Acta Psychologica 159 (2015) 22–32

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

The psychophysics of comic: Effects of incongruity in causality and animacy

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ARTICLE INFO

Article history:
Received 4 September 2014
Received in revised form 17 April 2015
Accepted 5 May 2015
Available online xxxx

Keywords:
Comic perception
Animacy
Causality
Michotte's launching paradigm
Violations of causality
Experimental phenomenology

ABSTRACT

According to several theories of humour (see Berger, 2012; Martin, 2007), incongruity – i.e., the presence of two incompatible meanings in the same situation – is a crucial condition for an event being evaluated as comical. The aim of this research was to test with psychophysical methods the role of incongruity in visual perception by manipulating the causal paradigm (Michotte, 1946/1963) to get a comic effect. We ran three experiments. In Experiment 1, we tested the role of speed ratio between the first and the second movement, and the effect of animacy cues (i.e. frog-like and jumping-like trajectories) in the second movement; in Experiment 2, we manipulated the temporal delay between the movements to explore the relationship between perceptual causal contingencies and comic impressions; in Experiment 3, we compared the strength of the comic impressions arising from incongruent trajectories based on animacy cues with those arising from incongruent trajectories not based on animacy cues (bouncing and rotating) in the second part of the causal event. General findings showed that the paradoxical juxtaposition of a living behaviour in the perceptual causal paradigm is a powerful factor in eliciting comic appreciations, coherently with the Bergsonian perspective in particular (Bergson, 2003), and with incongruity theories in general.

1. Introduction: the comic appeal of incongruity

From Aristotle to Kant, Schopenhauer, Bergson, Freud and many other thinkers, philosophers and scientists have always been fascinated by humour, and have tried to understand what humour is or why something looks funny. The ability to perceive it is "instinctive" and universal, and recent evolutionary theories claim that it is likely to rely on a genetically based neurological substrate (Polimeni & Reiss, 2006).

Because of the multilayered nature of humour, involving cognitive as well as social and emotional human competences, several different theories of humour have been developed. The most widely accepted nowadays in experimental psychology is *incongruity theory*, formulated by Koestler in 1964 (Berger, 2012; Martin, 2007). Incongruity theory, dating back from Aristotle's *Rhetoric*, and then further developed by Kant, Kierkegaard and Schopenhauer, emphasizes the crucial role of incongruity in humour appreciation. Incongruous events can take place on different dimensions, such as linguistic, logic, related to identity or to action (Berger, 2010, 2012; Deckers, 1993; Martin, 2007; McGhee, 1979; Rothbart, 1976; Rothbart & Pien, 1977; Shultz, 1976; Suls, 1972; Veatch, 1998). Specifically, the aim of the research reported in this paper is to see if incongruity theories may be investigated in the perceptual field, by manipulating the causal paradigm introduced by Michotte (1946/1963) to assess if paradoxical visual contingencies are effective in eliciting comic impressions.

According to Koestler (1964), incongruity involves the juxtaposition of two incongruous frames of reference — that is, the simultaneous presence of two contradictory meanings. Following this theory, the violation of an expected pattern may provoke humour in the observer.

This happens, for instance, with the perceptually plausible – but ecologically impossible – events that we see in many visual puns or in animated cartoons, as in the classical sketches of Walt Disney's movies. In these situations incongruity often takes place between the first phase of the event, which creates an expectation coherent with mechanical or bio-mechanical laws, and the second phase, in which this expectation is not met. We can evoke, for instance, the scene in which Mickey Mouse, on the baseball diamond, winds up to throw the ball and provokes such a vigorous action as to be propelled into the air like a helicopter. Or we can think of the surprising elastic-like stretched body of Mickey Mouse when Peg Leg Pete pulls him, or of the sudden change of a cow into a barrel organ[1] (see Figs. 1 and 2). So it seems reasonable to assume that causal violations do have the power to prompt a comic reaction.

One critical point of the incongruity approach is that not all incongruities are funny (Shultz, 1976; Suls, 1972); according to the theory of humour formulated by Henri Bergson, another philosopher who can be identified with the incongruity theory (Berger, 2010), a

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[1] See Thomas & Johnston, 1981; Ejzenstejn, 2004.

http://dx.doi.org/10.1016/j.actpsy.2015.05.002
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Fig. 1. Taken from: Walt Disney Treasures — Behind the Scenes at Walt Disney Studio, 2002/1956, "The plausible impossible". © The Walt Disney Company.

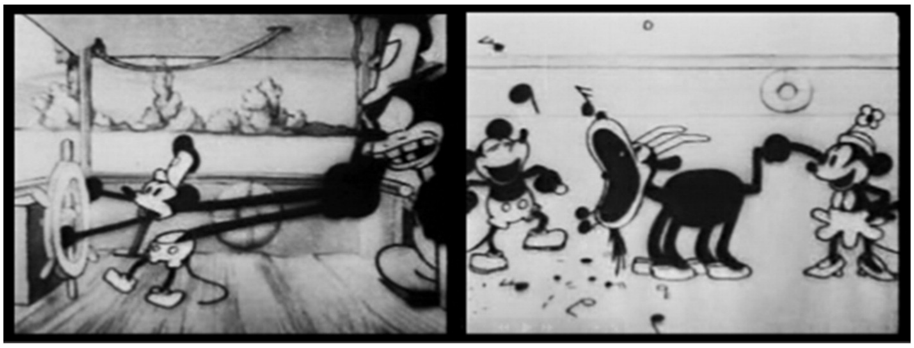

Fig. 2. Taken from "Steamboat Willie", the short film produced by the Walt Disney Production in 1928. © The Walt Disney Company.

disproportion of causality is not a sufficient condition to get comicality (Bergson, 1900/2003). More precisely, one of the most comic incongruities, Bergson suggests, is the perception of an animate or psychological behaviour embodied in a mechanical structure, maintaining that "any arrangement of acts and events is comic which gives us, in a single combination, the illusion of life and the distinct impression of a mechanical arrangement" (Bergson, 1900/2003, p. 45). For instance, an inanimate object always elicits humour when it evokes human behaviour (e.g. a puppet, or the *jack-in-the-box* trick), and, vice versa, human behaviour becomes funny when it exhibits mechanical attributes. Following Bergson, it would therefore seem that a specific kind of incongruity, the one in which causal incongruities are juxtaposed to psychological features, should be generally appropriate to elicit the impression of comic.[2]

1.1. Perception of causality, animacy and Michotte's experimental paradigm

Causal incongruities, intended as mechanical disproportions as well as inconsequential social contingencies, can be accidentally observed in everyday life or intentionally framed up in event perception, as in the case of cartoons, every time spatiotemporal contingency unifies two different events in one unitary incongruous configuration.

According to the gestalt psychologist Karl Duncker (1935/1969) (see also Bozzi, 1969, 1990), two discontinuities – in a homogeneous field – close in the temporal dimension, are spontaneously grouped and, paradoxically, causally related one to the other. This happens, for instance, when a gust of wind suddenly shuts the door and in the same instant a light comes on in the opposite side of the hallway. We *know* that there is no causal relationship between the two events, however we *perceive* a cause–effect relationship even if it is "implausible", so crucial is the temporal coincidence (Duncker, 1935/1969).

Starting from Michotte's (1946/1963) and Heider and Simmel (1944) seminal demonstrations, a large body of researches investigated the basic spatiotemporal conditions leading to causal perception. Even if causality and animacy are typically associated with higher levels of cognitive processing, there is now considerable agreement that the detection of causal relationships is rooted in the early visual processes, as it appears to be: largely automatic, irresistible, resistant to higher-level beliefs and intentions, and driven by highly constrained and stimulus-driven visual cues (see the review by Scholl & Tremoulet, 2000; Costall, 1991; Hubbard, 2013a, 2013b; Leslie, 1982; Leslie & Keeble, 1987; Opfer & Gelman, 2010; Runeson & Frykholm, 1983; Schlottmann & Shanks, 1992; Scholl & Gao, 2013; Wagemans, Van Lier, & Scholl, 2006; White, 1995). Moreover, the visual system seems specifically tuned for discriminating mechanical and social contingencies "in order to detect the presence of (physical or social) information in the local environment that cannot be deductively inferred, but that is of critical importance to our fitness and survival" (Scholl & Gao, 2013).

Michotte and his followers have studied the laws of causal perception with a phenomenological approach, introducing an experimental paradigm known as launch effect (Michotte, 1946/1963): a first square A moves towards a second stationary square B. After the contact, square A stops and square B starts to move along the same trajectory, but with a slower speed. We perceive this event as a mechanical collision, in which the motion of the second object B appears to be caused by the motion of the launcher A, as if 'pushed' forward.

As a matter of fact, temporal contingencies in the interaction of simple geometrical shapes can lead to two different perceptual outcomes, i.e. mechanical collisions or social causality, depending on whether the Newtonian principles are respected or violated (e.g. Gelman, Durgin, & Kaufman, 1995; Tremoulet & Feldman, 2006), or in relation to the

[2] Ejzenstejn (2004) applies this hypothesis to his analysis of the Walt Disney's animated cartoons (see Parovel, 2012).

presence of animacy cues in the trajectories (Schlottman & Surian, 1999; Schlottmann, Ray, & Cownie, 2006). So, even incongruent events, in which the two movements are heterogeneous or in some other way inconsequential, but close in space and in time, are always unified in a causal structure, qualitatively dependent on the global arrangements (see Parovel & Casco, 2006).

In the *trigger effect* (Michotte, 1946/1963), for instance, the sequence between the movement of the first square and the movement of the second one fails to respect the mechanical laws of collisions, as the second object is much faster than the first. Consequently, the movement of the second square has an active and self-propelling character, qualitatively very different from the "pushed-like" passive motion of the second square in the launch effect (Michotte, 1946/1963; see Thinès, Costall, & Butterworth, 1991). Incidentally, when Michotte described the trigger effect, he reported in a note that it looked comical. He briefly explained this effect in terms of a *disproportion* between the first and the second part of the event, the cause and the effect.

Successive researches exploring the trigger display showed that the perception of a "living" behaviour could be enhanced by varying the spatiotemporal structure. For instance, if the second object B is much faster than A, like in the trigger event, but begins to move before contact, it seems clearly "escaping" from the first, effect named "intentional reaction" (Kanizsa, 1991; Kanizsa & Vicario, 1968) and more recently "social causality", or "psychological causality" (Schlottmann, Allen, Linderoth, & Hesketh, 2002). Observers spontaneously report that the second object "runs away from the first", like "to avoid him", or "because it is afraid".

Another animacy cue which can effectively interact with perceptual causality is the motion of non-rigid expanding and contracting squares, suited in generating a powerful impression of caterpillar-like or frog-like locomotion, as observed firstly by Michotte (1946/1963) and later by Schlottman and Surian (1999) and Schlottmann et al. (2006), who showed that the non-rigid agent produces an increase in the number of attributions of social causality and animacy (Schlottmann & Ray, 2010). By the way, non-rigid deformations are also very close to Walt Disney's animation technique named "squash and stretch" (Thomas & Johnston, 1981), used to enhance the funniness of cartoons.

Other animacy or intentionality cues are, for instance, the C-shaped or S-shaped path of the trajectory (Blythe, Miller, & Todd, 1996, 1999; Gelman et al., 1995; Stewart, 1984), self-propulsion (Csibra, 2008; Dasser, Ulbaek, & Premack, 1989; Markson & Spelke, 2006; Schlottmann & Ray, 2010), synchronous movements (Bassili, 1976), increased acceleration and/or heading (Tremoulet & Feldman, 2000), speed and direction changes (Träuble, Pauen, & Poulin-Dubois, 2014) and certain patterns of approach or avoidance (Dittrich & Lea, 1994; Gao, Newman, & Scholl, 2009; Gao & Scholl, 2011; Pavlova, 2012; Schultz, Friston, O'Doherty, Wolpert, & Frith, 2005), or by mimicking the motion of naturally occurring stimuli (Schultz & Bülthoff, 2013). Moreover, in the absence of acceleration, it has been demonstrated that an object travelling at a relatively faster constant speed is more likely to be perceived as animate (Szego & Rutherford, 2007; Visch & Tan, 2009).

Other researchers investigated the emotional attribution of dynamic minimal expressive stimuli, and their relationship with genre recognition (Visch & Goudbeek, 2009; Visch & Tan, 2009). Visch and Tan (2009) adopted a basic chase scene between two abstract blocks, and varied the chasing object with respect to five parameters: velocity, efficiency, fluency, detail, and deformation. Interestingly, in their experiment animacy does not significantly correlate with emotion ratings, including funniness. Emotional responses (funny, sad, impressive, and scary) were however found to be related to genre categorization (i.e., comedy, drama, action, and non-fiction) and with some of the movements parameters considered. With respect to funniness, it seemed to be related to either very low or very high levels of directness of the chaser's track (i.e. efficiency) and of bodies deformation; to low levels of fluency smoothness of velocity transitions and to high levels of temporal density of velocity changes (i.e. detail).

1.2. The current study

All these causal demonstrations are generally fascinating and surprising to observe, because of their paradoxical and "living" character, but in which measure and in which conditions are they also funny, as Michotte noted? Apart from his incidental observation, so far there have been almost no empirical investigations about the emergence of comical effect in the perception of launching paradigm. At the same time, it would seem that Michotte's experimental display is particularly appropriate to generate causal contingencies that are incongruent with respect to a mechanical launch, potentially involving both the perception of social causality and animacy, and the perception of merely mechanical incongruities. This could, in turn, allow comparing different theories of humour by testing specific predictions derived by them with psychophysical methods, relative to the perception of surprising causal events, with or without the clear impression of a psychological behaviour embodied in a mechanical structure.

One previous exploratory experiment carried out by Bressanelli and Parovel (2012) supported this proposal. This research showed that incongruity between cause and effect provokes a comic impression if the two geometrical objects are perceived as animate agents, whereas if a mechanical incongruity is perceived between cause and effect, the event can generate a surprise reaction, but the comic impression is generally weaker. Bressanelli and Parovel tried variously shaped objects and differently-shaped trajectories in the second part of the causal event (i.e. the effect), and found that a "jumping-like" shape of the path was judged an animated motion and obtained the higher results in terms of comicality.

The aim of our research was to broaden previous results and investigate with different psychophysical methods the role of causal incongruities based on animacy cues in the Michotte's launching paradigm to get a comical effect. We run three experiments. In Experiment 1, we tested the role of the speed-ratio between the first and the second movement and the effect of incongruities based on animacy cues in the second movement; in Experiment 2 we manipulated the temporal contingency by varying the duration of the delay between the end of the first movement and the beginning of the second movement to check if the comic effect is strictly dependent on the perception of causality or not; and finally, in Experiment 3, we compared the strength of the comic impressions arising from incongruent trajectories based on animacy cues with those arising from incongruent trajectories not based on animacy cues in the second part of the causal event.

2. Experiment 1: the role of the speed-ratio and animacy cues

The aim of this experiment was to investigate the role of the speed-ratio between the two movements in launching paradigm, and the effect of the presence of animacy cues in the movement of the second square, i.e. a *frog-like* expanding and contracting motion and a *rabbit-like* jumping trajectory, in the emerging of comic impressions. Varying the speed-ratio in linear trajectories, moreover, we obtained both the optimal stimulus conditions of the Michotte's launching paradigm, where the first movement is faster than the second, and the stimulus conditions of the trigger paradigm (Michotte, 1946/1963), in which the second movement is faster than the first. In this way we could also check if the trigger event elicited comic impressions as reported by Michotte (1946/1963).

2.1. Method

2.1.1. Participants

Participants were 15 university students (11 females). Mean age of the participants was 23.6 years (SD = 2.6 years). All participants reported normal or corrected-to-normal vision.

2.2. Design

The stimuli were designed starting from the launching paradigm (Michotte, 1946/1963), where one square moves towards a second square, which appears to be 'pushed' away by the first. We varied this configuration by modifying the shape of the trajectory of the second square in two different ways, in order to obtain three main stimulus conditions: 1) linear trajectory; 2) frog-like expanding and contracting trajectory; and 3) rabbit-like jumping trajectory (see Fig. 3). For each of these conditions, 4 versions were generated by varying the speed of each square on two levels (slow, fast) independently. This resulted in 12 stimuli corresponding to all the possible combinations of 3 factors: the *trajectory* of the movement of the second square (3 levels), the *speed of the first square* and the *speed of the second square* (2 levels each).

The experiment included a total of 132 trials, consisting of two repetitions of all the 66 pairwise comparisons of the 12 stimuli. The order of presentation of the stimuli was balanced across repetitions (i.e. given stimuli A and B, A was presented before B in the first repetition A, and after B in the second). The trials were presented in randomized order (within each repetition) and grouped in four blocks of 33 trials each.

2.2.1. Stimuli

The stimuli were short Quicktime ® movies, of variable duration depending on the experimental conditions (from 1000 ms to 5000 ms).

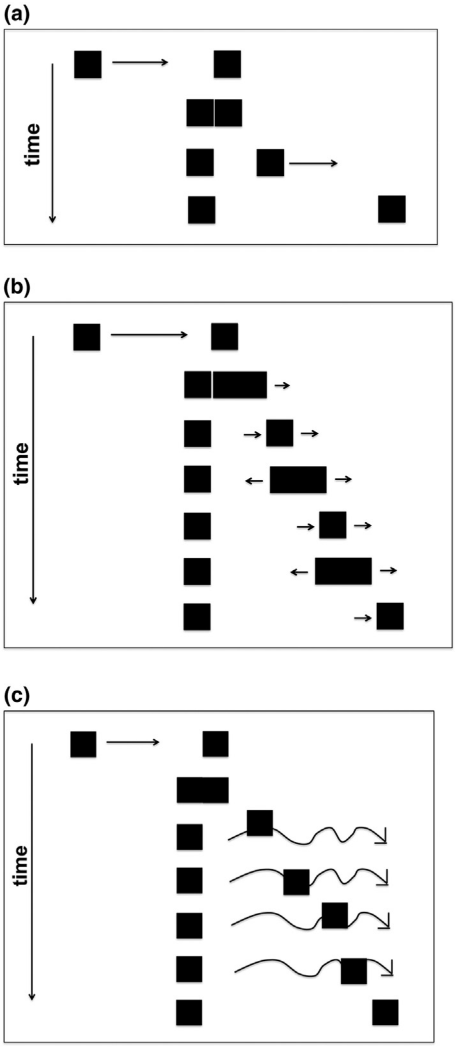

Fig. 3. Schematic illustrations of the stimuli adopted in Experiment 1: (a) linear trajectory; (b) frog-like expanding and contracting trajectory; and (c) rabbit-like jumping trajectory.

The first frame of each movie was the same, consisting of identical two black squares (side = 0.5°) inside a white rectangle (width = 12.2°, height = 8°) placed at the centre of the screen against a grey background. The squares were aligned along the horizontal midline of the rectangle. One square was horizontally displaced towards the left, so that it's left side was 3.8° away from the vertical midline of rectangle. The second square, instead, was slightly displaced to the right, so that its left side was laying along the vertical midline of the offset rectangle.

At the onset of the stimuli, the first square started to move horizontally towards the right with constant speed (on a straight path), stopping when its right side became adjacent to the left side of the second square. After a 30 ms delay, the second square started moving towards the right, stopping after the distance travelled horizontally was equal to the distance travelled by the first square (i.e. 3.8°), which remained still. The speed of the slow moving squares was 2°/s and the one of the fast moving ones was 12.6°/s.[3]

The stimuli were presented on a LED laptop monitor, with a screen measuring 11 in. diagonally, and participants viewed them from approximately 57 cm, with unrestricted head and eye movements.

2.2.2. Procedure

Participants were initially instructed about the nature of the task. They were told that on each trial they would see two simple movies, one after the other, and that their task was to choose which one had seemed more comical to them.

At the beginning of each trial, the fixation cross was presented on a grey background for 1500 ms. When the cross disappeared, the screen remained grey for another 500 ms, and then the first movie was presented and played. After the first movie stopped, the squares were removed and the white rectangle remained empty on the screen for other 1500 ms, before the second movie was played. After the second movie stopped, the screen turned grey again, and instructions were displayed to the participants, asking them to press the left key if they considered the first movie to be more comical, and the right key if they thought the second movie was more comical. At the end of each block of trials, participants were given the opportunity to take a short break before proceeding to the next block.

Stimuli presentation and data recording were controlled using PsychoPy2 v1.80.01 software running on a MacBook Air.

2.3. Results

Paired comparisons data were first analysed using the Thurstone–Mosteller scaling method (Mosteller, 1951; Thurstone, 1927a, 1927b), in order to derive relative "comicality" values for each of the 12 stimuli. Scale values were estimated fitting a generalized linear model (Critchlow & Fligner, 1991) to the data, using the "thurstone" function of the R package "eba". Confidence intervals for the scale values were also computed using the empirical formula proposed by Montag (2006).[4] The results of the scaling are plotted in Fig. 4(a) as function of the speed of the squares, and of the trajectory of the second square.

As can be seen in the plot, all the stimuli in which the speed of the second square was low (open symbols) are located in the lower half of the comicality scale, as opposed to the stimuli in which the speed of the second square was high (filled symbols). Moreover, for each given speed of the second square and type of trajectory, the stimuli were more comical when the first square moved fast (triangles) than when it moved slowly (circles).

[3] The speed along the articulated trajectories were approximately adjusted taking into account the different shapes of their paths, so that the second square appeared to have roughly the same speed of the first one, which moved on a linear trajectory.

[4] Given that n is the number of stimuli, and N the number of presentations of each pair times the number of subjects, according to Montag (2006) the standard deviation of the scale values can be computed using this formula: $\sigma_{obs} = 1.76 * (n + 3.08)^{-0.613}(N - 2.55)^{-0.491}$.

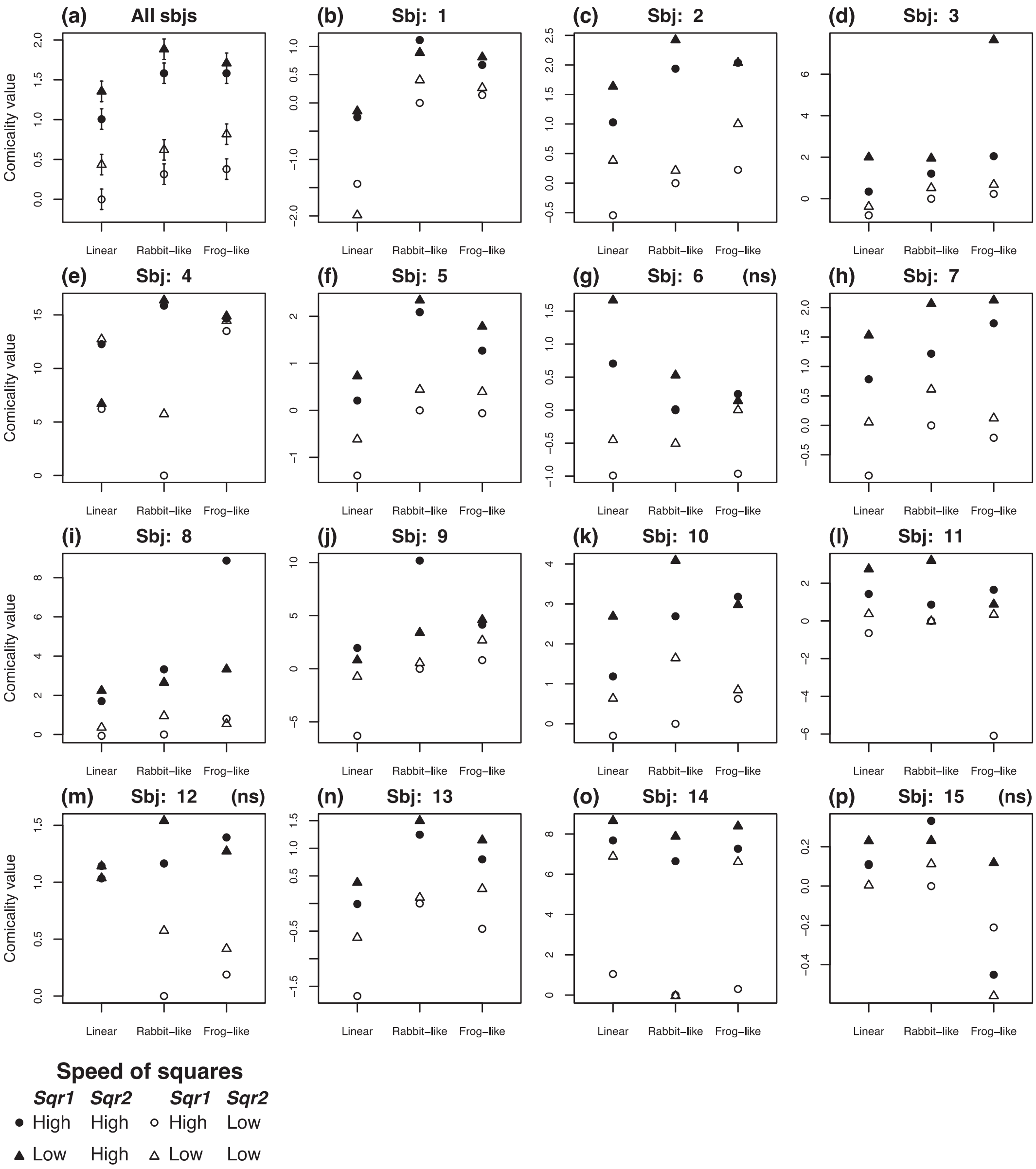

Fig. 4. Plots of the comicality values of the 12 stimuli as function of the speed of the squares and of the trajectory of the second square. Filled symbols represent stimuli in which the speed of the second square was high, and open symbols represent stimuli in which it was low. Circles represent stimuli in which the first square moved slowly, and triangles represent stimuli in which it moved fast. In (a), the values estimated using PC data from all the observers are plotted, with error bars representing confidence intervals. In (b–p), the scale values estimated for each observer separately are plotted.

Beside speed, also the trajectory of the second square seemed to determine comicality. For each given combination of speed for the squares, in facts, rabbit-like and frog-like trajectories were perceived as more comical than linear ones, although the effect seems only significant when the second square moved fast.

The statistical model exhibited a good fit to the data, and the log likelihood ratio test was not significant [$G^2(55) = 73.06$; *ns*], showing the existence of significant differences between the comicality of the stimuli (as opposed to no differences — Critchlow & Fligner, 1991). To verify the degree of individual variability in the perception of comicality, we also computed scale values for each participant. Out of 15 subjects, 12 exhibited significant preferences. The scale values for all the participants are plotted in Fig. 4(b–p), which allows verifying that, although comicality values of the stimuli did vary across observers, in most cases we can find either one or more of the effects that were evident in Fig. 4(a). Only the subjects for which the analysis did not reveal significant preferences (i.e. participants 6, 12, and 15) showed a different pattern of comicality values. In one case (subject 15) the range of the scale values is extremely compressed, suggesting that this observer did not perceive the stimuli as comically different. In the other cases the observers considered the linear trajectory more comical than the other two, either when the second square moved fast (subject 6) or when it moved slowly (subject 12).

To check whether there were differences between males and females in the perception of the comicality values of the stimuli we followed the procedure showed by Duineveld, Arents, and King (2000). In this procedure, likelihood ratio tests are used to compare a scaling model[5] having all the parameters (i.e. the scale values) restricted to be equal across groups (i.e. a model with a single set of parameters) to

[5] In this procedure, the stimuli scale values are derived fitting Bradley–Terry–Luce models (Bradley, 1984; Luce, 1959), which are slightly different from Thurstone–Mosteller models, although they yield very similar scale values on a ratio scale.

a more complex model allowing the parameter to vary freely across groups (i.e. one set of parameters per group).

The likelihood-ratio test showed significant differences between male and females [$G^2(11) = 97$; $p < 0.0001$]. However, when scale values were derived separately for females and for males, only the model for females exhibited a good fit to the data, as well as significant differences in the perceived comicality value of the stimuli. For males, conversely, the scaling model did not fit well the data, although significant differences were found in between the stimuli comicality values. We must however, notice that the lack of fit of the latter model could result from the limited number of male participants in the experiment. Moreover, all the 3 participants for which the Thurstone models did not fit well were males.

No differences were found instead in the perceived comicality values as function of the age of the participants. We must however notice that the limited sample size and the limited range of ages represented in the sample do not allow drawing definitive conclusion about whether or not age affects the comicality of the stimuli.

2.4. Discussion

The results of the first experiment seem to show that the introduction of animacy cues in the launching paradigm, for which the second movement is shaped as a life-like trajectory, increases the impression of comic. This effect is significantly greater in both the frog-like and rabbit-like trajectories, with respect to the reference case of a linear trajectory.

Moreover, the results seem to support an important effect of speed, in intensifying the amusing effect of animacy cues, and also in getting a funny impression even with linear movements, when the two movements are both fast, and when the first movement is slower that the second one. Michotte's observation about the comicality of trigger events, therefore, is confirmed here. The launching paradigm, in which the first object moves faster than the second, as in a mechanical collision, was not judged comic at all. Surprisingly, the trigger condition seems less funny than the condition in which both squares moved at the same high speed.

We propose two possible explanations for the effect of speed: first, the trigger condition may produce an impression of animacy because it displays a violation of Newton's mechanical laws, in that the pushed object has more kinetic energy than the preceding one; second, high values of speed might be themselves a cue of animacy, as other authors reported (see Szego & Rutherford, 2007). Consequently, when the two movements have the same velocity, but are both fast, they appear more alive that when they are both slow. We must notice, however, that even with low velocity values in both the movements, the addition of an animacy cue seems to enhance comicality.

In summary, three factors appear relevant in getting an amusing impression: the incongruity between the shapes of the two trajectories; the animal-like movement of the object (i.e. the non-rigid expanding and contracting locomotion or the jumping movement); the high value of speed.

Individual differences in the estimations of comicality, lastly, indicate that observers do not respond exactly in the same ways at the critical variables manipulated in the experiment, coherently with the literature on humour (see for instance Ruch & Hehl, 1998; Ruch & Köhler, 1998; Ruch, 2001). However, in this experiment, the majority of participants showed similar patterns of judgments about the comicality of the stimuli, and those who exhibit different patterns were mainly males, so it also possible that gender differences could play a role in our results, although further tests should be necessary to clarify this issue.

Finally, we should notice that while paired comparisons allow investigating even small differences in the perception of a given attribute of interest (in this case the comicality value of the different stimuli), the scaling results are only relative, and not absolute. In other words, paired comparisons do not speak about the degree to which the stimuli were actually considered funny, and it is possible that even those which were considered more comical, were still actually not funny.

3. Experiment 2: the role of temporal contingency

In Experiment 2 we investigated the role that temporal contingency in perceptual causality plays in evoking comic impressions in the observers. According to our main hypothesis, derived from the Bergsonian theory, the incongruity emerging from the juxtaposition of a living behaviour inside a mechanical event (mechanical causal relation) should look funny. In this experiment we manipulated the duration of the pause at the impact between the two squares, in order to check whether comic impressions are specifically dependent on the temporal constraints of perceptual causality (Schlottmann & Anderson, 1993) and whether they are preserved even when the two movements are no longer perceived as causally related but only as a sequence of two successive moving objects, independent from each other. It is in fact known that ratings of causality decrease with increasing delays between the two movements (Schlottmann & Shanks, 1992), even if small delays actually yield better impressions of causality than no delays (Michotte, 1946/1963; Parovel & Casco, 2006).

Furthermore, introducing a negative temporal interval between the two movements (i.e. making the second square start moving before it is touched by the first square), we replicated one crucial condition for the “intentional reaction” event (Kanizsa, 1991; Kanizsa & Vicario, 1968) or “psychological causality” (Schlottmann et al., 2002; Schlottmann et al., 2006), in which the second moving object appears to be “escaping” or “running away” just before the arrival of the first one.

A final aim of the experiment was to isolate the effect of trajectory cues of animacy from the one of velocity. More specifically, we wanted to test whether an animal-like trajectory would remain comical even with a lower speed value, by using a speed that was intermediate between the two speed values adopted in Experiment 1.

Moreover, to get absolute and not only relative values of comicality, after gathering the responses in the pairwise comparisons, we asked to participants to rate the perceived comicality of each stimulus on a 7-point Likert scale.

3.1. Method

3.1.1. Participants

Participants were 28 university students (22 females). The mean age of the participants was 25.9 years (SD = 7.2 years). All participants reported normal or corrected-to-normal vision.

3.2. Design and stimuli

The stimuli were generated as variations of some of the stimuli used in Experiment 1 by manipulating two factors: (a) the *trajectory* of the movement of the second square (2 levels: linear or frog-like), and (b) the *temporal delay* between the end of the movement of the first square, and the beginning of the movement of the second square (4 levels: −200 ms, +30 ms, +200 ms, +1000 ms). The speed of the two squares was the same (6.3°/s). Please note that when the delay was negative the second square started to move before the end of the movement of the first square.

The experiment included a total of 28 forced-choice trials, consisting of all the pairwise comparisons of 8 stimuli. Each trial was presented only once to contain the duration of the experiment, and prevent participants to become bored by the task, as it is reasonable to assume that boredom could influence their perception of comicality. The order of the stimuli in the paired comparisons was however balanced across participants (i.e. given the pair of stimuli A and B, A was presented before B to half the participants, and after B to the remaining observers). The trials were presented in randomized order in a single block.

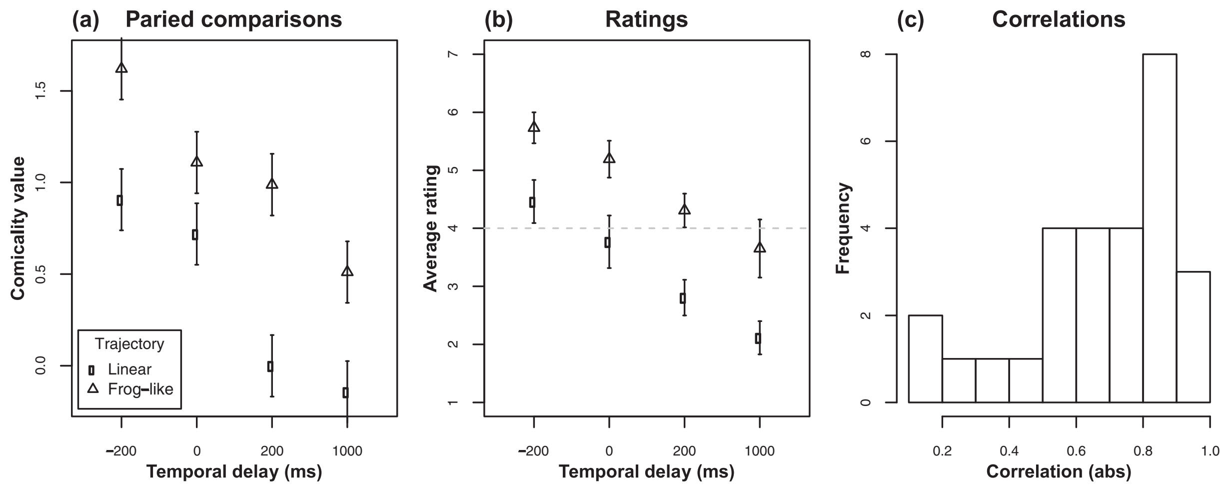

Fig. 5. Plots of the comicality scale values (a) and of the average comicality ratings (b) of the 8 stimuli in Experiment 2, as function of *temporal delay* (between the end of the first movement and the beginning of the second) and *trajectory*. Circles represent linear trajectory, and triangles frog-like trajectory. Error bars represent confidence intervals. (c) Histogram of the correlations (in absolute value) between scale values and ratings for each participant.

3.2.1. Procedure

The procedure for presenting the movies and gathering the responses in the pairwise comparisons was the same as in the first experiment. In addition, at the end of the experimental session subjects were asked to rate the perceived comicality of each stimulus on a 7-point Likert scale, where 7 refers to the strongest comic impression. Spontaneous reports and descriptions of the animations were also solicited and recorded by the experimenter.

3.3. Results and discussion

As in Experiment 1, paired comparisons were analysed using the Thurstone–Mosteller scaling method. After an initial inspection of the rating data and of the recorded post-experiment subjective reports, data coming from two participants were excluded from the analysis. One had reported that the two squares always appeared to him like a pair of eyes, the other reported finding the frog-like trajectory "very disturbing". The model fitted on the data for all the remaining participants revealed good fit, and significant differences between the stimuli perceived comicality values [$G^2(21) = 11.6$; $p = 0.95$]. No significant differences were found between females and males, nor the age of participants was found to affect the comicality scale values.

The results of the scaling are plotted in Fig. 5(a) as function of *trajectory* and *temporal delay* between the end of the movement of the first square and the beginning of the movement of the second square. The plots clearly reveal two main patterns. On the one hand, in the scale values there is a clear tendency towards decrease as the temporal delay increases. On the other hand, for each given level of temporal delay, the comicality value is greater for the frog-like trajectory than for the linear trajectory.

The analysis of the individual scale values revealed again a good amount of variability, albeit with significant preferences for basically all participants. Clearly, however, given the limited amount of data available for fitting each model, the reliability of these individual scale values is poor. Moreover, in several cases some stimuli were never chosen, resulting in singularities in the contingency tables from which the models were to be estimated, and further limiting the accuracy of scaling.

In Fig. 5(b) the average comicality ratings of the stimuli are plotted, once again as function of temporal delay and trajectory. As the figure shows, the same clear trends found in the scale values are present here. A 3-way ANOVA including 2 within-subject factors (*temporal delay* and *trajectory*) and one between-subject factor (*sex*) conducted on the ratings data revealed significant main effects of both the within-subject factors [*temporal delay*: $F(3,81) = 28.12$; $p < 0.0001$; *trajectory*: $F(1,27) = 12.69$; $p < 0.01$], but no significant effect of *sex* nor any significant interaction. The average ratings for all the stimuli are reported in Table 1, along with their standard deviations. As it can be seen in the table, not only the pattern of ratings means is consistent with the one of scale values, but the comicality ratings of stimuli with the highest scale values (such as the ones with frog-like trajectory and negative or no temporal delay) fall towards the higher end of the rating scale, indicating the participants indeed considered them pretty funny, not only more funny the other ones the were presented with.

To further check the consistency between scale values and ratings, we computed, for each participant, the Pearson's correlation between scale values and ratings. Correlations were significant for 15 of 26 subjects,[6] and ranged from -0.74 to 0.91, but only two participants showed negative correlations (respectively -0.11 and -0.74). In Fig. 5(c) the histogram of the correlations is plotted, in absolute value. In the majority of cases correlations were clearly moderate ($|r| > 0.5$) or strong ($|r| > .8$).

Overall, these results show that temporal contingency has a strong influence in eliciting a comic impression. Comicality scale values and ratings, in fact, tended to decrease with increasing delay, up to the point that with a 1 s delay, scale values were lowest and, more importantly, ratings indicated a breakdown of the comic effect.

The role of animacy cues (i.e. animal-like motion) in prompting a funny impression is also confirmed: the frog-like trajectory was in fact always preferred to the linear trajectory, even when the causal relation was actually weakened. With a 200 ms temporal delay, it is still possible to get an impression of causality: with the linear trajectory, however, the event is no longer judged comic, while with the frog-like trajectory absolute ratings still display a comic effect.

On the other hand, when spatiotemporal conditions convey an impression of psychological causality (-200 ms delay), as the second moving object looks as if it is escaping before the arrival of the first, even linear trajectories events are judged amusing (ratings $= 4.5$).

4. Experiment 3: animal-like versus mechanical-like trajectories

Experiment 1 and Experiment 2 showed that a perceptual incongruity between the two movements in the launching paradigm, based on the animal-like features of the second moving object, prompts a comic

[6] Given that each correlation was computed with only 8 pairs, one for each stimulus, statistical tests of the Pearson's coefficients have a very limited power.

Table 1
Average comicality ratings for the stimuli in Experiment 2.

Temporal delay (ms)	Trajectory	
	Linear Mean (SD)	Frog-like Mean (SD)
−200	4.5 (1.35)	5.6 (1.1)
0	3.9 (1.57)	5 (1.52)
200	3.04 (1.48)	4.2 (1.6)
1000	2.3 (1.44)	3.6 (2.1)

appreciation. Animacy cues appear to be related to the animal-like features of the second movement, or to high speed values, or to a negative temporal delay between the two movements.

The third experiment was carried out to see if an incongruous launch effect in which the trajectory of the second moving object is incoherent with respect to the trajectory of the first, but it does not display animal-like features, still generates an amusing impression or, instead, a weaker comic impression, as found by Bressanelli and Parovel (2012). We tested this hypothesis by matching the animal-like trajectories (frog-like and rabbit-like) of the previous experiments with two mechanical-like trajectories: a bouncing-like movement, as falling repeatedly after a step, and a rotating movement, like a spinning wheel.

We were thus able to directly compare the strength of comic appreciations produced by different kinds of incongruent causal events: some based on the presence of animal-like trajectories and others based on more passive mechanical-like trajectories outgoing after the impact.

4.1. Method

4.1.1. Participants

Participants were 28 university students (17 females). The mean age of the participants was 26.2 years (SD = 5.2 years). All participants reported normal or corrected-to-normal vision.

4.2. Design and stimuli

The stimuli have been generated by manipulating two factors: (a) the *trajectory* of the second moving object (4 levels: frog-like and rabbit-like; bouncing-like and clockwise rotating, see Fig. 6), and (b) the *speed* (2 levels: 12.6°/s and 6.3°/s). The length of the bouncing-like trajectory was 3.4° and the length of the rotating trajectory was 2.8°; the other two stimuli are identical of those adopted in Experiment 1. As in Experiment 2, the experiment included a total of 28 forced-choice trials, consisting of all the pairwise comparisons of 8 stimuli. The order of the stimuli in the paired comparisons was balanced across participants. The trials were presented in randomized order in a single block.

4.2.1. Procedure

The procedure for presenting the stimuli, and gathering the responses was the same as in the previous experiment. Moreover, just as in the second experiment, at the end of the experimental session subjects were asked to rate the perceived comicality of each stimulus on a 7-point Likert scale. Spontaneous reports and descriptions of the animations were again solicited and recorded by the experimenter.

4.3. Results and discussion

Comicality scale values were computed from paired comparisons data, as in the previous experiments. No significant differences were found between males and females, nor age was found to have a significant effect. The likelihood-ratio test indicates fit between the expected scale values and the collected data [$G^2(21) = 20.5$, $p = 0.49$]. Scale values are plotted in Fig. 6(a) as function of trajectory and speed. The plot seems to show that only one configuration was judged clearly more comical than the others: the condition in which the second square moved fast on a rabbit-like trajectory. There does not seem to be much difference between the comicality values of most of the other stimuli. Conversely to what previously found, moreover, speed seems to affect perceived comicality only with rabbit-like and bouncing trajectories.

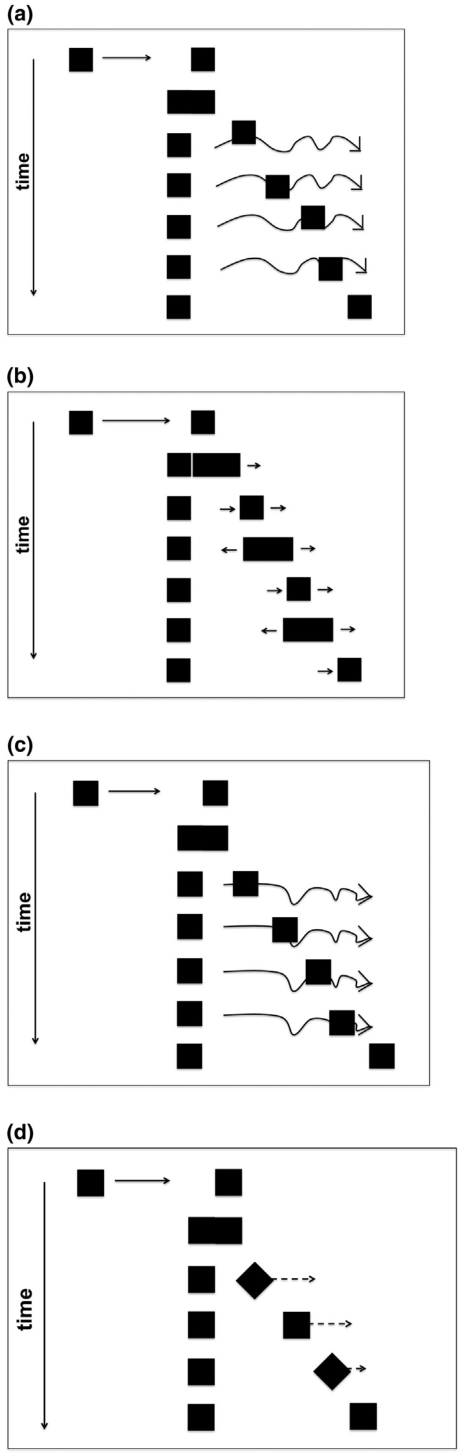

Fig. 6. Schematic illustrations of the stimuli adopted in Experiment 3: (a) the rabbit-like trajectory; (b) the frog-like trajectory; (c) the bouncing-like trajectory; and (d) the clockwise rotating trajectory.

Average ratings for each stimulus were also computed aggregating across participants, and are plotted in Fig. 6(d), and reported in Table 2, along with their standard deviations. As the plots show, the results closely mirror the ones derived from paired comparisons. An

Table 2
Average comicality ratings of the stimuli in Experiment 3. Ratings reported are averaged across all participants and across participants in the two clusters separately.

Trajectory	Speed	All subjects Mean (SD)	Cluster 1 Mean (SD)	Cluster 2 Mean (SD)
Rotating	Low	3.2 (1.1)	3.5 (1.04)	2.7 (1.06)
	High	4.2 (1.25)	4.4 (0.98)	3.8 (1.62)
Bouncing	Low	3.6 (1.59)	3.2 (1.46)	4.5 (1.51)
	High	4.7 (1.48)	4.2 (1.44)	5.7 (1.06)
Frog-like	Low	4.1 (2.02)	5 (1.61)	2.4 (1.58)
	High	4.5 (2.12)	5.4 (1.69)	2.8 (1.75)
Rabbit-like	Low	5.3 (1.05)	5.4 (0.98)	5.1 (1.2)
	High	6.5 (0.79)	6.6 (0.78)	6.3 (0.82)

analysis of variance revealed significant differences due to the trajectory [$F(3,81) = 12.19$; $p < 0.0001$] and the speed [$F(1,27) = 49.26$; $p < 0.0001$] of the second square, as well as a significant interaction between the factors [$F(3,81) = 3.44$; $p < 0.05$]. Planned comparisons confirmed that ratings for rabbit-like trajectory were significantly higher than ratings for the other trajectories [$t(27) = 7.31$; $p < 0.0001$]. For each trajectory, except the rabbit-like one, ratings were significantly higher for high speed than for low speed ($p < 0.01$).

Subjective reports collected at the end of the sessions, however, revealed that a subset of participants had strongly disliked or had been annoyed by the frog-like trajectory. We thus decided to perform further analyses on the rating data, with the aim of identifying cluster of subjects. A hierarchical clustering using Ward's procedure on a GDM2 distance matrix[7] cut at 1.1 yielded two clusters, comprising respectively 18 and 10 subjects. Scale values were then recomputed for each cluster, as well as average ratings for each stimulus (aggregating across the subjects in the cluster). The fit of the scales values to the collected data was good for the first cluster [$G^2(21) = 12.56$, $p = 0.92$], better than the fit of the model fitted on the data from all the subjects, and moderate for the second one [$G^2(21) = 28.08$, $p = 0.14$].

In Fig. 7(b) and (c) comicality scale values for the different clusters are plotted. As it can be easily seen comparing the plots for the two clusters, the main difference seems relative to the frog-like conditions: while for cluster 2 these conditions were judged the least comical stimuli, participants in the other cluster seemed to consider them quite comical, as in the previous experiments. A second difference between the clusters seems to be in the perceived comicality of the bouncing situation, which was greater in cluster 2 than in cluster 1, particularly at the lower speed. Finally, the two clusters differed in that the intermediate-speed rabbit-like trajectory was judged more comical by subjects in cluster 2 than by those in cluster 1.

Similar differences between the clusters are also clear in the rating plots (Fig. 7c, f). Not surprisingly, given that the ratings themselves had been used for finding clusters, differences between the groups are even more evident than in the scale values plots. Overall, the pattern of rating means show that for cluster 1, rabbit-like and frog-like trajectories were considered more comical than the other ones [$t(17) = 5.81$; $p < 0.0001$], and were the only trajectories for which the average ratings were above the mid-point of the scale. Interestingly, no significant differences were found for this cluster between the ratings for the frog-like and those for the rabbit-like trajectory. As for the second cluster, the pattern of means and the analysis show that both rabbit-like and bouncing-trajectories were rated as more comical than the other ones, and above the mid-point of the rating scale. The average ratings for each stimulus in the two clusters are reported in rightmost columns of Table 2 along with standard deviations.

Overall, the results of Experiment 3 showed that animal-like trajectories are judged more amusing than mechanical-like trajectories. The hypothesis formulated by Bergson is well supported by these data: a surprising trajectory after the collision can be a sufficient condition for a comic event, but the presence of animacy cues significantly enhances the probability of being comical. Speed too, as in the previous experiments, produces a significant effect, in all the stimulus conditions: the faster the movements, the bigger the comic evaluation. In the bouncing-like event (Fig. 6a), the high speed value is related to good impression of comicality. These results can be understood, according to the descriptions given by the participants, as a change from a passive motion of the object to a self-propelled motion, due to the high speed.

Individual variability was found, as in Experiment 2, both at the level of the scale values and of the ratings. In this experiment, however, a more systematic pattern of variability was found in both types of data, polarized upon two opposite perceptions of the frog-like stimuli. While the majority of participants considered it comical, consistently with the results of the previous experiments, some really disliked it, rating it almost every time at the bottom end of the Likert scale.

It is not clear why we did not observe the same pattern in the previous experiments, given that the frog-like trajectory was always included. We actually did find, in Experiment 2, at least two participants showing the same attitude towards this configuration, which might have something to do with latent subjective variables that were not considered in the study (e.g. personality or cultural factors). According to the literature, in facts, individual differences play a role in humour appreciation, as they can affect the identification of those variables involved both in structural properties either in content of the joke (Ruch, 2001). In our experimental stimuli, for instance, the frog-like trajectory has been described from the subjects who disliked it as a deformation of the square, like a strained stripe. About personality correlates of humour appreciation, the most potent predictor of humour appreciation seems to be conservatism: more conservative individuals dislike novel, unfamiliar, incongruous events and prefer stimuli which are simpler, more familiar and congruent (Ruch, 2001). Further studies would be needed to investigate this issue in more depth.

5. General discussion

This research suggests that incongruity, a crucial determinant of humour, as firmly established in cognition (Berger, 2010; Koestler, 1964; Martin, 2007; Polimeni & Reiss, 2006), can be observed and psychophysically investigated also in low-level processed visual events like causality and animacy (Scholl & Gao, 2013; Scholl & Tremoulet, 2000), by considering the comic appreciation as a qualitative dependent variable (see also Visch & Tan, 2009).

The results of our experiments generally show that the introduction of animal-like trajectories (frog-like and rabbit-like movements) in the second part of the causal paradigm, i.e. after the contact between the two squares, significantly increases the impression of comicality (Experiments 1, 2 and 3). It is also clear that the animal-like movement is not itself responsible of generating a comic appreciation, but the inclusion of animacy in a causal structure is: in fact, by increasing the temporal delay between the two movements, the impression of comicality significantly decreases (Experiment 2). This is also consistent with the results by Visch and Tan (2009), which found that animacy ratings of short movies were not correlated with funniness ratings.

Even linear trajectories, on the other hand, are appropriate in getting a funny impression of paradoxical social causality when the spatiotemporal organization does not follow Newtonian principles, as reported by Michotte (1946/1963): in particular when the second movement is faster that the first, as in the trigger effect (Experiment 1), and also when there is a negative delay (−200 ms) between the two movements (Experiment 2), and the second object seems to escape from the first (Kanizsa, 1991; Kanizsa & Vicario, 1968).

Also, the findings reveal a constant effect of speed in intensifying the amusing effect of animacy cues, both those related on the shape of the trajectories and those related on the spatiotemporal conditions,

[7] Walesiak & Dudek, 2010.

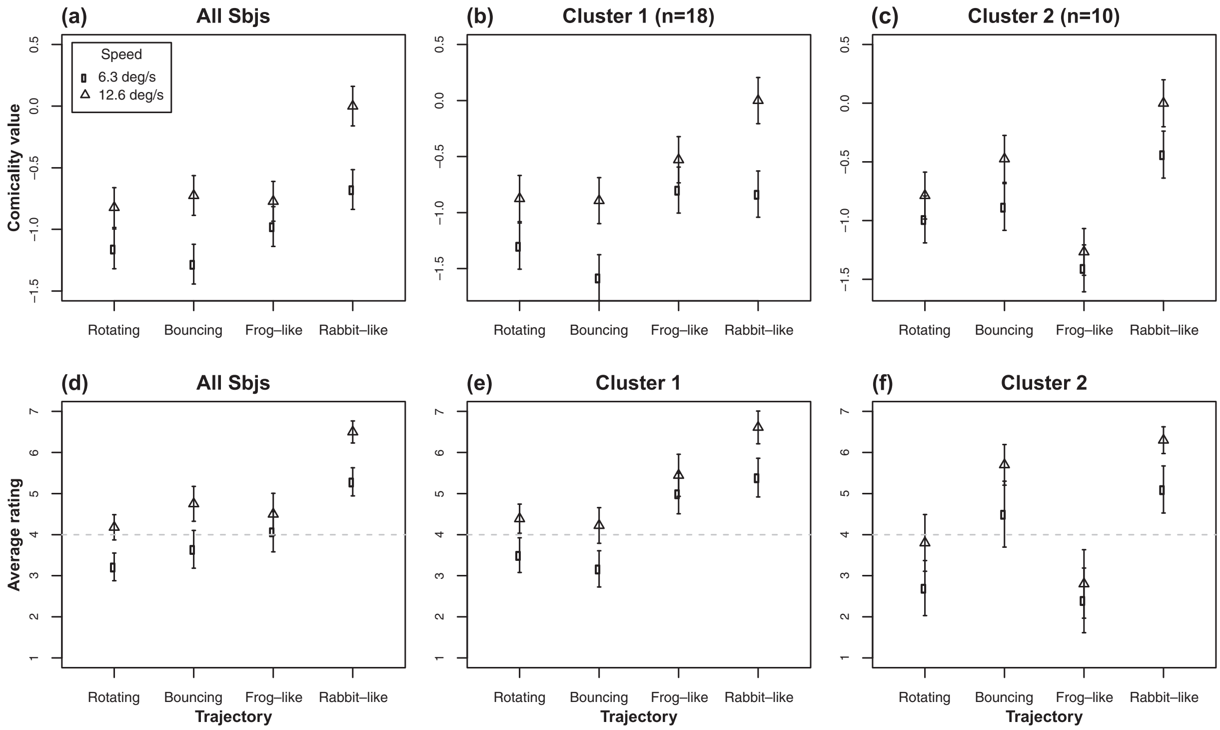

Fig. 7. Plots of comicality values (top row) and average ratings (bottom row) in Experiment 3, as function of trajectory and speed. Circles represent intermediate speed (6.3°/s) and triangles high speed (12.6°/s). In left columns the plots are relative to all subjects, while in the centre and right columns are relative to the two cluster of subjects extracted using hierarchical clustering.

plausibly confirming a relationship between speed and animacy as suggested by Szego and Rutherford (2007) and by Visch and Tan (2009).

Furthermore, in matching the animal-like with the mechanical-like movements (bouncing and rotating trajectories) after the causal collision, data showed that the first ones are generally deemed more amusing than the second ones (Experiment 3), as previously suggested by Bressanelli and Parovel (2012).

5.1. Conclusions

Our main findings support our hypothesis that the launch-effect paradigm, introduced by Michotte (1946/1963), is an extremely effective experimental paradigm in generating incongruous events and in isolating and systematically exploring the perceptual variables potentially relevant in prompting spontaneous comic impressions, such as the presence of different animacy cues.

To summarize, the paradoxical juxtaposition of a living behaviour in a mechanical structure (in our research, animacy cues inside a cause–effect perceptual relationship), seems to be a powerful factor in eliciting comic appreciations, totally in line with the Bergsonian perspective in particular, and with incongruity theories in general.

We draw the conclusion that comic impressions can be genuinely triggered by means of specific spatiotemporal configurations, obtained by manipulating perceptual causality and animacy to get incongruent and surprising causal contingencies. Like causality and animacy, these paradoxical events hold the same compelling evidence and surprising character of many perceptual illusions and other paradoxical visual phenomena, and can be systematically measured and explored with psychophysical methods.

Acknowledgements

We are grateful to Alan Costall and to Michael Kaschak for their significant suggestions and helpful comments on improving this paper.

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