What's Cracking?

How image schema combinations can model conceptualisations of events

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Abstract. Image schema profiles are described as clusters of spatiotemporal relationships learned from embodied experiences and function as the gathered conceptual information for event concepts. Looking at such profiles allows not only to model aspects of human conceptualisation but also offers a method to approach event conceptualisation for more formal purposes. This article investigates this research program by looking closer at how humans conceptualise events and specifies three combination methods of image schema profiles that each offer different aspects for concept construction. As a proof of concept, we present an in-depth analysis of the classic commonsense reasoning problem of 'Cracking an Egg' as a demonstration of how these profiles can be used in formal knowledge representation. This is formalised using the Image Schema Logic, ISL^M, a combined logic targeted at the spatiotemporal relationships present in image schemas.

Keywords. image schemas, events, knowledge representation, event segmentation

1. Introduction

Capturing the nature of events and the dynamic transformations they bring about in the world, is a difficult problem to formally model. However, where formal knowledge representation struggles, human cognition is a master. Based on experiences, humans have an understanding of *'what's cracking'* (i.e.,'what's happening', 'what's going on'), even in ongoing and future events with uncertain development and outcome. When there is a mismatch in our conceptualisation of the event we are faced with, we can easily modify this understanding to fit the new situation. When presented with a familiar scenario, e.g., *going to the supermarket* or *borrowing a book at the library*, we have a mental generalisation based on all previous experiences (explicit and implicit) with that particular scenario, and have a mental space of that concept that we use to verbalise our thoughts when conversing with other people. In the more generic, often-experienced situations human conceptualisation can be argued to be greatly overlapping. For instance, despite cultural

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differences, it is likely that all humans share the same, or an indistinguishable, conceptualisation of the concepts of *being hungry* and *going to sleep*. However, for events such as *going to war* or *preparing Turducken,*[2] events most of us never experience first hand, the conceptualisation may differ greatly.

This flexibility in representing and updating information is not as straightforward for formal knowledge representation. Classic commonsense reasoning problems such as *Cracking an Egg* [19] often require long and complex axiomatisations that offer little in terms of dynamic alterations (e.g. [24, 19]). In contrast, most human adults have a fair amount of experience with eggs and 'cracking them' and, therefore, have extensive knowledge of both *how* an egg breaks, as well as *what* happens when it does. In this paper, we look at human cognition as an inspiration to approach this problem for knowledge representation. We argue that the conceptualisation of such experiences can be broken down into a common structure using conceptual building blocks, the *image schemas* [17, 14], based on findings from embodied cognition [28]. To better model the complexity of events we look to *image schema profiles* [25] as a means to represent the different combinations image schemas can have and introduce three different characters by which these profiles seem to exist. These *Image Schema Combinations* are then structured and formalised using the Image Schema Logic, ISL^M, a multi-dimensional logic devoted to the spatiotemporal relationships present in image schemas. Finally, we return to the classic commonsense reasoning problem 'Cracking an Egg' as a proof of concept.

2. Foundation and Motivation

Deep learning techniques have greatly advanced perceptual and categorical aspects of Artificial Intelligence [27]. However, when it comes to conceptual processes such as understanding and generating concepts and event structures, the advancement does not display the same success. It appears as though the meaning of certain notions cannot be attained through pure *korvstoppning.*[3] Instead, conceptual meaning appears to be associated with uses and purposes of objects and events rather than their perceptible attributes and patterns [22]. For instance, while a *cup* might be visually identified by the combination of a hollow cylinder with a handle, it is the affordance to contain liquid that makes it a cup. Likewise, an event like *going to the library* can be cored down to 'person_walking_towards_library-building' as well as core *participants* therein (i.e., Person, Library, Road). But at the same time, we associate a library and going there with a full range of additional conceptual information such as 'lending/renting,' 'book collection,' 'knowledge,' 'public place,' etc. Information that in itself is not perceptual but based on particular experience through the affordances the concept realises.

One area of cognitive science aiming to explain the relationship between perception and conceptualisation is *embodied cognition* [28].[4] The theory suggests that conceptual meaning is a direct reflection of the generalised information from repeated sensorimotor

[2] A dish prepared through the iterative stuffing of a chicken into a duck, and the duck into a turkey.

[3] Korvstoppning is a Swedish idiom roughly translating to *'sausage cramming.'* It captures the notion of overfeeding a person with information without allowing for any real understanding to take place.

[4] Note that embodied cognition is a family of theories with similar theses. As this paper does not care for the exact replication of human cognition, we ignore the subtle differences among these theories in favour of the general theoretical framework.

experiences. While this theory has a fair amount of support from different directions (e.g., [4, 21]), it does not in itself provide a concrete description for *how* or *where* the conceptual information is stored. Instead, what it does provide is a framework in which conceptual processes can be viewed as a reflection of perceptual ones. When looking at the repeated perception of particular events, humans learn early how to distinguish different events from one another, as well as to 'break apart' conceptual parts from the events that are more or less irrelevant for the purposes of that particular event type. In the next section, we investigate some early stages of how humans identify events in an endless flow of perceptive information.

2.1. Event Perception and Segmentation

Objects can be distinguished by how they can be separated from other objects in their surroundings. Gestalt laws often dictate how objects relate to one another and which perceptive stimuli belong to which particular objects. Simultaneously the theory of *recognition-by-parts* suggests that objects are 'mentally broken down' into geometric shapes as a means of identification and categorisation [2]. In comparison, a common view of events is that they are fourth-dimensional entities [18]. While this view is too rigid to elegantly handle formal representation of the transformations in ongoing or future events, it does provide a starting point to investigate human event conceptualisation and its formal correspondence. One important distinction when drawing parallels between object and event perception is that, unlike for objects, there are no 'borders' in the passing of time. One event often floats seamlessly into another without pauses, beginnings or ends. They can and are often overlapping and it is unclear which parts are events in themselves or simply parts of other events. Additionally, as discussed in [8], different 'parts' of an event seem to have different degrees of significance. For instance, in the event *the death of Caesar*, Caesar's participation seems to be conceptually much more important than the daggers' participation.

Research on event individuation demonstrates that initially the events are distinguished by their end-states [31], i.e., *Caesar being dead* in the example above. However, as cognitive maturity develops a more fine-grained understanding of the individual parts and processes of particular events are learned. [1] demonstrates that infants presented with an 'event break' appear to have difficulty to perceive the full scenario as one event, regardless of the end state. [6] performed experiments investigating event and action individualisation abilities in toddlers only to discover that children are early capable of separating actions within events from the event as a whole. [29] performed experiments providing support for the notion that not only objects (and actions) are segmented but also the paths that objects move along go through the same kind of segmentation process. Another classic study made with three-months-olds showed that infants are at that age already able to make predictions and anticipate events based on their particular structure [9].

These results show a small section of the research demonstrating that the human mind has an ability to take perceptions and, based on certain cognitive principles grounded in spatiotemporality, identify when a new 'event' takes place [16]. This ability emerges already at an early stage as children learn to distinguish between different events and to make 'conceptual cuts' in the stream of perception. Arguably, infants learn to conceptually divide perceptual experiences. These 'event pieces', be either temporal, spatial or material, can then, in different combinations represent increasingly complex and large-scale events.

Research in cognitive linguistics also demonstrate these tendencies as there exists a range of different theories to explain how information is broken into smaller conceptual structures (e.g., Semantic Primes [32]). One promising theory that gathers research on embodied cognition, cognitive linguistics and developmental psychology is the theory of image schemas [14, 17]. As these conceptual building blocks are central to the present hypothesis they will be thoroughly presented below.

3. Image Schemas

Image schemas represent the abstract generalisations learned from the sensorimotor processes [17, 14]. They are conceptual gestalts, meaning that each part is essential for the whole meaning of the image schema,[5] and most often they are described as capturing sensorimotor relationships and their transformations. LINK[6], CONTAINMENT and CENTER_PERIPHERY are examples of static image schemas but transformations such as LINKED_PATH, Going IN and REVOLVING_MOVEMENT are also image schematic. The idea with image schemas is that they provide a bridge between perceptive experiences and conceptual expressions found in natural language. For instance, *time* is often described using spatial PATHs ("time moves on") and *love* is often conceptualised as CONTAINER ("falling in love").

In regards to object and event conceptualisations, image schemas are thought to be structured into *image schema profiles* defined as groupings of image schemas that capture the spatiotemporal relationships related to particular events [25]. Below, this phenomenon is further introduced.

3.1. Image Schema Profiles

[25] describes how *Image Schema Profiles* are a collection of image schemas that together describe the conceptualisation of particular events and concepts. For instance, in [7] the authors provide a plethora of image schema profiles for the word *stand* based on different linguistic contexts. Image schema profiles work in the following manner: if I am to describe the image schema profile of the event *going to the supermarket*, I might describe it using a collection of: SOURCE_PATH_GOAL—as I am going to the supermarket; CONTAINMENT—as myself and the groceries are inside the building, PART_WHOLE and COLLECTION—as there are plenty of pieces in the supermarket and I collect them, TRANSFER—as I am obtaining objects from the supermarket to my own 'person;' etc. Likewise, although I never cooked *Turducken*, I can conceptualise the process of preparing the dish through an image schema profile largely consisting of: going IN—as the chicken goes into the duck, and the duck goes into the turkey; CONTAINMENT—as the animals remain inside 'each other;' ITERATION—as this process is repeated three times; and SCALE—as the chicken, the duck, and the turkey are treated in their respective sizes. Naturally, an expert chef frequently preparing the dish might understand that there is more at work.

[5]For instance, consider a container without an inside.

[6]Following convention, image schemas are written using uppercase letters.

Image schema profiles are one way in which the conceptualisation of particular scenarios and events can take place. However, note that image schema profiles are not hierarchal or temporally structured like Schankian scripts. Rather, image schema profiles are collections without explicit internal structure or order. While this is the cognitive reality of the profiles, with the intention to use the profiles for formal knowledge representation, it is beneficial to internally organise the image schemas in a more structured manner. In the next section, we introduce three ways image schemas can be combined.

3.2. Image Schema Combinations

Image schemas can be combined with one another in many different ways. To illustrate this we back-trace from a few concepts and real-world events into their image-schematic construction. One of the most common ways to conceptualise the passing of time is to make an analogy to the spatial dimension in a 2D world, basically a 'path.' For instance, *marriage* is often perceived as two people walking together through life [22]. Basically embodying the combination of the image schemas SOURCE_PATH_GOAL and LINK. In a (traditional) marriage what happens to one of the parties, arguably also affects the other. This means that the gestalt properties of the image schemas are **merged** into LINKED_PATH, an image schema in its own right. In another scenario, with the concept of *transportation*, the conceptualisation is treated more as a **collection** of image schemas, in this case, SOURCE_PATH_GOAL and SUPPORT (or CONTAINMENT) [15]. This is particularly interesting because, like how a cup is 'defined' by the affordance of CONTAINMENT, it illustrates how image schemas also become part of the definition of more abstract concepts.

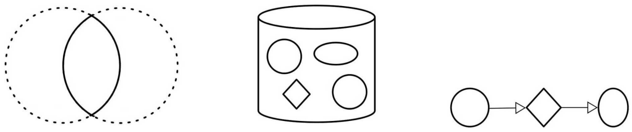
Another metaphorical example is the idiom *to hit the wall*. In many contexts, this does not mean to physically crash into a wall but instead implies some form of mental or physical breakdown. The idiom captures the image schema of BLOCKAGE. It is clear that BLOCKAGE is not an atomic image schema but rather a **sequential** combination of several ones (see [12] for an in-depth analysis). Breaking it down, there are at least two OBJECTs, a SOURCE_PATH_GOAL, and at least one time-point when the two objects are in CONTACT. Translating it to a natural language expression: The OBJECTs represent the person and the abstract time point and/or scenario with which the person 'crashed,' so to speak, and this moment captures an abstract version of the image schema CONTACT.

As demonstrated, this kind of image-schematic breakdown can be done not only on concrete scenarios but also on many abstract natural language expressions. The mentioned examples lead to primarily three different ways in which image schemas can be combined (see Fig. 1):

Merge: Occurs when two image schemas are combined in such a way that the Gestalt laws are altered.[7]

Collection: A collection of image schemas do not, *per se*, alter the Gestalt properties of a particular spatiotemporal relationship, but instead functions as a joint representation for a particular concept. This is the most classic form of image schema profiles.

[7] In [13, 12] the authors suggest that image schemas can be structured as interlinked families of theories. The image schema combinations falling under *Merge* would occur where different image-schematic families intersect.



(a) Merging (b) Collection (c) Sequence

Figure 1. The three different ways image schemas can be combined.

Sequence: This represents the image-schematic conceptualisations that behave much like *collection*, only with the addition of a sequential 'cause-and-effect' dimension. In many cases, this takes a linear form but there are situations with branching routes or circular patterns.

3.3. Formal Representation Using ISL^M*: The Image Schema Logic*

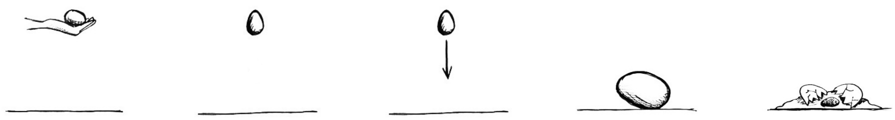
While image schemas are cognitive patterns without any concrete formal correspondence, there exist attempts to capture them formally (e.g., [15, 5]). In [12], an approach towards an expressive logical language devoted to image schemas, ISL^M, was introduced.[8] Simplified, ISL^M is an expressive language building on the Region Connection Calculus (RCC) [26], Ligozat's Cardinal Directions (CD) [20], Qualitative Trajectory Calculus (QTC) [30], with 3D Euclidean space assumed for the spatial domain, and Linear Temporal Logic over the reals (RTL). The work on formalising the individual image schemas and their dynamic transformations in this logic has been initiated, for instance, in [11]. Due to page limitation, we refrain from further elaboration of the logic and for a more detailed account, we refer instead to previous publications.

Formalising the image schemas using the ISL^M language makes it possible to represent the individual image schemas and by taking their spatial, and temporal, primitives (such as PATH, OBJECT, OUTSIDE and INSIDE [23]) into account similar image schemas can be grouped together into 'families' represented as graphs of theories with increasing complexity [13]. The latter provides a means to investigate the merged combinations of image schemas by looking at the intersection of two different image schema families (ie. 'Going IN' would lie at the intersection of SOURCE_PATH_GOAL and CONTAINMENT). The collection of formalised image schemas and their spatial components can be seen as a repository of cognitively-based *ontology design patterns* [3] that can be used when building conceptualisations of concepts and events. In the next section, we illustrate this phenomenon by generating image schema profiles for Egg-Cracking.

4. Studies in Egg-Cracking with Image Schema Combinations

In the introduction one of the prototypical knowledge representation problems 'cracking an egg' was introduced as an event that is conceptually rather simple but highly complex to formally model. Following the reasoning in this paper, it is possible to utilize image schema profiles, or their more structured versions image schema combinations, as a way to represent conceptual information. Below we look at two different scenarios.

[8] In [10], this language was further developed under the name ISL^{FOL} by the addition of a First-Order concept language.



(a) Scene 1: The egg is supported by a hand.

(b) Scene 2: The egg is no longer supported, i.e. dropped.

(c) Scene 3: The egg falls to the ground.

(d) Scene 4: The egg hits the ground.

(e) Scene 5: The egg breaks.

Figure 2. Event Segmentation of Dropping an Egg.

4.1. Dropping an Egg

Infants do not have enough experience with the object 'egg' to immediately understand that if you drop it, it falls and as it hits the ground it (usually) breaks. This we learn as we get more and more experience in the kitchen, or at chicken farms. While all temporally dependent scenarios happen in more or less a sequence without defined borders, based on the findings presented in Section 2.1, the event can be divided into conceptually distinct steps (see Fig. 2). One important hypothesis is that for each step a conceptually different scene of undefined temporal length takes place. This translates into there being an image-schematic alteration or transformation at work. The scenario can be described with a *sequential* image schema combination based on the following scenes:

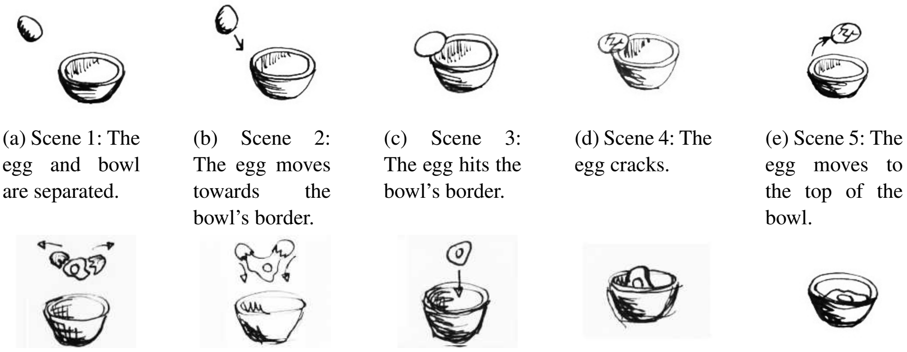
1. The egg is SUPPORTed by a hand.[9]
2. The egg is no longer SUPPORTed. Note that in most natural cases there is still CONTACT between the hand and the egg at this stage. In a human conceptualisation, it is likely that this event takes place more or less simultaneously as the consecutive scene in which ...
3. ...the egg falls from the SOURCE: hand, to the GOAL, where *Falling* is a **merge** between SOURCE_PATH_GOAL and VERTICALITY as the gestalt properties of each image schema rely on one another.
4. The egg is BLOCKED by the ground, stopping its SOURCE_PATH_GOAL.
5. The final scene is an image-schematic transformation of SPLITTING. In which the WHOLE(egg) → PARTs(egg),[10] and the egg remains SUPPORTed by the ground.[11]

Following the idea behind the ISL^M language, each image schema can be formalised as a design pattern that can be referenced in different situations. In [10] a large selection of these image schema patterns can be found. Due to page limitation we limit our formalisation to capture the overlaying patterns and only report on a few of them (see

[9]Here it is possible to substitute SUPPORT for CONTAINMENT if the egg is 'grabbed'. This would alter the properties of the agent's involvement in the 'drop'.

[10]In ISL^M DC means DisConnected (based on RCC8) and **U**, is taken from LTL and denotes 'Until'. Thus, the image schema SPLITTING can be formalised in the following manner:
$\forall X, x_1, x_2 : Object\ \big(\textsc{Splitting}(x) \rightarrow \textsc{Whole}(X) \wedge Part(x_1, X) \wedge Part(x_2, X)\ \mathbf{U} \neg \textsc{Whole}(X) \wedge\ DC(x_1, x_2)\big)$

[11]Note that this is due to the BLOCKAGE relation from the previous scene, only now, the force is removed - resulting in the SUPPORT (see [12] for details on their respective formalisations).



(a) Scene 1: The egg and bowl are separated.

(b) Scene 2: The egg moves towards the bowl's border.

(c) Scene 3: The egg hits the bowl's border.

(d) Scene 4: The egg cracks.

(e) Scene 5: The egg moves to the top of the bowl.

(f) Scene 6: The egg separates into parts.

(g) Scene 7: The egg′ leaves the shell and falls.

(h) Scene 8: The egg′ falls.

(i) Scene 9: The egg′ enters the bowl.

(j) Scene 10: The egg′ is inside the bowl.

Figure 3. Event Segmentation of Cracking an Egg into a Bowl.

Footnote[12]). In ISL^M the entire event could be formalised as follows:

$$\begin{aligned}\forall Egg{:}Object, \forall Hand, Ground{:}Region\ \big(Dropping\_an\_egg \rightarrow \\ \textsc{Support}(Hand, Egg) \\ \mathbf{U}\ (\neg\textsc{Support}(Hand, Egg) \land \textsc{Contact}(Hand, Egg)) \\ \mathbf{U}\ (\text{On\_}\textsc{Path}\text{\_Toward}(Egg, Ground)) \land \neg\textsc{Contact}(Hand, Egg)) \\ \mathbf{U}\ (\textsc{Blocked}(Egg, Ground) \land \neg\text{On\_}\textsc{Path}\text{\_Toward}(Egg, Ground)) \\ \mathbf{U}\ (\textsc{Splitting}(Egg) \land \textsc{Support}(Ground, Egg))\big)\end{aligned}$$

4.2. Cracking an Egg into a Bowl

In most scenarios where there is an intention to crack the egg, this is done by gathering the contents in a bowl. We argue here that such an event can be divided into ten conceptually distinct spatiotemporal scenes (depicted in Fig. 3):

1. Scene one presupposes two OBJECTs: an egg and a bowl. The bowl is a CONTAINER and represents the egg's GOAL location. Additionally, the egg needs to be described as a WHOLE with two PARTs: the shell (CONTAINER) and an egg′[13] (CONTAINed). This is a conceptual **merge** between CONTAINMENT and PART_WHOLE.[14]

[12] $\forall O_1, O_2{:}Object\ (\textsc{Contact}(O_1, O_2) \leftrightarrow \neg DC(O_1, O_2))$
$\forall O_1, O_2{:}Object\ (\textsc{Support}(O_1, O_2) \leftrightarrow EC(O_1, O_2) \land Above(O_1, O_2) \land Forces(O_1, O_2))$
$\forall O_1, O_2{:}Object\ \big(\text{On\_}\textsc{Path}\text{\_Toward}(O_1, O_2) \leftrightarrow (O_1 \rightsquigarrow O_2 \land \mathsf{outside\_of}(O_1, O_2))\big)$

[13] While in natural language both the whole egg and its content is referred to as an egg, we need to formally distinguished them. Thus, we refer to the whole egg as *egg* and the content as *egg′*.

[14] For eggs, it is rather straightforward that the part that we use is on the inside of the shell, however, consider an apple or other items in which the 'border' is (most often) used as well. In these cases it not appropriate to speak of a merge between CONTAINMENT and PART_WHOLE in the same sense.

2. Scene two has all the same properties as scene one, with the addition of SOURCE_PATH_GOAL as the egg is moving from its original position towards the edge of the bowl.
3. As the egg hits the border of the bowl, the movement is BLOCKED. This means that instead of the previous SOURCE_PATH_GOAL image schema, the image-schematic relationship is that of BLOCKAGE. As the egg hits the edge of the bowl, it is intended to crack. However, conceptually this is a different event component that may or may not take place, dependent on how hard the impact between the bowl and the egg was. Then ...
4. ... the egg cracks: breaking from a WHOLE into PARTs: the shell and the egg′. This is an image-schematic transformation of PART_WHOLE. While this event may be perceived to happen simultaneously as the third scene, it is conceptually different as the properties of the egg suddenly are altered. Likewise, if not enough force has been applied there is no guarantee that the egg cracks or if too much force has been applied the egg′ pours out all over the bowl's edge (considerations on *force* is addressed in Section 4.3).
5. Still CONTAINed in the cracked shell, the egg′ moves towards the bowl's opening. A scene that functions as a **collection** (as neither is dependent on the other) and captures both CONTAINMENT and SOURCE_PATH_GOAL.
6. Removing the CONTAINMENT schema of the egg, by SPLITTING the shell from the egg′ through the existence of their PART_WHOLE relationship.
7. As a **merge**, the egg′ goes OUT from the shell and begin to fall towards the bowl's INSIDE.
8. The egg′ continues to fall towards the bowl's inside.
9. Still moving, the egg′ falls into the bowl: the **merge** between going IN and the pre-existing **merge** of falling based on SOURCE_PATH_GOAL and VERTICALITY.
10. Finally, the scenario ends with static CONTAINMENT in which the egg′ rests inside the bowl.

Formalised it reads:

$$
\begin{aligned}
&\forall Egg, Bowl, Egg'{:}Object, \forall Hand, Bowl, Bowl^{op}, Shell{:}Region \; \big(cracking\_an\_egg \rightarrow \\
&\quad (\text{Contained\_Inside}(Hand, Egg) \wedge \text{WHOLE}(Egg) \wedge \text{PART}(Shell, Egg) \wedge \\
&\quad \text{PART}(Egg', Egg) \wedge \text{Contained\_Inside}(Egg', Shell)) \\
&\quad \mathbf{U}\ (\text{Contained\_Inside}(Hand, Egg)) \wedge \text{On\_PATH\_Toward}(Egg, Bowl) \\
&\quad \mathbf{U}\ (\text{Contained\_Inside}(Hand, Egg) \wedge \text{BLOCKAGE}(Egg, Bowl)) \\
&\quad \mathbf{U}\ (\text{Contained\_Inside}(Hand, Egg) \wedge \neg\text{WHOLE}(Egg)) \\
&\quad \mathbf{U}\ (\text{Contained\_Inside}(Hand, Egg) \wedge \text{On\_PATH\_Toward}(Egg, Bowl^{op})) \\
&\quad \mathbf{U}\ (\text{SPLITTING}(Egg)) \\
&\quad \mathbf{U}\ (going\_\text{OUT}(Shell, Egg') \wedge \text{On\_PATH\_Toward}(Egg', Bowl)) \\
&\quad \mathbf{U}\ (\text{On\_PATH\_Toward}(Egg', Bowl)) \\
&\quad \mathbf{U}\ (\text{On\_PATH\_Toward}(Egg', Bowl)) \wedge going\_\text{IN}(Egg', Bowl)) \\
&\quad \mathbf{U}\ (\text{Contained\_Inside}(Egg', Bowl)\big)
\end{aligned}
$$

4.3. The Problem of Force in Egg-Cracking

One of the limitations of the egg-cracking scenarios presented above is that they both represent the ideal "successful" scenario. In a natural scenario, for an egg falling to the ground, little can go 'wrong' with the exception that the egg might not actually break. This could be the result of an unusually hard shell, a 'soft landing' on a carpet or that it has been dropped at a distance too short for the accumulated force from gravity to break the egg. All of this comes down to one physical component *force*. Image schemas have a lot of force relations built into them. For instance, SUPPORT relies on the notion that enough force keeps the object in place, and BLOCKAGE captures the counterforce equivalent (or stronger) present in the movement. In [23], the authors describe the concept of force as a conceptual add-on to image schemas. When modelling any scenario, propositional add-ons such as the hardness of the shell or the ground, the height of the drop or the force by which the egg hits the bowl can be attached to the individual scenario to provide a more detailed account of the scenario. This way, the image schemas construct the skeletal information and details, perceptive descriptions and characteristics can be added to flesh out the event conceptualisation for a richer description.

5. Discussion and Conclusion

This paper illustrates how image schema profiles can represent the conceptualisation of particular events, more concretely for the scenario of egg-cracking. It is supported by findings of event segmentation and from cognitive linguistics that illustrate how clusters of image schemas can capture the conceptualisation in particular linguistic contexts. In terms of scientific contribution, the paper introduces three different characters by which image schemas can be combined: merge, collection and sequence. While these forms of combinations capture some of the most apparent combinations of image schemas, they are by no means intended to be exhaustive. Other combinations, or even combinations of these combinations, are possible to exist that was not considered for the purposes of this paper. These profiles were then formalised using ISL^M, a logical language especially developed to deal with the spatiotemporal dimensions of image schemas.

As the focus of this paper was not to introduce the logical language nor to present the audience with a repository of formalised image schemas, both of these aspects were mentioned only in passing through references to previous literature and footnotes. In a future paper, we intend to further explore on how image schema, image schema profiles and their combinations formalised using ISL^M can serve as cognitively-inspired *Ontology Design Patterns* [3] for the representation of events. However, in order to do that, a more complete repository is required. At the moment, formalisations of the image schemas are largely limited to the families SOURCE_PATH_GOAL, CONTAINMENT and the static 'two-object' relationships (CONTACT, SUPPORT and LINK) [10]. Naturally, for a more complete representation of image schema profiles and the conceptualisation of events, more image-schematic patterns are required.

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