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# That went over my head: Constraints on the visual vocabulary of comics

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## Abstract

“Upfixes” are graphic representations originating in the visual vocabulary used in comics where objects float above a character’s head, such as lightbulbs to mean inspiration. We posited that these graphic signs use an abstract schema stored in memory. This schema constrains upfixes to their position above the head and requires them to “agree” with the expression of their associated face. We asked participants to rate and interpret upfix-face pairs where the upfix was either above the head or beside the head, and/or agreed or disagreed with the face. Our stimuli also contrasted conventional and novel upfixes. Overall, both position and agreement impacted the rating and interpretations of both conventional and unconventional upfixes, and such understanding is modulated by experience reading comics. These findings support that these graphic signs extend beyond memorized individual items, and use a learned abstract schema stored in long-term memory, governed by particular constraints.

**Keywords:** visual language; visual morphology; visual metaphor; emotion; comics.

## Introduction

Comics have long been recognized as using a visual vocabulary of unique graphic representations, many of which have permeated the broader visual culture. For example, iconic lightbulbs floating above the head no longer represent a source of light, but mean inspiration. Meanwhile stars, a symbol of an object, mean dizziness when above someone’s head. “Visual morphemes” (Cohn, 2013) like these have generally been viewed as unique and individualized representations (Kennedy, 1982; McCloud, 1993; Walker, 1980), possibly with metaphoric or embodied meanings (Forceville, 2005, 2011; Kennedy, 1982; Slepian, Weisbuch, Rutchick, Newman, & Ambady, 2010). However, we have argued that many graphic signs extend beyond individual instances, and instead belong to a class of abstract schema stored in memory which uses combinatorial structure (Cohn, 2013). Here, we explore this hypothesis specifically for these “above the head” meanings.

Some work has recognized that the context and position of visual morphemes matters for their interpretation (Cohn, 2007; Forceville, 2011; McCloud, 1993). For example, McCloud (1993) noted that curvy lines above coffee indicate heat, but curvy lines above trash indicate a bad smell. Similar observations were made by Forceville (2011), who noticed that a spiraling “twirl” above a character’s head meant dizziness, but twirls next to a body showed motion. Stars also vary in meaning: when above the head they mean dizziness, but substituted for eyes they indicate a desire for fame (Cohn, 2007, 2013). Thus, context matters for interpretation. Because of this context sensitivity, it has

been hypothesized that comic reading experience is necessary to understand these signs (Forceville, 2011), and indeed several studies have provided evidence that their comprehension is modulated by age and experience reading comics (Nakazawa, 2005).

We have theorized that these form-meaning pairs are encoded in memory analogously to lexical items in a language (Cohn, 2013). To create meaning with these “morphemes,” this “visual language” uses similar combinatorial strategies as in the morphology of verbal languages: speech balloons attach one sign to another (affixation), eyes that become hearts or dollar signs replace one sign with another (suppletion), and multiple body parts repeat elements to show movement (reduplication). It is important to stress that this comparison between the “visual language” of graphics and verbal languages of speech is an analogy of function only. Speech balloons are not meant as an affix in exactly the same way that “un-” serves as affix in the word “untie.” Rather, the analogy here is that the brain may use a similar strategy of “attachment” in governing combinatorial structure across domains, whether or not they involve a common underlying cognitive process.

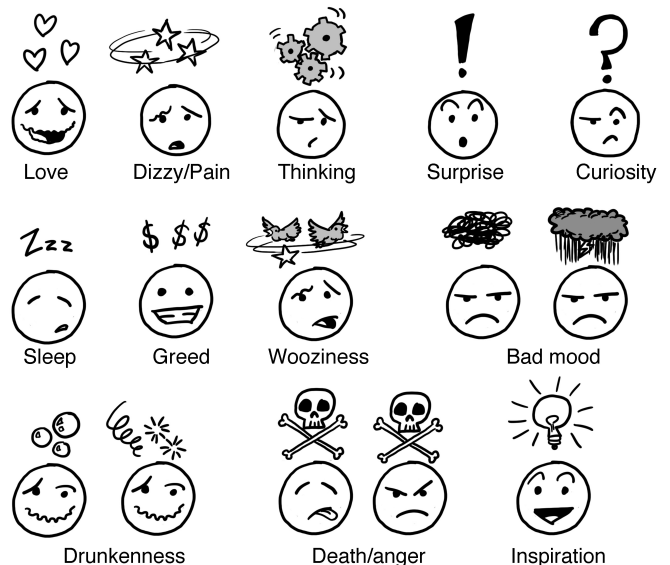


Figure 1. Conventionalized “upfixes” from the visual vocabulary used in comics.

“Upfixes” provide particularly rich examples of visual affixation, named because they go “up” from a head (Cohn, 2013). As in Figure 1, upfixes use a diverse range of images and symbols to convey their meaning. Some upfixes involve symbols with fixed meanings, such as hearts or exclamation

marks, which retain their meaning even away from a face. Other upfixes derive from idiomatic verbal expressions, such as “seeing stars” with stars twirling above characters’ heads to show dizziness. Still others use metaphors (Forceville, 2011; Lakoff & Johnson, 1980), often using iconic representations. Gears turning above the head indicate thinking, invoking the metaphors that the MIND IS A MACHINE and MOVEMENT IS PROGRESS (Cohn, 2010), while storm clouds meaning a bad mood rely on a metaphor of WEATHER AS AN EMOTIONAL FORCE (Shinohara & Matsunaka, 2009). Thus, specific upfixes use several methods to derive meaning, though they may involve a general metaphor related to mental states due to their proximity to the head.

Prior work has established that comic readers do interpret emotional meanings from upfixes, beyond their facial expressions. Ojha (2013) asked participants to interpret four different upfixes (spirals, spiky lines, twirls, sweat drops) placed above faces with neutral expressions. When choosing between possible interpretations (anger, surprise, confusion, agitation), participants identified a variety of emotions for each upfix, but most frequently chose the same two meanings (surprise: ~38%, agitation: ~38%) regardless of the specific upfix. While these results support that upfixes contributed to the interpretation of emotion, they contrasted the idea that certain upfixes carried specific meanings. In a second study, participants were given this same list of particular emotions and were forced to choose an upfix paired with a neutral face which best represented that emotion. Here, interpretations more consistent with the specific upfixes appeared (max: 53%), though with a wide range for each upfix. Also, no interaction appeared between participants’ interpretations and comic reading expertise.

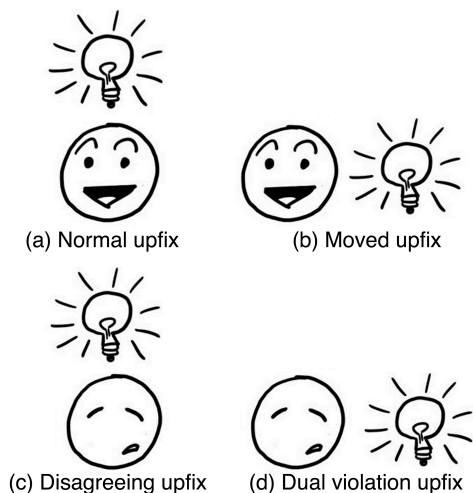


Figure 2. Constraints on the position and agreement of an upfix with its associated face/head.

In theoretical work, we have argued that upfixes are not simply context-dependent, conventionalized visual tokens (Cohn, 2013). Rather, they use an abstract schema encoded in the long-term memory of individuals who have acquired this visual vocabulary (prototypically, comic readers).

While conventionalized upfixes are stored in memory, this abstract schema is “semi-productive,” allowing for novel upfixes using this broader pattern. In addition, this schema has certain constraints. It restricts upfixes to a space above the head and pushes the emotion of the facial expression to “agree” with this graphic sign. Thus, a lightbulb above the head to indicate inspiration would make less sense if placed beside the head (Figure 2b). It also must accompany a happy face, and would be strange if placed above a sleeping face (Figure 2c). An even more strained interpretation should appear if both constraints are violated, such as when a lightbulb appears beside a head and with a sleeping face (Figure 2d).

If upfixes do use an abstract schema, the constraints on agreement with the face should be motivated by each individual upfix. Within this schema, item-specific constraints determine their relationship to the face. For example, a lightbulb as an upfix may carry with it constraints that it should accompany a happy or inspired face, while storm clouds would carry information about being associated with a sad face. That is, meaning does not come from the face or upfix alone, but out of their combination. This interpretation may explain the variety of interpretations found in Ojha’s (2013) studies: the upfixes had no specific relationship to the *neutral* facial expressions. Essentially, these upfixes “disagreed” with their faces, although possibly a “weak” disagreement because the faces used neutral expressions rather than conflicting emotions. If true, more consistent interpretations should arise for upfixes that agree with their matched facial expression than those disagreeing with their faces.

Given these precedents, we sought evidence that comic readers store this abstract “upfix schema” in their long-term memory—beyond just individual conventions—and that restrictions on position and agreement constrain the interpretation of these combinatorial signs. Participants were presented with faces and conventional and unconventional upfixes manipulated like those in Figure 2. They rated these images for how “easy they were to understand,” and offered an interpretation of their meaning.

If upfixes do not involve specific constraints, manipulations to position or agreement should have little effect on their rating or interpretation. In contrast, lower ratings to moved or disagreeing upfixes would show that such restrictions do affect comprehension. Such findings alone would not show evidence for an abstract schema. Because of their unfamiliarity, unconventional upfixes should lead to lower ratings than to conventional upfixes. If these items are indeed fully unconventional and do not invoke an abstract schema, then consistent ratings should appear across all manipulations. However, if manipulations to agreement or position in unconventional upfixes follow the same pattern as to conventional upfixes, this would provide evidence for an abstract schema, since these instances should otherwise be novel and not stored in long-term memory.

## Methods

### Stimuli

We created 32 face-upfix pairs (16 conventional and 16 unconventional). Our novel upfixes used images that could have a logical semantic association (rainbows, pot leaf), a fixed meaning (peace sign), or more abstract shapes that with no overt meaningful associations (plus signs, circles, triangles). Conventional upfixes were: hearts, stars, gears turning, an exclamation mark (!), a question mark (?), Zzzzs, dollar signs (\$), birds and stars, storm clouds, bubbles, skull and crossbones, light bulb, spiral and stars, scribble, halo, and music notes. Unconventional upfixes were: triangles, a flame, a pot leaf, a rainbow, a four leaf clover, clouds, a single large water droplet, a fork and knife, Xs, plus signs (+), spirals, a peace sign, a sun, ellipses (...), sparkles, and circles.

Normal upfixes were located above the head and had an emotion that agreed with the meaning of the face (Figure 2a). Moved upfixes displaced the sign directly to the right of the head, instead of above it (Figure 2b). Disagreeing upfixes altered the emotional expression of the face so that it disagreed with the upfix (Figure 2c). Finally, Dual violations both moved the upfix to the right side of the head and altered the emotion so that the face disagreed with the upfix (Figure 2d). Altogether, this yielded a 2 (Conventionality: conventional vs. unconventional) x 2 (Position: above head vs. beside head) x 2 (Agreement: agree vs. disagree) experimental design. We counterbalanced stimuli in a Latin Square design with four separate lists each containing 32 face-upfix pairs, such that each participant would view each type of upfix only once. We then created packets containing these stimuli which presented them in a randomized order.

Because meaning might vary based on the relationship between upfix and face, our stimuli used a variety of different reference types. “No meaning” signs had no intrinsic meaning when separated from the upfix, such as triangles or scribble. “Fixed” meanings had a symbolic meaning outside of their use as upfixes, such as hearts (regardless of whether their origins may have been metaphoric or metonymic). “Metaphoric” meanings used underlying mappings between domains, such as lightbulbs or gears (Forceville, 2011; Lakoff & Johnson, 1980), and finally “associative” meanings may have had intrinsic and/or metonymic meaning, which changed when acting as an upfix, such as spiraling birds. Similar emotions (such as Happy or Angry/Grumpy) used several different faces, so as not to repeat the same face multiple times.

All normal face-upfix pairs were categorized using a list of 25 different emotions/meanings, which was subsequently used in analyzing participants’ interpretations to these stimuli. These categories were assigned based on knowledge of conventionalized upfixes and graphic depictions of emotional facial expressions. They included: Happy, angry/grumpy, peaceful, love, dizzy/dazed, pain, surprise, curious/ unsure, sleepy/tired, drunk, death, greed, thinking,

lucky, high, hurried, daydreaming, angelic, inspired, hungry sad/depressed, singing, confused, or afraid. A final label of “other” was used where interpretations were ambiguous or unclear.

### Participants

Seventy-two volunteers (39 males, 33 females, mean age: 21.5) from the UC San Diego community participated in the study. Prior to experimentation, all participants gave their informed written consent and filled out the “Visual Language Fluency Index” (VLF) questionnaire used to assess their expertise at the visual language of comics by asking about the frequency with which they read various types of visual narratives (comic books, comic strips, graphic novels, Japanese comics, etc.) and drew comics, both currently and while growing up. We then computed a “VLF score” shown to correlate significantly with both behavioral and neurocognitive measures (see Cohn, Paczynski, Jackendoff, Holcomb, & Kuperberg, 2012). An idealized average along this metric would be a 12, with low being below 7 and high above 20. Participants on the whole had an average fluency, with a mean score of 15.7 (SD = 9.1, range = 1.75 - 41.25). Data from two participants were excluded due to misunderstanding the task.

### Procedure

Participants were given packets that contained the various face-upfix pairings. Beneath each graphic was a row of numbers from 1 to 7 where participants circled the rating for how easy the meaning was to understand (1 = very difficult, 7 = very easy). Below this rating, participants were given a line where they were asked to write their interpretation of the images. The experiment took participants roughly 5 minutes to complete.

### Data Analysis

We averaged across participants’ ratings for each type of upfix and then calculated the mean rating for each condition for each participant, collapsing across items. To investigate what participants thought these upfixes meant, we assigned participants’ freely given interpretations of the upfixes to one of 25 different emotional categories. For example, responses like “having an idea”, “eureka!”, and “realizing something” were all grouped into the category of “inspired” (such as for lightbulb upfixes). We then compared these responses against our coding of expected interpretations for the upfixes. A participant whose response agreed with the predicted interpretation was given a “1” and all other interpretations were given a “0.” For each participant, we then calculated their mean rate of making the expected interpretation for each condition, collapsing across items. Ratings and interpretations were analyzed using 2 (Conventionality) x 2 (Position) x 2 (Agreement) repeated-measures ANOVAs, followed by t-tests to analyze pairwise interactions between conditions. Finally, to investigate the role of comic reading frequency on participants’ assessment

of the stimuli, mean ratings and accuracies were then correlated with each individual's VLFI score.

## Results

### Ratings

Analysis of participants' ratings found main effects of Conventionality, Position, and Agreement and interactions between Conventionality and Agreement, (all  $F_s > 23.92$ , all  $p_s < .001$ ). A trending interaction appeared between

$p_s < .001$ ), though we found only a trending effect between Conventional Disagreeing and Dual upfixes,  $t(69)=1.8$ ,  $p=.08$ . Finally, faces that disagreed with their upfix (Disagree, Dual) were rated lower than those that agreed with their upfix (Normal, Moved), (all  $t_s > 4.0$ , all  $p_s < .001$ ). However, violations of position on the whole were rated higher than those with disagreements, though this effect was more noticeable in Conventional upfixes, since no difference appeared between Unconventional Moved and Disagreeing upfixes ( $p=.217$ ).

Participants' VLFI scores positively correlated with the ratings for Normal Conventional upfixes,  $r(68)=.29$ ,  $p < .05$ , Conventional Moved upfixes,  $r(68)=.23$ ,  $p=.059$ , Normal Unconventional upfixes,  $r(68)=.235$ ,  $p=.051$ , and Unconventional Agreement violations,  $r(68)=.26$ ,  $p < .05$ . In all cases, the correlations suggested that participants with greater fluency gave higher ratings than those with lower fluency.

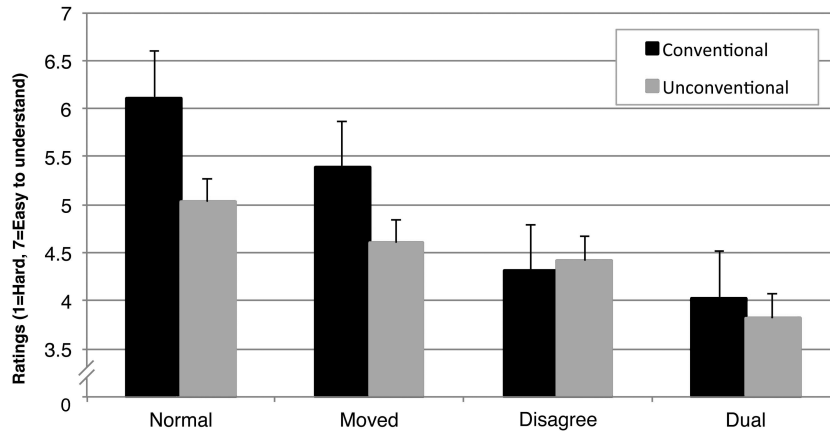
### Interpretations

Our second analysis focused on participants' interpretations of the face-upfix pairs. We found main effects for Conventionality and Agreement (all  $F_s > 20.7$ , all  $p_s < .001$ ), but not Position, ( $p=.728$ ). We also found interactions between Conventionality and Agreement, Agreement and Position, and Conventionality, Agreement, and Position (all  $F_s > 4.2$ , all  $p_s < .05$ ).

As depicted in Figure 3b, interpretations of Conventional and Unconventional upfixes differed the most for Normal upfixes,  $t(69)=4.7$ ,  $p < .001$ , and Moved upfixes,  $t(69)=1.97$ ,  $p=.053$ . No difference in Conventionality arose for Disagreeing or Dual upfixes, (all  $t_s < 1.5$ , all  $p_s > .144$ ). The lack of a main effect of Position suggested that location of the upfix alone did not influence its meaning as much as Agreement between upfix and face. Differences were found

between positions of Conventional Normal and Moved upfixes and between Conventional Disagreeing and Dual upfixes (all  $t_s < 2.2$ , all  $p_s < .05$ ). However, Unconventional agreeing upfixes (Normal, Moved) were interpreted with the same consistency, as were disagreeing upfixes (Disagreeing, Dual) (all  $t_s < -.15$ , all  $p_s > .884$ ). Agreement had a larger influence on interpretation of their meaning. Upfixes that agreed with their faces (Normal, Moved) were interpreted more accurately than those disagreeing with their faces (Disagree, Dual), regardless of conventionality (all  $t_s > 4.28$ , all  $p_s < .001$ ).

a) Ratings to upfixes



b) Rates of agreement with expected interpretations of upfixes

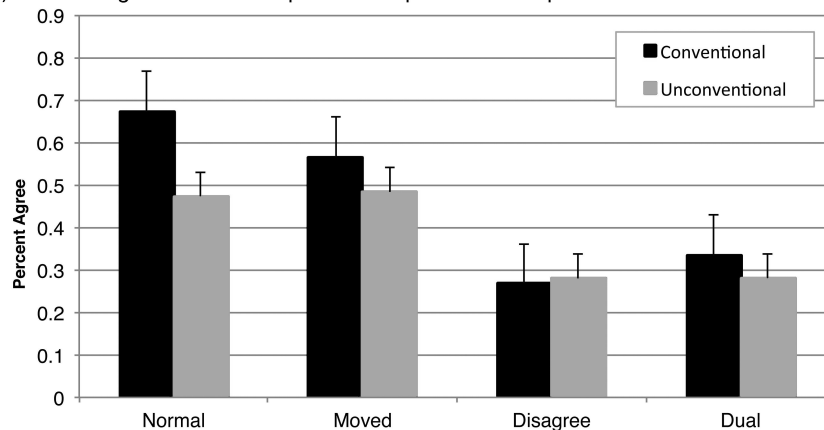


Figure 3. Participants' (a) ratings and (b) rates of agreeing with expected interpretations for manipulated upfixes.

Conventionality, Position, and Agreement,  $F(1,69)=2.97$ ,  $p=.089$ . No two-way interactions were found between Conventionality and Position, or Agreement and Position, (all  $F_s < .776$ , all  $p_s > .38$ ).

As depicted in Figure 3a, Conventional upfixes were rated higher than Unconventional upfixes, but only those that agreed with their faces (Normal, Moved), (all  $t_s > 3.9$ , all  $p_s < .001$ ). No differences appeared between Conventional and Unconventional upfixes with disagreements, both with and without movement (all  $t_s < 1.2$ , all  $p_s > .24$ ). Upfixes moved beside the head (Moved, Dual) were rated lower than those above the head (Normal, Disagree) for both Conventional and Unconventional upfixes (all  $t_s > 4.0$ , all

Participants' VLFI scores also correlated with the means for the expected interpretation, but only for Conventional Normal upfixes,  $r(68)=.267$ ,  $p<.05$ , again showing higher agreement for interpretations by participants with greater expertise.

## Discussion

This experiment sought evidence for an abstract combinatorial schema within the visual vocabulary used in comics. We examined whether “upfixes”—the graphic signs that float above character's heads—are constrained by their position above the head and by their agreement with a face's emotion.

Participants' ratings suggested that manipulations to position and agreement had a significant impact on how easy the images were understood. Upfixes that were moved beside the head were rated as significantly harder to understand than those where the upfix remained above the head. An even greater decrement in understandability occurred for violations to the agreement of upfix and facial expression. Ratings decreased further to dual violations that manipulated both of these factors, suggesting a compounded effect of violating both constraints. Crucially, these manipulations affected the judgment of both conventional and unconventional upfixes. If upfixes were simply stored as specific instances, then we would expect unconventional upfixes to be rated the same no matter their agreement or position with the face, since these novel instances would have no instantiation in memory. Rather, ratings to unconventional upfixes displayed the same pattern as to conventional upfixes. This suggests that these constraints applied beyond associations made to individual conventionalized signs, but rather reflects an abstract schema stored in memory.

Nevertheless, Conventional upfixes were rated higher than unconventional upfixes, but only for those that agreed with their faces—whether moved or normal. Conventional and unconventional upfixes that disagreed with their face were rated as equally understandable. These findings suggest that conventional upfixes appear just as novel as unconventional upfixes when the face disagrees with its meaning. That is, conventional upfixes that disagree with their face appear “novel.”

Participants' interpretations of these upfixes reinforced these results. The location of the upfix mattered less in participants' interpretations of upfix meanings than agreement. Upfixes that agreed with their face were more accurately interpreted than those that disagreed. For these disagreeing upfixes (Disagreeing, Dual), conventionality did not influence interpretations. As in the ratings, the conflict between upfix and face meant that conventional upfixes appeared just as novel as unconventional ones, and thus were less likely to conform to the expected interpretations of their meaning (i.e., the meaning when they were in normal position and agreed with their face).

These results suggest that, despite tapping into an abstract schema, conventionality does have an influence, as upfixes

have item-specific constraints. That is, upfixes on their own do not determine the meaning by mere placement above a head, but rather each upfix carries specifications for how it should contextually relate to an accompanying face. These results may therefore inform why interpretations may have been less forthcoming for upfixes above neutral faces, as found in Ojha's (2013) study. Neutral faces would “disagree” with the upfixes that they accompanied, and thus yield more variability of interpretations than if paired with agreeing faces. It is also worth noting that, methodologically, the present study elicited unprompted responses from participants. Yet, interpretations of Normal conventional upfixes (67%) were greater than the highest rates of interpretation for all upfixes in Ojha's (2013) study (max: 53%) where participants were provided with an explicit list of emotions to choose from. Given the fact that higher rates of expected interpretations in our study were provided by unprompted responses, these results further support that comic readers are able to recognize the explicit meanings of upfixes when they agree with their faces.

Overall, agreement appeared to impact the interpreted meaning more than position. These results may be caused by both the face and the upfix contributing meaningful information, which unite to form a combinatorial meaning. Their relative position merely connects these two semantic components together. Thus, more of the meaning may be recoverable when altering the position between upfix and face than if those component parts do not agree. This indicates that agreement is a stronger constraint on the semantics of upfixes than position, though both factor into the overall meaning (as indicated by the differences in ratings across all manipulations).

Despite this seeming lack of an influence by upfix location, the positional information tested here was fairly restricted: for positions above versus beside the head, position appears to contribute little dissociable interpretation so long as the elements agree with each other. It may be the case that other positions carry more semantic weight. As discussed, twirls above the head mean something different than behind a body (Forceville, 2011), and stars in the eyes differ in meaning from those above the head (Cohn, 2013). Comparison between visual morphemes where the positions carry meaningful contrast may therefore yield different results.

In addition, our correlations with visual language fluency scores also suggested that participants with more experience reading comics rated upfixes as being more comprehensible, even when conventional upfixes were moved or when unconventional upfixes disagreed with their face. In these cases, proficient comic readers may have been able to use their prior knowledge to interpret familiar meanings (as in moved upfixes) or to generalize across unfamiliar meanings (unconventional normal and disagreeing upfixes). These results suggest that knowledge of these particular upfixes, and the construction of an abstract upfix schema, is acquired as part of a “fluency” in the visual vocabulary used in comics (Cohn, 2013). Such findings are consistent with

previous work showing that understanding of visual morphology increases with age and frequency reading comics (Cohn & Maher, 2015; Nakazawa, 2005).

These results support that upfixes are constrained by particular rules, and are not merely memorized on an item-specific basis. Yet, it remains an open question whether they constitute a unique case that uses combinatorial rules or whether other visual morphology is constrained by similar abstract principles, either within or outside visual narratives. In our previous work, we have argued that several elements of the visual vocabulary used in comics involve abstract schemas and/or morphological processes analogous to those in verbal morphology such as affixation, suppletion, and reduplication (Cohn, 2013). Would other schema be restricted by comparable constraints, or are upfixes an isolated case? Further study on these visual vocabulary items (both within and across cultures' unique graphic conventions) would need to investigate these possibilities.

It is also unclear through this experiment what sort of cognitive processes might guide these combinations. Given the broad analogy between verbal and visual morphology, it is worth asking whether combinatorial principles in both of these domains draw upon similar underlying cognitive resources, or whether these constraints require domain-specific processing. While this analogy between the “morphology” of verbal and visual languages does not necessarily predict shared cognitive mechanisms (Cohn, 2013), similar neurocognitive responses are evoked by violations to the “grammar” of sequential images as by violations of syntactic structure in sentences (Cohn, Jackendoff, Holcomb, & Kuperberg, 2014; Cohn et al., 2012; Sitnikova, Holcomb, & Kuperberg, 2008). Thus, it is not inconceivable to posit that combinatorial rules used to construct the units *within* such sequences—the morphology of words or images—may also recruit similar cognitive processing. Indeed, neurocognitive responses similar to those shown to language have appeared in research on motion lines in visual narratives (Cohn & Maher, 2015) and the processing of natural scenes (Vö & Wolfe, 2013), which has already suggested the potential for such overlap.

Altogether, these findings provide initial support for combinatorial principles underlying the comprehension of visual morphology. These results suggest that the construction of meaning in the graphic form—at least in the structure conventionally used in comics—uses complexity beyond recognizing individual visual signs. Rather, “fluent” readers may generalize across conventional items to derive novel meanings from an abstract schema stored in memory for graphic meanings above the head.

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