a list of interpretations that express how this sign is used in different ways to convey meanings such as *info-container, document, text, page, file*. Intuitively, this means that the shapes used in the icons are sometimes interpreted as a document and other times as a page, etc. Moreover, the specific shapes can be used interchangeably to embody a Document, i.e. there is no clear distinction, regarding the shapes, between document vs. page vs. file. Another example of a sign is the MagnifyingGlass shown in Figure 4II, with interpretations *examine, analyse, preview, search*, and *find-in*.

We will also describe a library of annotated *icons* $\mathcal{I}$, where each icon $I \in \mathcal{I}$ consists of two parts: (1) a spatial configuration of signs and (2) the intended meaning of that icon. For instance, in Figure 5I, the icon (b) has the spatial configuration of a 'cloud on top of a downward-arrow' and its meaning is 'downloading content from the cloud'.

Sign patterns

In our framework, sign patterns relate signs in icons using spatial qualitative relationships such as *above*, *behind*, *up*, *down*, *left*, etc. We assume that these relationships are represented as binary predicates, *Above*(X,Y), *Up*(X,Y), etc., where X and Y are variables ranging over signs in $\mathcal{S}$. For our current purposes, we use the qualitative spatial relationships defined in (Falomir et al., 2012).

Let us consider two examples of sign patterns that include the DownArrow sign. DownArrow has a vertical downward-pointing arrow shape and is associated with the interpretations $\{$*down*, *downward*, *downloading*, *download-from* and *download-to*$\}$. The sign pattern called From-DownArrow (shown in the schema labelled (a) in Figure 5I) uses the qualitative spatial relationship *up* between a variable X and the sign DownArrow. Examples (b), (c) and (d) in Figure 5I illustrate the intuitive meaning of the sign pattern From-DownArrow: 'downloading X'. Thus, example (b) refers to downloading cloud content, (c) document content, and (d) audio content.

The inherent asymmetry of arrows in general, and arrow signs particularly, can be appreciated when considering the opposite spatial relation, when the sign DownArrow is "up" from another sign (Figure 5II). Then, the sign pattern DownArrow-Toward is used to mean that X is the destination of the downloading. Example icons (b) and (c) are intended to mean that the data being downloaded (whose type or origin is now elided) is to be stored in a destination such as a hard disk or an optical disk.

Evaluating Blends using Argumentation

As briefly described previously, the amalgam-based computation of concept blending amounts to combine different input spaces into a new space, called blend, by taking the commonalities of the inputs into account, by generalising some of their specifics and by projecting other elements. In the following, we describe how concept blending can account for modeling the creative process of a designer of computer icons.

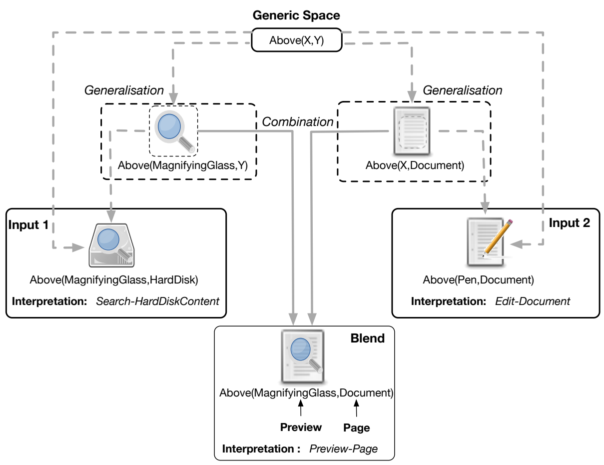


Figure 6: Generating an icon interpreted as *Preview-Page* through amalgam-based concept blending.

A design scenario

Assume a designer is looking for creating a new icon with the intended meaning of previewing a document or a page. The creation of such icon can be achieved by the following amalgam-based concept blending process (Figure 6). In addition to the Document and MagnifyingGlass signs, we assume we have available a HardDisk sign and a Pen sign which have already been used to make icons.

The input mental spaces. The input mental spaces of the designer are an icon of a hard-disk with a magnifying glass hovering above it, whose meaning is *Search-HardDiskContent*, and an icon of a document with a pen above it, whose meaning is *Edit-Document*.

The generic space. The sign pattern *Above*(X,Y) is used in both icons. The first icon contains the relation *Above*(MagnifyingGlass, HardDisk) between the MagnifyingGlass and the HardDisk, and the second contains the relation *Above* (Pen,Document) between the Pen and the Document.

Further generalisation. Two generalisation steps are needed: *Above*(MagnifyingGlass,HardDisk) $\rightarrow$ *Above(*MagnifyingGlass,Y*)*; correspondingly, *Above*(Pen,Document) $\rightarrow$ *Above*(X,Document).

Combination via variable substitution. We combine the schemas *Above*(MagnifyingGlass, Y) and *Above*(X, Document) via [X/MagnifyingGlass, Y/Document]. The icon of a page with a magnifying glass hovering above it is generated.

The intended meaning. The designer associates to the icon the intended meaning of *Preview-Page*, by selecting the interpretations (*Preview*, *Page*) for the MagnifyingGlass and Document signs.

In this case, the designer decided that the intended meaning of *Above*(MagnifyingGlass, Document) is *Preview-Page*, that is, a page can be examined without opening it. However, during the creative process, the designer could have generated other blends, not only by combining other signs, but also by selecting different interpretations associated to the MagnifyingGlass and Document signs. For instance, the icon in Figure 7 still represents a page with a magnifying glass hovering above it, but it has been given a different intended meaning.

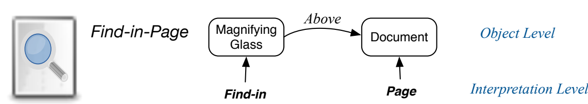


Figure 7: An example of interpreting the sign pattern of an icon as *Find-in-Page*.

The meaning of a blended icon cannot simply be considered right or wrong: interpretation depends on different points of view. Thus the evaluation of whether it is useful or valid for a specific purpose can be the object of a discussion.

Arguments about intended meanings

In the icon domain, arguments may include a clear interpretation of any constituent signs in the icon if it is a composition of signs, or a good fit with other icons in the icon set.

For example, we can consider a counter-argument, i.e. an argument that *attacks* the interpretation a_1 "magnifying glass above document means *Preview-Page*" in Figure 6, to be phrased as follows:

> a_2 : "However, the icon in Figure 6 can also be interpreted to mean *Find-in-Page*."

The rationale is that the MagnifyingGlass sign can often be understood as *finding* or *searching* for something. Thus, the icon can be also interpreted as *Find-in-Page* by associating the interpretation *find-in* instead of *preview* for the same sign MagnifyingGlass (Figure 7).

This attacking argument can be made at an abstract/conceptual level, for instance, by taking other possible blends of the Document and MagnifyingGlass signs related by the sign pattern *Above*(X,Y) into account. Or, alternatively, if there is an icon library that contains an icon that 'satisfies' the argument above, then this attacking argument can be supported by a specific counterexample. Any of these two forms of attack evaluates negatively the icon in Figure 6. Therefore, if there are several alternative designs for a new icon, this attacking argument diminishes the degree of optimality/adequacy of that design with respect to alternative designs.

The original interpretation can be defended, as usually done in computational argumentation models, by a new argument that attacks the attacking argument a_2. For instance, the designer may say:

> a_3 : "The icon in Figure 6 can only be interpreted differently if MagnifyingGlass is understood to mean *find-in* instead of *preview*. However, the other icons in

my library use MAGNIFYINGGLASS to mean *preview*, not *find-in*.”

Argumentation semantics can then be used, once a network of arguments is built, to determine the outcome. For instance whether argument a_1, the original interpretation, is defeated or not can be determined as follows (Figure 2): in this example a_3 has no attack, so it is undefeated, which means it defeats a_2; since a_2 is defeated, the attack against a_1 is invalid and a_1 is undefeated (i.e. is accepted).

Arguments about the intended meanings of an icon can be embedded in a dialogue modeled in terms of Lakatos’s moves and the dialogue pattern shown in Figure 3.

Lakatosian reasoning for blend evaluation

Here we present a Lakatos-style dialogue between two players, a proponent P and an opponent O. The goal of each player is to persuade the other player of a point of view, in this paper, the intended meaning of a new blended icon. In such a setting, we expect to see negotiations over the meaning of an icon take place between experts and novices, or between people designing icons and people using (interpreting) them, or various combinations.

To discuss a given icon using Lakatosian reasoning, we assume that an initial conjecture is about the interpretation of an icon usually being an *action-in-the-world* or a *concept*, together with an example of a particular icon and a particular interpretation. The conjecture could be constructed by inductive generalisation.

Example 1. In this example, Lakatosian reasoning is used for discussing the intended meaning of a new icon generated by concept blending:

P_1: “An icon with a magnifying glass over a page means *Preview-Page*” (Conjecture)

O_1: “I disagree, this icon (Figure 7) means *Find-in-page*.” (Counterexample)

P_2: “No, this is a different case because the magnifying glass must be over pages with text on them to magnify (it shows what we’re about to magnify).” (Monster-barring)

After this dialogue, it is agreed that the intended meaning of the icon is *Preview-Page* and the icon itself has been clarified. Alternatively, the proponent and the opponent could make a different evaluation by following different moves. For instance, if the proponent accepts the counterexample, then the intended meaning of the icon can be refined due to piecemeal exclusion:

P_1: “An icon with a magnifying glass over a page mean *Preview-Page*” (Conjecture)

O_1: “I disagree, this icon (Figure 7) means *Find-in-page*.” (Counterexample)

P_3: “Ok, only icons with a magnifying glass over a page with text mean *Preview-Page*”. (Piecemeal exclusion)

After this dialogue the intended meaning about the new icon has been changed by modifying the conjecture and taking the counterexample into account.

Sometimes players have different points of view due to the sign patterns they have used in their concept blending.

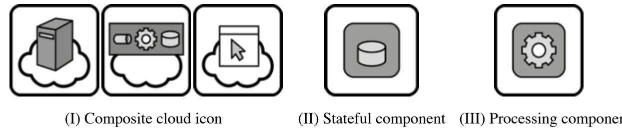


Figure 8: Interpreting the design of cloud icons[2]

Example 2. Let us imagine that the proponent has generated an intended meaning for an icon using the FROM-DOWNARROW sign pattern, whereas the opponent has used the DOWNARROW-TOWARD pattern (Figure 5 illustrates these cases). The two players can engage in the following dialogue:

P_1: “Look at icons in Figure 5I, icons with a DOWNARROW relate to content.” (Initial Conjecture)

O_1: “The icon in Figure 5IIb has a DOWNARROW but doesn’t relate to content.” (Counterexample)

O_2: “The icon in Figure 5IIc also has a DOWNARROW but doesn’t relate to content.” (Counterexample)

P_2: “The conjecture is right because the two examples actually do relate to content as they are to do with storage and content is part of storage.” (Monster-adjusting)

In this case, the proponent excludes the counterexamples using monster-adjusting, and reinterpreting them in a way that they are not counterexamples anymore.

A conjecture might even be at a higher level, for asserting that a particular metaphor is appropriate or inappropriate.

Example 3. For example, someone who is familiar with the ‘gear means adjust setting’ metaphor in one program may be comfortable with it in another program:

P_1: “ An icon containing the ‘gear’ sign is a good one for Settings, because it invokes the idea of a gear change on a bicycle” (Initial Conjecture)

O_1: “The ‘gear’ sign does not invoke the idea of a gear change on a bicycle *from my point of view*.” (Counterexample)

P_2: “Ok, you’re right, it does not invoke the idea of a gear change on a bicycle, but it is often used for Settings.” (Monster-adjusting)

Example 4. Argumentation may also consider the role a given abstract design plays within a given icon set.

P_1: “Even without knowing what the first or third icon in Figure 8I stands for, I can make a conjecture that it has to do with a server or a user interface accessed via the cloud. However, with the second icon, I’m not sure what it means. It is composed of various signs that I don’t understand. It’s probably badly designed.” (Conjecture)

O_1: “Did you notice that icons in Figure 8II and Figure 8III are both defined as part of the same icon set? They mean ‘Stateful component’ and ‘Processing component’ respectively. Therefore, the second icon is actually well designed, because it uses signs appearing in other icons of the same icon set.” (Counterexample)

[2]From `http://cloudcomputingpatterns.org`.

P_2: "But the second icon contains a pipe sign that is not used anywhere within the icon set, so I still don't know what the second icon means. If there were an icon with a pipe sign with a clear meaning, then I could understand the second icon better. " (Strategic withdrawal)

The main characteristic of employing Lakatosian reasoning is that it allows a dynamic and social development of the intended meaning of blended icons. This cannot be achieved by using only abstract argumentation frameworks, since they assume that the object of discussion does not evolve. Therefore, having an argumentation process of this kind has several advantages: it promotes not only open-discussions around the meaning of an icon, but also the construction of a discourse about how an intended meaning is obtained.

This is a desirable characteristic in computational creativity when evaluating creative outcomes such as concept blends. In this way, the evaluation evolves into a refinement process of an initial created concept, giving much more flexibility at the moment of deciding whether a blend is suitable.

Discussion

We have illustrated the use of argumentation to evaluate completed blends. We alluded earlier to the role argumentation can play in the *generation* of blends, for instance by suggesting different ways to generalise the input spaces. Indeed, successive statements may serve to carry out the steps in the blending process iteratively, relaxing or refining as needed. These steps can be modelled using Lakatos's moves. From a conjectural candidate solution, to additional criteria that reveal this blend to be a 'monster' (i.e. which identify features of the candidate solution that cannot be allowed in the final solution for one reason or another), to adjustments that yield a more complete description of the problem and point the way toward a more satisfactory solution. An example of using argumentation for deciding which generalisations to use for creating a new icon is the following:

A: "We can create a different blend icon starting from the same icons of before." (see Figure 6)

B: "We could use the HARDDISK sign from the first icon and the DOCUMENT sign from the second icon."

A: "But putting the DOCUMENT sign above the HARDDISK does not make sense from my point of view."

B: "You're right, let's use the HARDDISK sign from the first icon and the PEN sign from the second icon."

A: "Sounds good, now we have a *Write-HardDisk* icon."

From this discussion and the previous sections, we think that it is feasible to bring the framework of argumentation inside the concept blending process. Moreover, this appears to work in a symmetric direction: the steps in an argumentation process can be carried out through blending. For instance, concept blending could be seen as the process behind the creation of rational arguments (Coulson and Pascual, 2006).

One area closely akin to the icon domain is the domain of *sentences* in a natural or artificial language. These can be evaluated for their coherence, succinctness, and fitness-to-purpose from a semantic standpoint (including relationship to other sentences), among other criteria; cf. (Abramsky and Sadrzadeh, 2014) for a category-theoretic view.

Since people have different standards for evaluation, they frequently disagree about what constitutes a satisfactory result, be it a final outcome or a design decision that is only a step the way to developing an artefact. They may also disagree at a more fundamental level about what can be considered a valid point of view or an appropriate manner of conducting an argument. For example, "Godwin's law" states that an online discussion ends when someone compares one of the discussants to Hitler and whoever made the comparison automatically loses the debate. Naturally, the validity of this principle is itself debatable. During the course of argumentation, the goalposts may shift, as new information is revealed about the domain under discussion, and about the discussants themselves. The relationship between argumentation and decision-making has been explored (Ouerdane, 2009), including the case of updating models of preferences (Ouerdane et al., 2014); the latter is quite similar to our previous work on Lakatos's games (Pease et al., 2014).

Conclusion and Future Work

Computational models of combinatorial creativity faces the daunting issue of evaluating a large number of possible novel combinations. Particularly, Fauconnier and Turner (1998) propose a model that includes a collection of optimality principles to guide the construction of a 'well-formed integration network'. Our computational model, based on generalisations of input spaces and amalgams, makes this combinatorial nature more explicit. The heuristic criteria called 'optimality principles' are too underspecified to be used as computational measures to evaluate and select possible blends. Moreover, alternative numeric measures may be not enough to evaluate the quality or novelty of creative artefacts. Our intuition is that in the context of creative outcomes, people use argumentation to understand, criticise, modify and evaluate them, and that computational argumentation is a useful tool for computational creativity.

The domain of computer icons generated by blending, where the evaluation of new icons is focused on their intended meaning, shows that symbolic argumentation is a process that is adequate to distinguish well-formed icons from mix-and-match combinations, unambiguous and clear icons from ambiguous or incomprehensible icons. This domain supports our claim that numeric heuristic evaluation measures are insufficient to recognise good blends, and shows the usefulness of an argumentation-based process for identifying good blends, detecting their critical problems, and refining them in an evolving, open-ended process.

We have shown how Lakatosian reasoning can be used in evaluating concept blending for icon design. Our approach offers two main advantages. Firstly, the evaluation process can *improve* the blend, since the dialogue about it refines resulting blends. Secondly, the *reasons behind* a particular evaluation are made explicit. This is crucial given recent work on the importance of context in creativity judgments (Charnley, Pease, and Colton, 2012; Colton, Pease, and Charnley, 2011). Argumentation offers a framing story that shows how and why a particular artefact was constructed, which can be presented alongside the artefact itself.

We envision several future works. First, we intend to specify an ontology for modelling the semiotic system presented and to build a library of icons. Having a domain knowledge will allow us to generate arguments by induction, for instance, by analysing icons cases. Moreover, it will also open the possibility to explore the use of value-based argumentation (Bench-Capon, Doutre, and Dunne, 2002) for selecting the input icons to be used in the concept blending process. This latter point is important, since usually the inputs of a blending process are assumed to be already provided. Second, as far as the interpretation of icons is concerned, we are thinking to take advantage of existing approaches to natural language processing and understanding, especially Construction Grammars (CxG). In CxG, the grammatical construction is a pairing of form and content. In our semiotic system, sign patterns seem equivalent to the form, while interpretations would be akin to the content. Working with a grammar would make evaluation more explicit, e.g. we could use quantitative measures of ambiguity; and this would open many other domains for application.

Finally, we plan to implement Lakatosian reasoning by employing existing computational tools for argumentation (Devereux and Reed, 2010; Wells and Reed, 2012). Our goal is to provide a computational argumentation framework and to integrate it into the framework for computational creativity we are developing in the COINVENT project.

Acknowledgements

This work is partially supported by the COINVENT project (FET-Open grant number: 611553).

References

Abramsky, S., and Sadrzadeh, M. 2014. Semantic unification – A sheaf theoretic approach to natural language. In *Categories and Types in Logic, Language, and Physics*, volume 8222 of *LNCS*, 1–13. Springer.

Bench-Capon, T. J. M., and Dunne, P. E. 2007. Argumentation in artificial intelligence. *Artificial Intelligence* 171(10-15):619–641.

Bench-Capon, T. J. M.; Doutre, S.; and Dunne, P. E. 2002. Value-based argumentation frameworks. In *Artificial Intelligence*, 444–453.

Boden, M. A. 2003. *The Creative Mind - Myths and Mechanisms (2nd ed.)*. Routledge.

Bou, F.; Eppe, M.; Plaza, E.; and Schorlemmer, M. 2014. D2.1: Reasoning with Amalgams. Technical report, COINVENT Project. http://www.coinvent-project.eu/fileadmin/publications/D2.1.pdf.

Chandler, D. 2004. *Semiotics: The Basics*. Routledge.

Charnley, J.; Pease, A.; and Colton, S. 2012. On the notion of framing in computational creativiy. In *Proc. of the 3rd Int. Conf. on Computational Creativity*, 77–81.

Colton, S.; Pease, A.; and Charnley, J. 2011. Computational creativity theory: The FACE and IDEA descriptive models. In *2nd Int. Conf. on Computational Creativity*.

Coulson, S., and Pascual, E. 2006. For the sake of argument: Mourning the unborn and reviving the dead through conceptual blending. *Ann. Rev. of Cognitive Linguistics* 4:153–181.

Devereux, J., and Reed, C. 2010. Strategic argumentation in rigorous persuasion dialogue. In *ArgMAS*, volume 6057 of *LNCS*. Springer Berlin Heidelberg. 94–113.

Dung, P. M. 1995. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. *Artificial Intelligence* 77(2):321 – 357.

Falomir, Z.; Cabedo, L. M.; Abril, L. G.; Escrig, M. T.; and Ortega, J. A. 2012. A model for the qualitative description of images based on visual and spatial features. *Computer Vision and Image Understanding* 116(6):698–714.

Fauconnier, G., and Turner, M. 1998. Principles of conceptual integration. In Koenig, J. P., ed., *Discourse and Cognition: Bridging the Gap*. Center for the Study of Language and Information. 269–283.

Lakatos, I. 1976. *Proofs and refutations: the logic of mathematical discovery*. Cambridge University Press.

Ontañón, S., and Plaza, E. 2010. Amalgams: A formal approach for combining multiple case solutions. In *Proc. of the Int. Conf. on Case Base Reasoning*, volume 6176 of *LNCS*, 257–271. Springer.

Ouerdane, W.; Labreuche, C.; Maudet, N.; and Parsons, S. 2014. A dialogue game for recommendation with adaptive preference models. Technical report, Ecole Centrale Paris. Cahiers de recherche 2014-02.

Ouerdane, W. 2009. *Multiple Criteria Decision Aiding: a Dialectical Perspective*. Ph.D. Dissertation, University Paris-Dauphine, Paris, France.

Pease, A.; Budzynska, K.; Lawrence, J.; and Reed, C. 2014. Lakatos Games for Mathematical Argument. In *Proc. of COMMA*, volume 266 of *Frontiers in Artificial Intelligence and Applications*, 59–66. IOS Press.

Prakken, H. 2005. Coherence and flexibility in dialogue games for argumentation. *J. Log. and Comput.* 15(6):1009–1040.

Rahwan, I., and Simari, G. R. 2009. *Argumentation in Artificial Intelligence*. Springer Publishing Company.

Schorlemmer, M.; Smaill, A.; Kühnberger, K.-U.; Kutz, O.; Colton, S.; Cambouropoulos, E.; and Pease, A. 2014. Coinvent: Towards a computational concept invention theory. In *5th Int. Conf. on Computational Creativity*.

Walton, D., and Krabbe, E. C. W. 1995. *Commitment in Dialogue: Basic Concepts of Interpersonal Reasoning*. State University of New York Press.

Wells, S., and Reed, C. 2012. A domain specific language for describing diverse systems of dialogue. *Journal of Applied Logic* 10(4):309 – 329.