Mark the unexpected! Animacy preference and goal-directed movement in visual language

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Abstract:

A preference for animate entities over inanimate entities is commonly found in perception and language. In our corpus study based on a cross-cultural set of 331 comics from 81 countries, we asked whether animacy preference plays a role in the morphological marking of motion in the visual language(s) used in comics. We were interested in whether animates or inanimates are more or less marked (i.e., use pictorial cues to signal motion) when compared to each other, similarly to differential marking modulated by animacy in grammars of many languages. We considered the animacy preference as the expectation that animates are moving in a goal-directed way, while inanimates are not (Opfer, 2002). We focused on motion lines (i.e., lines trailing behind a moving object) and circumfixing lines (i.e., lines surrounding a moving object) that indicate motion in comics, which are visual morphological markings that differ in their goal-directedness: Motion lines are goal-directed, while circumfixing lines are not. We found that inanimates are more marked by motion lines than animates in our data, while there is no difference between the two groups regarding circumfixing lines. These results persist across all global regions and styles of comics. Thus, similarly to spoken languages, visual morphology obeys what we call the *Mark the unexpected!* principle, defined in the context of surprisal minimization: Inanimates need to be marked in order to signal that they are moving in a goal-directed way, which is otherwise unexpected and of high surprisal. Animates are comparatively marked less because their goal-directed movements are already expected and of low surprisal. As this principle persists across modalities and their diverse expressive systems, *Mark the unexpected!* is a strong candidate for a cognitive universal.

Keywords: animacy; motion; goal-directed movement; visual language; motion lines; grammar; surprisal; comics

1 Introduction

Distinguishing animate entities, which are perceived as alive or sentient, from inanimates, perceived as not alive nor sentient, is a fundamental human ability observed in humans as early as 12 weeks of age (Opfer & Gelman, 2011). Animacy distinctions are often realized

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in perception and language, where animate entities are consistently preferred over inanimate entities (e.g. Kirchner & Thorpe, 2006; New et al., 2007; Pratt et al., 2010; Altman et al., 2016). While this effect has been found robustly in the literature on perception and language, here we ask whether it also appears in systems of pictorial representation, particularly in the visual language(s) used in comics.

1.1 Animacy preference

The preference for animates over inanimates persists across domains. In perception studies, participants react faster to pictures of animate than inanimate entities (Kirchner & Thorpe, 2006), they detect changes in animates more rapidly than in inanimates (New et al., 2007), react faster to animate motion (with changes in direction and speed not attributable to an external source) than to inanimate motion (Pratt et al., 2010), and they are most sensitive to animacy changes (Altman et al., 2016). New et al. (2007) attribute animacy preference to an evolutionary bias for monitoring of animates, which presented important opportunities as well as dangers to our ancestors. According to New et al. (2007), human attention system evolved to prioritize monitoring humans and animals over inanimates (e.g., plants, terrain) because they cannot move or change as fast as animates, and, thus, pose less immediate threats than animates.

This bias also extends to language. Animacy factors into structural and grammatical preferences of animate entities over inanimates. Animate nouns are more likely to be agents and subjects of a sentence than inanimate nouns (Hopper & Thompson, 1980) and human arguments often precede inanimate ones (Meir et al., 2017). In linguistic processing experiments, de Swart & Van Bergen (2019) found that in anticipation of the subject of the sentence, participants preferred to attend to animates over inanimates in visual stimuli. Similarly, in processing of visual representations of agents and patients, agents incur a processing advantage across different experiments (Segalowitz, 1982; Cohn & Paczynski, 2013; Sauppe et al., 2023; Isasi-Isasmendi et al., 2023). Huber et al. (2024) also show psycholinguistic evidence that there is a preference for the initial unmarked noun phrases to be interpreted as agents, as opposed to patients.

Most languages exhibit some animacy effects in certain areas of their grammar, such as in case, gender, or agreement (Vihman & Nelson, 2019; Dahl, 2000). One of the most studied areas of the grammar argued to be subject to animacy effects is the Differential Object Marking. Differential Object Marking refers to a different grammatical treatment of a subset of syntactic objects, for example animate ones, whereby they receive overt grammatical marking (Sinnemäki, 2014), such as affixes or inflection.

In languages with morphological marking of objects, direct objects[1] are more likely to be marked with an affix or another morphological element if they are animate (Dahl, 2000), while inanimate objects are more likely to be morphologically unmarked (Vihman & Nelson, 2019). Consider examples from Croatian, a language with Differential Object Marking restricted to masculine nouns. In example (1),[2] the direct object “tiger” is morphologically marked by the affix *-a* for the accusative case because *tigar* “tiger” is an animate noun. The noun *stol* “table” in example (2), on the other hand, cannot receive such marking because it is inanimate.

[1]Direct objects are arguments of the verb, which are affected by the action denoted by the verb, typically in the semantic role of a patient.

[2]Abbreviations: 1SG–first person singular, ACC–accusative, F–feminine, PST–past.

(1) Vidje-la sam tigr**-a**.
see-PST.F be.1SG tiger-ACC
"I saw a tiger."

(2) Vidje-la sam stol.
see-PST.F be.1SG table.ACC
"I saw a table."

We find a similar pattern in Spanish. In (3), the direct object *mujer* "woman" is marked by the preposition *a* because it is animate and human,[3] while the noun *mesa* "table" in (4) cannot be marked by *a* because it is inanimate (Von Heusinger & Kaiser, 2003).[4]

(3) Vi **a** la mujer. / *Vi la mujer.
see.PST.1SG to the.F woman
"I saw a woman." (Von Heusinger & Kaiser, 2003, 43)

(4) Vi la mesa./ *Vi a la mesa.
see.PST.1SG the.F table
"I saw a table." (Von Heusinger & Kaiser, 2003, 43)

We can explain this difference in morphological marking in the following way. Since animate entities are seen as alive and active, they align with the semantic role of agent in the sentence (de Swart et al., 2008) i.e., the one performing the action. Thus, when animate entities are syntactic objects instead, typically in a semantic role designating that the action is performed on them by something or someone else, additional marking is needed to disambiguate their syntactic role as an object (for related theoretical explanations resorting to efficiency principles in language see Aissen 2003; Hawkins 2004; Haspelmath 2021, 2019; Levshina 2021).

Whether the animacy preference in Differential Object Marking described above is a typological universal or restricted to certain languages (e.g., Croatian, Hindi, Spanish, Malayalam, among others) is still debated (see Bickel & Witzlack-Makarevich, 2008; Sinnemäki, 2014). However, it is apparent that animacy can play a role in many areas of the grammar in different spoken languages (de Swart et al., 2008), which is also the case in sign languages (Börstell, 2019). While Differential Object Marking modulated by animacy is commonly attested in linguistic typology (e.g Woolford, 2001; Donohue, 2011; Levin, 2019; Irimia, 2020), the opposite is the case when it comes to Differential Agent Marking, which is the mirror image of Differential Object Marking or the morphological marking of inanimate agents (Fauconnier, 2011). According to Fauconnier (2011), the reason for its cross-linguistic rarity is that most languages structurally avoid inanimate agents altogether, because they are not expected to occur in the role of an agent.

In this paper, we use the notion of "unexpectedness" coined by Fauconnier (2011) and "surprisal" (Friston, 2010) to explain why disambiguation by marking is necessary in language. While Fauconnier (2011) uses the notion of unexpectedness to refer to inanimates not being expected to occur as agents, we expand it to any category misaligned with its expected role. For instance, animate entities are not expected to occur as direct objects, as passive entities on which action is performed, and thus need to be marked to signal that they are in this unexpected grammatical role, as in examples (1) and (3). In this paper, we formulate this mechanism as the principle *Mark the unexpected!*, where marking refers only to morphological

[3] Non-human animates like *tiger* would not be marked by *a* in Spanish because they are lower on the animacy hierarchy than human animates (Silverstein, 1986).

[4] Asterisk in the example means that the sentence is not grammatically possible in the language.

marking. We define *Mark the unexpected!* as a general cognitive principle in the context of surprisal minimization (Friston, 2010), which sees the brain as a predictive machine (Clark, 2016) that aims at diminishing surprisal to maintain an optimal state. *Mark the unexpected!* is as a mechanism that minimizes the number of possible interpretations, and thus surprisal, by means of explicitly morphologically marking the element appearing in an unexpected context. We argue that this cognitive principle might be relevant not only in spoken and sign languages, but also in the visual language(s) used in the pictorial content of comics and other graphic systems. Crucially, *Mark the unexpected!* might offer answers to when and why grammatical marking is needed in language in general. In Section 4.2, we hypothesize that grammatical marking is needed when surprisal is in the sweet spot between getting heightened often (e.g., animates as direct objects), requiring a systematic lowering by marking, but not often enough that the interpretation with the lowered surprisal becomes the default one.

Taking into consideration the effects of the animacy preference in language and perception, we posed the question of whether the animacy preference also exists in the visual language(s) used in comics. Visual Language Theory (Cohn, 2013) argues that pictorial representations follow similar structural and cognitive principles as spoken and sign languages, such as using compositional rules akin to grammar. While visual languages are used in many sociocultural contexts (for producing all drawn pictures), they are particularly rich in comics, yielding conventionalized variation across diverse systems, such as American superhero comics versus Japanese manga (McCloud, 1993; Cohn, 2024). Yet, typological universals also persist despite this diversity, such as Zipfian trade-offs between length and frequency that appear throughout spoken languages (Piantadosi, 2014) and visual languages (Cohn, 2024).

Visual Language Theory posits that cognitive organizational principles persist across both spoken and pictorial systems, but do so in ways tailored to the affordances of those modalities. For instance, as in spoken languages, visuals also use the strategy of affixation (i.e., attachment) in which elements that do not have meaning on their own must attach to stems, which have their own meaning (Cohn, 2018; Cohn & Foulsham, 2022). An example of these "visual affixes" are motion lines which trail behind movers to indicate their paths and circumfixing lines which surround movers to indicate motion, see Figure 1 (Hacımusaoğlu & Cohn, 2023). In their formal characteristics, these lines are parallel to affixes in spoken languages, because just like the accusative affix *-a* in Croatian in example (1), they do not have meaning unless they are bound to their stems (e.g., a figure or an object). These types of visual affixes have been shown to vary across comics of different cultural origins (Forceville et al., 2010; Tasić & Stamenković, 2018; Cohn, 2024), and psychological studies have shown that they obey various constraints, which, if violated, elicit similar neural responses as grammatical violations in spoken/written languages (Cohn & Maher, 2015; Cohn & Foulsham, 2022).

Given this parallel between the visual and spoken morphology, we ask whether the visual morphological marking is also subject to the animacy preference. Specifically, are animates or inanimates more morphologically marked and if so, why?

1.2 Motion and goal-directedness

Our study focuses on the marking of motion, which is one of the crucial perceptual cues for identifying animates (Pratt et al., 2010). Opfer & Gelman (2011) suggest that dynamic information, such as movement, can signal agency, intentionality, and goal-directedness, all of which are animate features. Nevertheless, autonomous motion alone is not sufficient to trigger an interpretation that something is animate (Gelman et al., 1995), as inanimates manipulated in an experiment to be moving autonomously are still perceived as inanimate on average. Gelman et al. (1995) also found that aimless autonomous movements were ambiguous as to the animacy interpretation. Opfer (2002) argues that the goal-directed movement is unambiguously perceived as animate and defines it as "a type of autonomous movement in which the agent contingently directs its movement toward (or away from) another object, state, or location".

In an experimental study, Opfer (2002) shows that goal-directed movement is perceived as more animate as opposed to aimless movement. When participants saw a blob moving toward a goal, they were likely to attribute animate features to it, such as life, biological properties, and psychological capacities. In contrast, when participants saw the identical movements of the blobs, but with the goal being removed, they were not likely to attribute animate characteristics to the blobs. Thus, Opfer (2002) suggests that goal-directed movement is a decisive factor for distinguishing animates from inanimates.[5] In addition, animates often have perceptual cues, such as posture and outstretched limbs (Kawabe & Miura, 2006; Hafri et al., 2013), which can signal the direction of their movement. Note, however, that Opfer's (2002) experiment used blobs without postural cues, which shows that goal-directed movement is expected from animates regardless of their perceptual features. In subsequent experimental research, goal-directedness has been maintained as one of the crucial factors in perceiving entities as animate (e.g. Gao et al., 2010; van Buren et al., 2016; van Buren & Scholl, 2017). The reason for this most likely resides in the fact that goal-directed movement often indicates intentional motion toward a goal, which is associated with the sentience of animates allowing them to freely change direction of their own volition (cf. New et al., 2007).

We propose that when it comes to the visual language of comics, the preference for animates to be moving in a goal-directed way would lead to observable differences in the marking of motion. Thus, we define animacy preference as applied to the visual marking of motion as an expectation that animates move in a goal-directed way. Conversely, inanimates are not expected to be moving in a goal-directed fashion, which may require additional marking to indicate motion.

We focus on two common types of morphological marking of motion in comics, which differ only in their goal-directedness. Motion lines trail behind animates and inanimates (movers) to indicate motion and the traversed path, which disambiguates the direction of movement (Kawabe et al., 2007; Hacımusaoğlu & Cohn, 2023), see a) and c) in Figure 1. In other words, motion lines index where the mover was at an earlier moment in time, which allows the reader to understand the direction of movement by looking at the beginning and the end of the lines, i.e., the traversed path. In experiments with human subjects, Kawabe et al. (2007) showed that motion lines "trigger anticipation of the future position of the object", biasing the memory of the object's location in the direction lines suggest. This shows that motion lines are not only graphically directional, but are also perceived as such.

Circumfixing lines, on the other hand, are lines drawn on the sides of the mover (Kim & Francis, 1998),[6] typically parallel to its contours to indicate motion (Cohn, 2013), but they do not indicate the direction of the movement. The movement marked by circumfixing lines can sometimes be interpreted as going back and forth (Kim & Francis, 1998) or shaking, but its temporal order is not specified and thus directionality remains ambiguous. For instance, in b) in Figure 1, the head can be seen as shaking or moving left and right continuously. However, it is impossible to tell which direction came first and we cannot exclude the possibility of

[5] Opfer (2002) notes that "other factors may be important in deciding whether the thing is sentient".

[6] Kim & Francis (1998) do not use the term "circumfixing lines", introduced by Cohn (2013), although they discuss them separately as a type of motion lines.

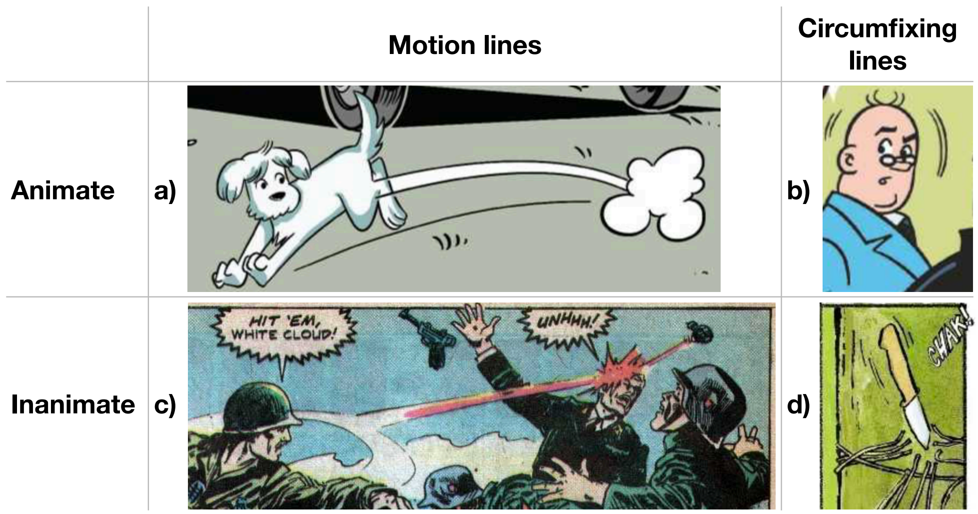

Figure 1: Examples of motion lines and circumfixing lines in our corpus: a) motion lines (in the shape of a white ribbon) trailing behind an animate figure; b) circumfixing lines mimicking the contours of an animate figure (both from "Archie's Friend Scarlet" by Ray Felix and Fernando Ruiz, © Archie Comics (USA) (Felix & Ruiz, 2017); c) motion lines in the shape of a red ribbon trailing behind an inanimate object (grenade) to mark its path in "One Armed Beast" by John Albano, Patrick Broderick, and Jack Sparling (USA) (Albano et al., 1975); d) circumfixing lines around a falling knife as an inanimate object from "The Yankee Comandante" by Gani Yakupi (Albania) (Yakupi, 2019).

moving up and down as well.[7] Both motion lines and circumfixing lines appear in all styles of comics, but they might be used with different frequencies in different styles (Cohn, 2024).

In this study, we use a corpus analysis of global comics to ask whether animates or inanimates are more marked by motion lines, indicating goal-directed movement, and circumfixing lines, which are not specified for goal-directedness. Adhering to our definition of animacy preference applied to motion, animates are expected to be moving in a goal-directed way and inanimates are not. We expect then that, when it comes to motion lines, inanimates should be more marked than animates. This is because we need to signal that they are moving in a goal-directed way, which is otherwise not expected from them. When it comes to circumfixing lines, we do not expect a difference in either direction because they do not indicate goal-directedness and should not interfere with expectations about animate and inanimate movement. Since there are many factors that can influence the structure of comics, including style and culture (Cohn, 2013, 2024), in order to ascertain that our findings reflect universal trends and not stylistic or culture-driven preferences, we also compared different global cultural regions and styles regarding their marking of animates and inanimates with motion lines and circumfixing lines.

[7]In some cases, circumfixing lines might appear only on one side of a mover, which might contribute to the understanding of direction, but this type of marking is exceedingly rare in our data.

2 Methods

2.1 Corpus

Our study is based on a subset of the TINTIN Corpus of 1,030 comics from 144 countries and territories, which were annotated with the Multimodal Annotation Software Tool (MAST) (Cardoso & Cohn, 2022). For this study, we analyzed 331 comics which were annotated for motion events, including the morphological marking of motion, such as motion and circumfixing lines. These 331 comics come from 81 different countries and are written in 35 languages, see Figure 2.[8] Our aim is that by analyzing such a diverse dataset, we come closer to finding cross-cultural patterns reflecting cognitive universals.

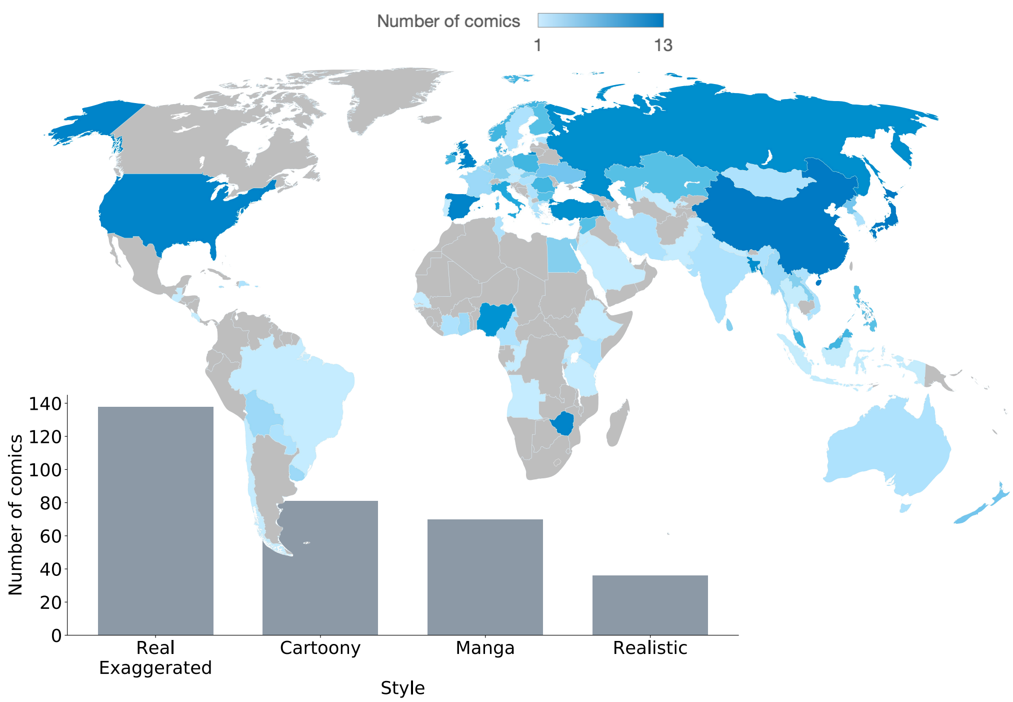

Figure 2: World map with countries represented in our sample of 331 comics, accompanied by a histogram of number of comics per artistic style, see Section 2.2 for definitions of style categories.

Motion events in the TINTIN Corpus were annotated using the annotation schemas of "Visual Language Theory: Morphology: Motion Events v.2" (Hacımusaoğlu & Cohn, 2022a) and "Semantics: Path Structure v.2" (Hacımusaoğlu & Cohn, 2022b). Each moving entity on a comic page is annotated with a region (see Figure 3), which receives either an annotation of a "Mover (figure)" or "Mover (object)". "Mover (figure)" was defined as a moving figure with a body and posture, and it corresponds to our category of animate entities.[9] "Mover (object)"

[8]World map from Wikimedia Commons, `en.m.wikipedia.org/wiki/File:BlankMap-World.svg` with our own coloring.

[9]In a few rare examples, certain inanimates with posture, such as statues and dolls, were annotated as "Mover (figure)" even when they were moved by an external force. However, since the number of figures annotated as "Mover (figure)" per comic is very high, these isolated cases should not bear any influence on our results. For a discussion on cases when animacy is ambiguous in comics, see Edlin & Reiss (2023).

was defined as a moving inanimate object. Only moving inanimates were annotated, which excludes all stationary objects in a scene.

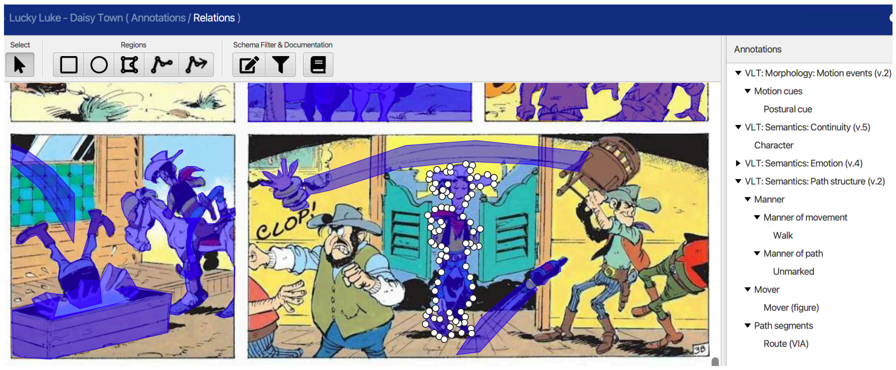

Figure 3: "A Lucky Luke Adventure: Daisy Town" by René Goscinny and Maurice de Bevere (Belgium) (Goscinny & de Bevere, 1983) in the Multimodal Annotation Software Tool (MAST). The regions in blue are annotated according to the annotation schema for motion events.

Due to different timescales of annotating, there were some differences between early and more recent annotations regarding the annotation of "Mover (figure)". In early annotations, only the movers moving in more intense ways (e.g., walking, running, jumping) were annotated, while in the rest of the annotations, all movers in a comic, regardless of intensity, were annotated. These criteria do not affect inanimates, which were always annotated as long as they are perceived as moving. Since this difference in criteria could lead to a higher proportion of marked animate movers, we assessed whether these differing criteria impacted our analysis by conducting our analysis twice, once on the entire dataset and second time on the dataset excluding the early annotations with the different criteria. As we report in Section 3, there were no differences between the two datasets regarding the significance of our results. Additionally, the method of annotation used in early annotations overestimates the number of animates with lines, which does not favor our hypothesis, and thus, cannot bias the results in a favorable direction.

2.2 Procedure and analysis

Since our goal is to calculate which animates and inanimates are marked by motion lines, we used a series of annotations that indicate whether the "Mover (figure)" or "Mover (object)" have motion lines. The annotation schema was designed prior to this study and because of that it does not have a direct annotation for whether a mover has motion lines. Therefore, we used the annotation "Manner of path / Unmarked", which records movers that are on route and do not have motion lines behind them. However, the absence of this annotation does not necessarily mean the mover has lines because "Manner of path / Unmarked" was not used for movers who reached the goal or endpoint of their movement. Thus, when "Manner of path / Unmarked" annotation was not present on a given mover, our Python script then looked for the annotations "Manner of path / Straight / Curving / Spinning / Twirling / Bouncing", which describe the shape of the path of motion lines, indicating that the mover is marked by motion lines. In some cases, the latter annotation was not present, and then we retrieved the presence or absence of motion lines from the MAST "relations", which record the dependencies between movers and their routes, including motion lines. In this case, we calculated an average number of motion lines per mover in each relation, some of which include multiple instances of the same mover. The presence of circumfixing lines on a mover was annotated as “Manner of path / Shaking” on the mover.

In a Python script, we then calculated the average number of lines, motion and circumfixing separately, per mover per comic. We did the analysis per comic because it is the smallest unit in which we can measure the difference in marking between animates and inanimates. For both motion lines and circumfixing lines, we counted the presence of lines as 1, without taking into consideration the actual number of lines graphically. We compared the difference in the amount of marking of animates and inanimates via the Mann-Whitney U test, which is an appropriate test for the data that is not normally distributed. We then calculated the Rank-Biserial Correlation Coefficient (r) to report on the effect size.

All the comics that do not have any motion lines marking either animates or inanimates were excluded from the statistical analysis, because, since both categories are zero, they cannot tell us anything about the relationship between the amount of marking on animates and inanimates.[10] The same procedure was applied to circumfixing lines. This meant that out of 331 comics, 210 comics with motion lines and 167 with circumfixing lines were analyzed. Since some comics in our corpus do not have have moving inanimate objects,[11] the number of analyzed comics differs slightly across these two categories, see Figures 5 and 6 and Tables 1 and 2.

Figure 4: Example of manga on the left and real exaggerated style on the right, from “There is No Plan B” by Jeffrey Roberto Lopez (Nicaragua) (Lopez, 2018), and “MANU: Altiplano” by Gustaffo Vargas (Peru) (Vargas, 2019), respectively.

We then performed an additional analysis in which we subdivided our data according to global cultural regions and artistic styles, to test whether there are any significant differences between these groups. Global regions include Asia, Europe, Africa, and Americas (i.e., North, Central, and South). Each comic is classified in one of these regions according to its place of publication. We excluded comics from Australia and New Zealand from this part of the analysis, as there were too few instances (8 comics) for a statistically meaningful comparison with other groups.

The categories of style we considered in our analysis are manga, cartoony, real exaggerated, and realistic, which we describe below. The TINTIN Corpus also contains a category called alternative, which we excluded from this analysis, because there were only seven comics in that style in our sample.

[10]Not having any lines for animates and inanimates is not the same as having the same number of lines for both categories. Our question about the difference in the amount of marking is not applicable to the comics without lines.

[11]In contrast, all comics in our dataset have moving animate figures.

The styles of the TINTIN corpus were determined by a combination of manual annotations and computer vision methods described in Titarsolej et al. (2004) and Cohn et al. (2024). The manga category refers to the style of comics originating in Japan, which now spans worldwide (Brienza, 2015), exemplified in Figure 4. The style of cartoony in our corpus refers to comics in which characters have exaggerated features and unrealistic proportions of body parts, such as large heads and eyes in a) and b) in Figure 1. This category also includes the style known as *Ligne claire*, shown in Figure 3. The category of real exaggerated includes a superheroic style and comics in which characters have exaggerated body parts but otherwise maintain realistic proportions of human body, see Figure 4 and d) in Figure 1. The category of realistic refers to comics drawn in the style more closely resembling reality in that depictions of characters and their features are not exaggerated, such as in the case of c) in Figure 1. Many older classical comics belong to this category.

In order to compare the difference between animates and inanimates across all global regions and across the four styles, we performed a multivariate analysis with the Kruskal-Wallis test, followed by Dunn's test, with Bonferroni corrections, which is an appropriate post-hoc test for not normally distributed data. Additionally, we calculated Cliff's Delta (δ) effect size.

3 Results

3.1 Motion lines

We first compared motion line marking of animates and inanimates in comics throughout the whole corpus. As in Figure 5 under "All data", inanimates are more marked by motion lines than animates on average, $p < .001$, $r = 0.43$, animates $Mdn = 0.05$, inanimates $Mdn = 0.21$.

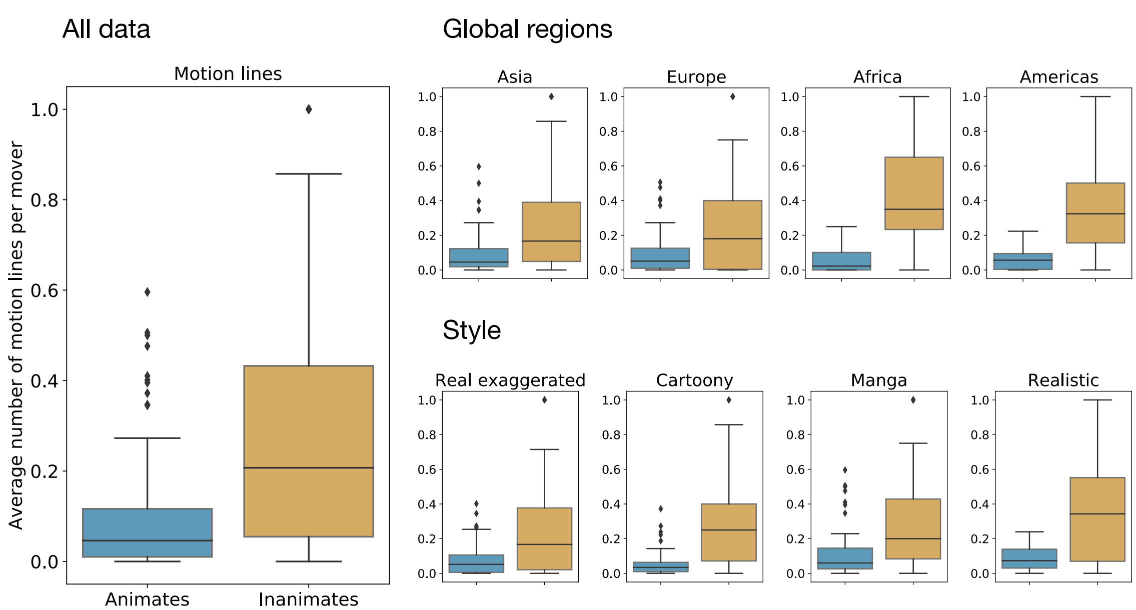

Figure 5: Left: Average number of motion lines per animate/inanimate mover per comic, $n = 210$ (animates), 196 (inanimates). Right: Plots for each global region and style, cf. Table 1.

Table 1: Results for motion lines per global region and style

Global region	*Mdn* (animates)	*Mdn* (inanimates)	p (adjusted)	δ
Asia	0.05 ($n = 69$)	0.17 ($n = 63$)	0.008	-0.38
Europe	0.05 ($n = 86$)	0.18 ($n = 80$)	0.019	-0.3
Africa	0.02 ($n = 31$)	0.35 ($n = 29$)	<.001	-0.73
Americas	0.06 ($n = 20$)	0.32 ($n = 20$)	0.018	-0.65
Style	***Mdn* (animates)**	***Mdn* (inanimates)**	**p (adjusted)**	**δ**
Real Exaggerated	0.05 ($n = 83$)	0.17 ($n = 77$)	<.001	-0.38
Cartoony	0.03 ($n = 51$)	0.25 ($n = 49$)	<.001	-0.58
Manga	0.06 ($n = 50$)	0.20 ($n = 45$)	0.17	-0.34
Realistic	0.07 ($n = 23$)	0.34 ($n = 22$)	0.29	-0.45

We next asked whether this effect differed across global regions. After a significant Kruskal-Wallis result ($p < .001$), we found that inanimates are more marked by motion lines than animates in all global regions, see Table 1.[12]

Regarding style (Kruskal-Wallis, $p < .001$), inanimates are more marked by motion lines than animates in cartoony and real exaggerated, while in manga and realistic style the difference between animates and inanimates was not significant, see Table 1.

As mentioned in Section 2, we performed the same analysis excluding early annotations (36 comics with motion lines) due to slightly different criteria of annotation. We found the same pattern as above. In the overall data, we found that inanimates ($Mdn = 0.20$, $n = 162$) are more marked by motion lines than animates ($Mdn = 0.04$, $n = 175$), $p < .001$, $r = 0.47$. The same is the case for all global regions, all adjusted $p < .037$, while the styles follow the same pattern as when the whole dataset is considered, as above. In cartoony and real exaggerated inanimates are more marked by motion lines than animates, $p < .001$, and the difference between them is not significant in manga, $p = 0.2$, and the realistic style, $p = 0.22$.

3.2 Circumfixing lines

We next examined circumfixing lines from the entire corpus, as shown in Figure 6 under "All data". We found no difference between the marking of animates and inanimates with circumfixing lines, $p = 0.23$, $r = 0.08$, animates $Mdn = 0.06$, inanimates $Mdn = 0.09$.

[12]Note that Cliff's Delta has negative values, while the Rank-Biserial Coefficient we calculated for the overall data is positive even though they refer to the same trend. This is because Rank-Biserial Coefficient is positive if animates tend to have lower ranks than inanimates, while Cliff's Delta is negative if more elements in animates are less than elements in inanimates.

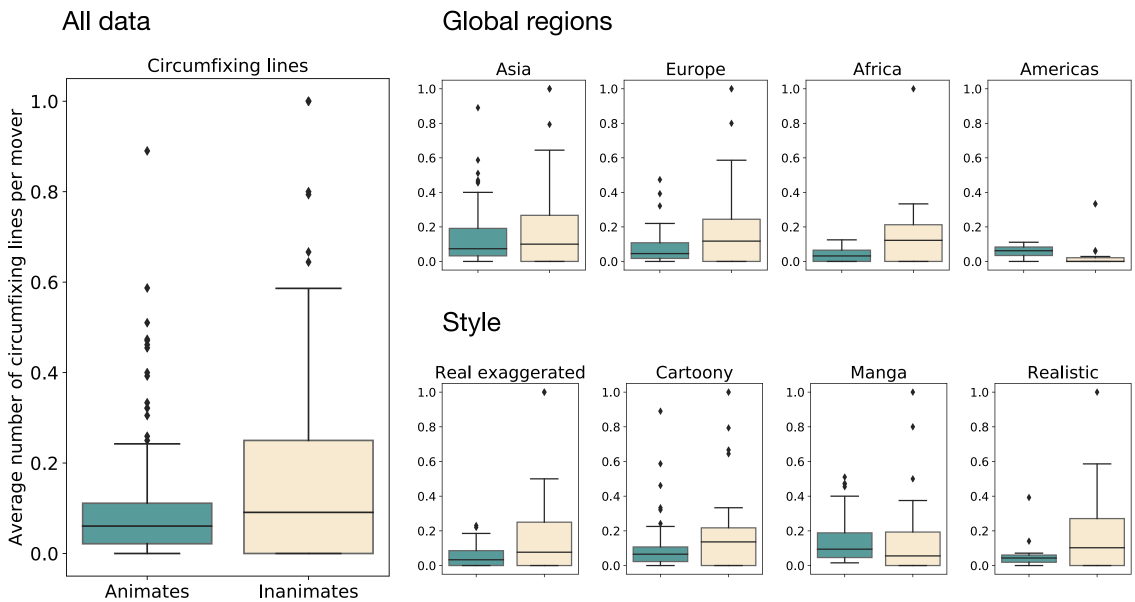

Figure 6: Left: Average number of circumfixing lines per animate/inanimate mover per comic, $n = 167$ (animates), 152 (inanimates). Right: Plots for each global region and style, cf. Table 2.

Table 2: Results for circumfixing lines per global region and style

Global region	*Mdn* (animates)	*Mdn* (inanimates)	p (adjusted)	δ
Asia	0.07 ($n = 68$)	0.10 ($n = 58$)	1	-0.03
Europe	0.05 ($n = 61$)	0.12 ($n = 58$)	0.78	-0.24
Africa	0.03 ($n = 17$)	0.12 ($n = 16$)	0.79	-0.42
Americas	0.06 ($n = 18$)	0 ($n = 18$)	1	0.61
Style	***Mdn* (animates)**	***Mdn* (inanimates)**	**p (adjusted)**	**δ**
Real Exaggerated	0.03 ($n = 55$)	0.08 ($n = 51$)	0.4	-0.24
Cartoony	0.07 ($n = 46$)	0.14 ($n = 45$)	1	-0.14
Manga	0.09 ($n = 49$)	0.06 ($n = 40$)	0.9	0.23
Realistic	0.04 ($n = 17$)	0.10 ($n = 16$)	1	-0.14

We next turned to examine whether differences would arise between global regions. After a significant result from the Kruskal-Wallis test ($p < .001$), we compared the average numbers of circumfixing lines per animate and inanimate movers across all global regions, but there were no significant differences, as shown in Table 2. The same was the case for circumfixing lines and style, despite a significant Kruskal-Wallis test ($p < .001$), see Table 2.

As mentioned in Section 2, we performed the same analysis excluding early annotations (i.e., 30 comics with circumfixing lines) and we found the same pattern as above. There is no difference in the amount of marking between animates ($Mdn = 0.06$, $n = 137$) and inanimates ($Mdn = 0.11$, $n = 124$) with circumfixing lines in the overall data, $p = 0.13$, $r = 0.11$. The same is the case for all global regions (all adjusted $p > 0.22$), and styles (all adjusted $p > 0.42$).

Figure 7: Example of motion lines co-occurring with circumfixing lines. The traversed path is marked by motion lines, which leads to the interpretation of direction, additionally indicated by figure's posture. The direction of the movement of the arms marked by the circumfixing lines is ambiguous but compatible with the overall direction. From "Archie's Friend Scarlet" by Ray Felix and Fernando Ruiz (Felix & Ruiz, 2017), © Archie Comics.

4 Discussion

4.1 General discussion

In this study, we asked whether animates or inanimates are more morphologically marked in comics. Given that inanimates are not expected to move in a goal-directed way (Opfer, 2002), we hypothesized that they might need more marking when they are moving in a goal-directed way, and this expectation was supported by our results. Inanimates are more marked by motion lines than animates in our dataset of comics. This finding persisted across all global regions and artistic styles except for manga and realistic comics, which suggests a universal tendency. Unlike motion lines, circumfixing lines, which do not disambiguate the direction of motion in comics, did not differ regarding the marking of animates and inanimates, and this finding held across all global regions and styles. These differing results when it comes to motion lines and circumfixing lines suggest that goal-directed movement is indeed a distinguishing feature between animates and inanimates in the visual language(s) used in comics. Additionally, we interpret these results as indicating a more general cognitive preference for grammatical marking of elements occurring in unexpected roles, which we call *Mark the unexpected!*. We discuss these findings below in more detail.

In comics, animate figures are depicted as moving from one panel to another, while inanimate objects are typically stationary elements in the background. This is in accordance with the expectation that animate figures move in a goal-directed way by default (i.e., animacy preference in this paper), while inanimates do not. Since inanimates are not expected to occur as agents (Fauconnier, 2011) nor engage in goal-directed movement (Opfer, 2002), we hypothesized that overt morphological marking signaling goal-directedness is required to show that they move along a path. Thus, motion lines which indicate the traversed path by marking a relative starting point and an endpoint would be needed for inanimate movers to disambiguate their direction. With animates, on the other hand, the goal-directed movement is inherently expected and can be understood by perceptual cues specific to animates, such as limbs and posture (Kawabe & Miura, 2006; Hafri et al., 2013), which might facilitate the interpretation of direction even when there are no motion lines. Therefore, motion lines would be less needed, compared to inanimates, to signal this type of movement.

Overall, our results suggested that that is the case in our corpora, even when possible cultural effects are considered, given that our results did not differ across different global cultural regions. Regarding artistic styles, we found the same result of inanimates being more marked than animates in the cartoony style and real exaggerated. However, the difference between animates and inanimates was not significant in manga and the realistic style. Despite a substantially higher median of inanimates with motion lines compared to animates in manga and realistic, suggesting a similar tendency as the rest of our results, the wide spread of inanimate data points and a low number of comics in the case of realistic could have led to the lack of statistical difference between animates and inanimates. The causes for why these two styles differ in this way warrants further research, which would also benefit from a larger sample of comics, especially in the case of the realistic style.

Regarding circumfixing lines, which typically do not indicate the direction of motion in comics and therefore cannot disambiguate goal-directedness, we hypothesized that they would not be modulated by animacy. We confirmed that there was no significant difference between the marking of animates and inanimates with circumfixing lines, which held across all global regions and all styles. This is exactly in line with our expectations regarding the animacy preference. Since circumfixing lines do not specify goal-directedness, they are compatible with both goal-directed and aimless movement. This makes them equally compatible with the expected movements of animates and inanimates. Their compatibility with different types of movement can be illustrated with the following example. In Figure 7, a running figure with motion lines indicating their direction also has circumfixing lines around their arms signaling the back-and-forth movement of the limbs without a specified direction. This shows that circumfixing lines are compatible not only with different expectations around goal-directedness, but also that they can co-occur with explicitly goal-directed movements. We can conclude that there are no violations of the expectations about the movement of animates and inanimates that circumfixing lines could disambiguate. It is therefore expected that we observe no difference between the marking of animates and inanimates with circumfixing lines. We summarize our findings in Table 3.

In the next section, we take these findings to argue for an existence of a cognitive principle rooted in surprisal minimization, which we call *Mark the unexpected!*.

Table 3: Relationships between the marking strategies and animate/inanimate entities in the visual language of comics.

Marking	**Animate** (goal-directed movement expected)	**Inanimate** (goal-directed movement not expected)
Motion lines (goal-directed movement)	less marked	more marked (*Mark the unexpected!*)
Circumfixing lines (any movement)	compatible	compatible

4.2 Mark the unexpected!

While the notions of disambiguation (Fedzechkina et al., 2012), unexpectedness (Fauconnier, 2011), efficiency (Hawkins, 2004; Haspelmath, 2019; Fedzechkina & Jaeger, 2020) and surprisal minimization (Friston, 2010) have been explored extensively in the literature, we claim that the current study in the context of these previous works points to a particular feature of grammar in language, including the visual language of comics, that has not yet been formulated in this way.

The phenomenon of inanimates being more marked than animates by motion lines in comics in our data mirrors the mechanism of unexpectedness (Fauconnier, 2011) at play in Differential Object Marking in spoken language, which we expand here to a more general cognitive principle *Mark the unexpected!*. We should note that we would not expect marking to appear in the same way across modalities, but rather that general cognitive principles may manifest in ways that adapt to the affordances of each modality (Cohn & Schilperoord, 2024).

One notable difference between the visual phenomena analyzed in this study and the Differential Object Marking in language is that the latter is contingent on identifying the animates and inanimates as agents or direct objects. Instead of making a direct parallel to spoken language, here we focus on goal-directed movement as a relevant cognitive feature of animacy signaled by motion lines in comics. Thus, we broaden the scope of the notion of unexpectedness (Fauconnier, 2011) to visual language. We argue that *Mark the unexpected!* should be considered as a principle of organization of patterns of grammatical systems that makes it easier to reconcile conflicts between the expected patterning of form (subject/direct object) and meaning (animate/inanimate). We describe *Mark the unexpected!* in more detail in the following paragraphs.

We propose that *Mark the unexpected!* relies on the notion of surprisal minimization or free energy principle (Friston et al., 2006; Friston, 2010). Surprisal minimization assumes that agents act in ways in order to remain in a restricted set of preferred states and minimize their surprisal, resisting a natural tendency to disorder (Friston, 2010; Mazzaglia et al., 2022). In this theory, the brain is a predictive machine (Clark, 2016) that aims at diminishing surprisal to maintain an optimal state. Applied to spoken or signed languages, and visual languages in our case, humans typically prefer one interpretation of a stimulus, even when more interpretations are possible (Van der Helm, 2000). Thus, in our study, in cases where goal-directed movement was not expected, additional morphology marked the unexpected in order to reduce surprisal. We now explain in more detail the implications of applying the theory of surprisal minimization to our results.

The bias of human attention for the monitoring of animates as opposed to inanimates (New et al., 2007), together with the fact that the sequential nature of visual languages used in comics indicates previous motion (cf. Abrams & Christ, 2003) of drawn characters as salient figures in a story (cf. Zarcone et al., 2016), leads to a strong expectation that animates should move from one panel to the next. Due to its association with volition and sentience, goal-directed movement is expected from animates (Opfer, 2002) and can also be easily indicated by perceptual cues, such as posture (Kawabe & Miura, 2006; Hafri et al., 2013). All these cues make the number of possible interpretations regarding the type of movement of an animate figure quite low. In other words, the expected interpretation is the one of goal-directed movement. This means that for animates, the default surprisal is low regarding their motion interpretation.

Inanimates, on the other hand, pose much more of a challenge in terms of interpreting their motion. Not only do humans pay less attention to inanimates (cf. New et al., 2007), but there is also a higher number of possible states associated with them, and thus more possible interpretations of their motion. This is because inanimates cannot move on their own, and thus, any motion of inanimates has a high surprisal by default. Certain visual cues and specific contexts, such as seeing the source manipulating or moving an inanimate object (e.g., a person throwing a ball) can disambiguate that an inanimate object is in a goal-directed movement (Hacımusaoğlu & Cohn, 2024). However, our data show that on average, the higher intrinsic surprisal of the inanimate motion, compared to animate, leads to more marking of inanimates by means of goal-directed motion lines. We argue that the necessity for disambiguation via marking in grammar can be united in a single cognitive principle *Mark the unexpected!*.

Given the above explanation, we might ask why animates have motion lines at all, if they are expected to be moving in a goal-directed way by default, that is regardless of the presence of motion lines. Marking animates with motion lines is sometimes required because they do not only indicate goal-directedness, but index the full traversal of the path, including the starting point (Hacımusaoğlu & Cohn, 2023; Hacımusaoğlu & Cohn, 2024). In certain contexts, the omission of motion lines makes drawn actions harder to process, which can evoke brain responses comparable to the processing of incongruous motion lines with a reversed direction of motion, i.e., towards a source (Cohn & Maher, 2015). Furthermore, motion lines serve other functions, such as indicating higher speed than when no lines are present (Hacımusaoğlu & Cohn, 2024), and conveying manner of motion (i.e., the characteristics of the motion) with their varying shapes, such as twirling or bouncing (Hacımusaoğlu & Cohn, 2023).[13]

Another question that might follow from our discussion is why animates do not get additional marking when they are *not* moving in a goal-directed way, since that behavior would be unexpected in light of the above arguments. The answer to this requires us to make a comparison to spoken language. A plausible equivalent to the case where animates are marked when not moving in a goal-directed way would be Differential Agent Marking, where inanimates are morphologically marked for the unexpected role of agent (Fauconnier, 2011). However, Differential Agent Marking is exceedingly rare in the languages of the world (Fauconnier, 2011), while the marking of animates in the role of an object with Differential Object Marking is exceedingly common (e.g. Haig, 2018). This disparity and apparent lack of need to mark animates when they are not moving in a goal-directed fashion can be explained in the following way.

Animates are rarely ever stopped in an absolute sense; for example, an animate may sit still but move their head or limbs. The available marking for aimless, non-goal-directed movement are circumfixing lines, which are also compatible with all types of movement. Further research is necessary to ascertain whether circumfixing lines fulfill this structural gap of marking animates moving in a non-goal-directed way, or whether they are a piece of a more complex system.

We offer an alternative explanation, which resorts to an avoidance strategy, similar to the structural avoidance of inanimate agents in spoken languages and Differential Agent Marking (Fauconnier, 2011). In other words, animates not moving in a goal-directed way are so rare in the real world that, when it comes to visual languages, these types of situations are avoided altogether, or marked by circumfixing lines.[14] When these cases do appear, they might indicate an extraordinary situation or even the death of an animate entity. Thus, surprisal can in this case be mitigated by inference, which is readily available for such extraordinary situations. A regularized grammatical marking might be more needed in cases where surprisal gets heightened often enough that a systematic lowering of surprisal is needed, but not

[13]Note that, in certain cases, shapes of motion lines can be more indicative of the artistic style than of the actual characteristics of motion. For example, the twirling shape is often used in the *ligne claire* style even when the motion is not twirling. This shows that the shape of motion lines can become so conventionalized that its relation to the path shape is somewhat arbitrary.

[14]An important thing to consider is that limbs on animates can be moving aimlessly, while the orientation of the entire body indicated by posture and/or motion lines can remain goal-directed, as in Figure 7. Aimless movement of the entire body of an animate is presumably a much rarer occurrence.

often enough that the low surprisal becomes the default. In our case, inanimates move in a goal-directed way in comics often enough that the strategy of using motion lines emerged. However, the goal-directed motion of inanimates is still too rare to become the default type of motion expected from inanimates. This indicates that *Mark the unexpected!* might be directly governed by frequency of usage and its relationship with surprisal. In fact, *Mark the unexpected!* interpreted in this way could be seen as one of the core features of grammar, that is to manage surprisal in cases that are frequent enough to form patterns. Beyond grammatical systems, *Mark the unexpected!* could be at play as a cognitive principle in other systems, such as music, where surprisal plays a role in the organization of the system (Cheung et al., 2019).

The fact that the morphological marking of motion lines is an important strategy of disambiguation in visual languages shows that it relies on grammatical principles. In theory, inference could be sufficient to yield correct interpretations of goal-directed inanimate movement (e.g., a ball in the air leads to the inference that the ball is moving). Given that morphological marking is on average a necessary strategy per our results, and functionally equivalent to what we observe in language with differential marking, it provides further evidence that visual languages share structural properties with spoken languages. This suggests that shared cognitive principles underlie systems of communication across modalities, tailored to the affordances of those modalities. The fact that our results did not differ across different cultures and styles of comics, and that they mirror the structures modulated by animacy in spoken and sign languages, strengthens the idea that *Mark the unexpected!* is a good candidate for a cognitive universal.

5 Conclusion

In our corpus study, we found that animacy preference and goal-directed movement play a role in the morphological marking of motion in the visual language of comics of different cultures and styles. We defined the animacy preference as the expectation that animates are moving in a goal-directed way, while inanimates are not (cf. Opfer, 2002). By analyzing animates and inanimates marked by motion lines, which are goal-directed, and by circumfixing lines, which are compatible with all types of movement, we tested the role of goal-directedness in relation to animacy in visual languages. We found that inanimates are more marked with motion lines than animates, while there is no such difference in marking with circumfixing lines. This suggests that goal-directedness is a decisive cue of animacy in visuals. It also mirrors the pattern we observed in languages with the Differential Object Marking, where animate direct objects are more grammatically marked because their animacy is interpreted as misaligned with their passive status as a syntactic object. Similarly, inanimates moving in a goal-directed way in visuals are misaligned with the expectation of inanimate movement as non-goal-directed, and have to be more morphologically marked with motion lines. We argued that this misalignment is reconciled via additional morphological marking due to the cognitive principle *Mark the unexpected!*.

We defined *Mark the unexpected!* as a principle of surprisal minimization, which might be one of the core principles of grammar organization. Since animates are expected to be moving in a goal-directed way, the surprisal of goal-directed animates is typically low. The movement of inanimates, on the other hand, is typically not expected to be goal-directed (Opfer, 2002). Thus, when inanimates move in a goal-directed way, surprisal is high. Our results indicate that, in comics, this surprisal was lowered by the morphological marking of motion lines. We argued that this mechanism of lowering surprisal by marking can be generalized to both spoken and visual languages as *Mark the unexpected!*. We further argued that *Mark the unexpected!* could be a cognitive principle that stands at the core of grammar organization. Grammatical marking might be needed, generally speaking, only when surprisal gets heightened often enough that its systematic lowering in form of marking is required, but not often enough that the interpretation with low surprisal becomes the default.

Given the cultural diversity of our dataset spanning across 81 countries and the fact that our results did not differ across different global regions and most artistic styles, our findings about the nature of the animacy preference in visuals are a strong candidate for a cognitive universal that can be formulated as *Mark the unexpected!*. We showed that *Mark the unexpected!* applies to the spoken language as well as the visual language(s) used in comics and, thus, provides support for the idea that shared cognitive principles underlie communication across different modalities.

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