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Perceiving object dangerousness: An escape from pain?

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Abstract

A variety of studies showed that participants are facilitated when responding to graspable objects, while it has not been fully investigated what happens during interactions with graspable objects that are potentially dangerous. The present study focuses on the mechanisms underlying the processing of dangerous objects. In two experiments we adopted a paradigm that has never been employed in this context, a bisection task. The line was flanked by objects belonging to different categories. We explored the sensitivity to the distinction between neutral and dangerous objects, by measuring whether the performance was biased toward a specific object category. In Experiment 1 both teenagers and adults bisected lines flanked by dangerous and neutral graspable objects, and they misperceived the line midpoint toward the neutral graspable object or, stated differently, on the opposite side of the dangerous graspable object.

In Experiment 2 adults bisected lines flanked by dangerous and neutral objects matched on graspability (both graspable or ungraspable, Experiment 2a), or by graspable and ungraspable objects matched on dangerousness (both neutral or dangerous, Experiment 2b). Results confirmed the finding of Experiment 1, but also indicated that participants misperceived the line midpoint toward the ungraspable object when it was presented, being it dangerous or not. This evidence demonstrated a sensitivity to object dangerousness maintained across lifespan and the emergence of aversive affordances evoked by dangerous graspable objects, strengthening the importance to consider graspability in the investigation of dangerous objects. Possible neural mechanisms involved in the processing of dangerous graspable objects are discussed.

Keywords: line bisection task; affordances; dangerous objects; graspability; motor simulation; embodied cognition; canonical neurons.

Introduction

An important human ability is to respond properly to objects in the environment, for example discriminating objects that can be useful from objects that can cause danger. Gibson (1979) used the term "*affordances*" to refer to properties of the environment providing the observers with practical opportunities that they are able to perceive and use. This term refers to the relationship between the organisms' motor repertoire, their goals, and the environment. Recent studies on human-object interaction started from this first conceptualization of affordances, but also slightly departed from it: for example, Ellis and Tucker (2000) proposed to use the term "*micro-affordances*" to refer to the activation of specific motor components (e.g., reaching or grasping motor response) during object observation. The results of a variety of studies on the processing of object and action highlight that this activation would re-enact perception-action brain assemblies, formed during previous experience (for reviews, see also Martin 2007; Bub and Masson 2010; Borghi et al. 2012). Therefore, the representation of dangerous objects may also rely on previous sensory-motor experiences.

Several studies have shown that perceiving graspable objects induces compatibility effects: the kinematic parameters and speed of action execution are influenced by the relation between object properties (e.g., size: Castiello 2003; Edwards et al. 2003; orientation: Craighero et al. 1998; consistence: Anelli et al. 2010) and action properties (e.g., side of response: Tucker and Ellis 1998; kind of grip: Ellis and Tucker 2000; Tucker and Ellis 2001, 2004). Moreover, neuroimaging studies have shown that the neural activity in motor-related brain areas increases during object observation (Chao and Martin 2000; Creem-Regehr and Lee 2005; Gerlach et al. 2002; Grafton et al. 1997; Johnson-Frey 2004). Again, a planned or executed action can bias attention, inducing facilitation in detecting targets whose properties are compatible with the action (Craighero et al. 1999; Symes et al. 2008, 2010). Importantly, the execution of an action is not necessary to induce attentional biases, in that observing a hand acting toward an object is sufficient to direct attention (Fischer et al. 2008; Ranzini et al. 2011; Fagioli et al. 2007). These findings converge in suggesting that object and action representations communicate bidirectionally (Goslin et al. 2012).

While much evidence shows that participants are facilitated when responding to graspable objects (i.e., objects that evoke the affordance of grasping), what happens when interacting with potentially dangerous objects has not been fully investigated. The most part of studies that have made use of dangerous or painful stimuli pertains to the domain of pain investigation. These studies were conducted by means of different techniques: behavioral measures as reaction times (e.g., Morrison et al. 2007b), brain imaging (e.g., Singer et al. 2004; Morrison et al. 2007a), or transcranial magnetic stimulation (TMS) paradigms (e.g., Avenanti et al. 2005, 2006, 2010). For instance, in a series of TMS studies on empathy for pain participants observed images of a needle, which was inserted into a model’s hand (e.g., Avenanti et al. 2005, 2006, 2010). Results showed that the motor evoked potential (MEP) amplitude was modulated by pain observation. This pain-related inhibition was linked both to measures of the model’s sensory qualities of the pain (such as the pain intensity) and of the state sensory empathy (e.g., Avenanti et al. 2005), suggesting the activation of motor resonance mechanisms.

Recent behavioral studies aimed at distinguishing the effects evoked by the presentation of the graspable objects (dangerous vs. neutral) and the motor resonance effects elicited while observing hands in potential interaction with them (Anelli et al. 2012a; Anelli et al. 2012b). These studies investigated the sensitivity to the distinction between graspable neutral and dangerous objects in school-age children and adults, as well as the possible motor resonance induced by the observation of others’ actions. To this aim a priming paradigm was used: a hand prime or a control object prime was followed by a neutral graspable or dangerous object. Participants were required to categorize it into artefact or natural object by pressing a different key. In both adults and children, neutral graspable objects facilitated the motor response. In contrast, the response to dangerous objects was slower than to neutral ones, suggesting that dangerous objects evoked aversive affordances, generating an interference effect. Moreover, both children and adults were sensitive to the distinction between biological vs. non-biological hands, indicating that motor resonance mechanisms were at play only during biological hands observation, and that the higher the motor resonance evoked by biological hands, the stronger the inhibition obtained with dangerous objects. More relevant to our aims, dangerous objects produced a slowdown of responses and an interference effect. These findings are in line with a body of studies investigating the ability to detect fear-relevant and fear-irrelevant stimuli by means of a visual search paradigm (e.g., Blanchette 2006). These studies have revealed a threat-superiority effect, namely threatening objects were detected faster and more efficiently than non threatening ones.

The behavioral studies described so far showed that human motor responses are influenced by object dangerousness, but objects were always primed by hands in potential interaction with them. In contrast, the present work investigates neutral and dangerous objects processing when no agent is interacting with them, thus allowing to investigate the dangerousness perception independently from the observation of others’ actions. In fact, it is important to understand how humans represent dangerous or painful objects, which mechanisms are at play while interacting with them, and which relevant variables (such as developmental stages or relevant experiences) may influence dangerous object representations (for another study on neutral and dangerous objects processing when no agent was shown, see Anelli et al. under review).

While most of the studies on affordances employed a stimulus-response compatibility paradigm (SRC), in the present work we explore whether and to what extent performance is influenced by object dangerousness with a paradigm that has never been employed in this context, i.e., the cued line bisection task. In this task, participants are required to bisect a line flanked by two different irrelevant cues at the extremities. So, one of the novelties of the present research is the chosen paradigm, the cued line bisection task, in which the role of cues is irrelevant for the execution of the task, permitted to avoid SRC. Typically, the line bisection task is used as research instrument to study visuospatial attention in healthy individuals, and as neuropsychological diagnostic instrument, for example with patients with visuospatial neglect or hemianopia (e.g., Barton et al. 1998; Bisiach et al. 1976; Kerkhoff and Bucher 2008; Schenkenberg and Bradford 1980). Typically, healthy individuals show a leftward bias in this task, named *pseudoneglect*, revealing visuospatial asymmetries in the attentional system (Jewell and McCourt 2000). More relevant to our aim, this paradigm has proven to be useful to study symbolic cueing processing through the analysis of bisection biases (see Fischer 2001). For example, Ranzini et al. (2011) investigated action- and object-related motor cueing effects, by means of a hand-cued line bisection task. Participants were presented with a line (thin vs. thick line) flanked with images of hands (biological vs. non-biological hand) representing different actions (power vs. precision grip). Performance was biased toward the action more compatible with the object (power grip-thick line and precision grip-thin line), showing that the bisection paradigm was sensitive to action- and object-related motor cueing. Importantly, this effect was reduced or absent with non-biological hands, suggesting that motor resonance mechanisms underlie bisection performance with hand cueing. Here, participants were presented with a line flanked by two pictures of objects, with the idea that objects observation would evoke affordances, which in turn would bias bisection performance. The line was flanked by objects – not by hands pictures as in Ranzini et al. (2011) – since our interest lied in investigating the object affordance effect independently from the effect evoked by the presentation of the hand.

We conducted two experiments, where the line stimulus was flanked by images of objects belonging to different categories. In Experiment 1 both teenagers and adults bisected lines flanked by a pair of stimuli representing a dangerous and a neutral graspable object. In Experiment 2 adults bisected lines flanked by a pair of stimuli representing a dangerous and a neutral object matched on graspability (both graspable or ungraspable, Experiment 2a), or representing a graspable and an ungraspable object matched on dangerousness (both neutral or dangerous, Experiment 2b). We explored the sensitivity to the distinction between neutral and dangerous objects, by measuring whether the performance was biased toward/away from a specific object category. On the basis of aforementioned evidence, we hypothesized to observe in Experiment 1a bias in the opposite direction to the dangerous object and, as a consequence, toward the neutral graspable object. We also investigated how the sensitivity to aversive affordances differed at different life stages, by testing both performance of teenagers and adults. As mentioned above, the ability to distinguish dangerous and neutral objects emerges quite early in development, as it might be crucial from an adaptive point of view (Anelli et al. 2012a, 2012b). However, it is possible that this ability increases with age: we tested this hypothesis by comparing teenagers and adults performance.

Finally, in Experiment 2 we investigated whether the predicted bias in the opposite direction to the dangerous object was due to an affordance effect caused by neutral graspable objects (hypothesis 1) or to a withdrawal effect caused by dangerous graspable objects (hypothesis 2). To disentangle this point, we adopted stimuli matched on graspability but differing on dangerousness (Experiment 2a), or matched on dangerousness but differing on graspability (Experiment 2b). Following hypothesis 1, we would expect a bias toward the neutral graspable object (in Experiment 2a with graspable objects; in Experiment 2b with neutral objects). On the other hand, following hypothesis 2, we would expect a bias in the opposite direction of the dangerous graspable object side (in Experiment 2a with graspable objects; in Experiment 2b with dangerous objects). We do not have clear predictions about ungraspable objects, except that they should not evoke grasping affordances.

Experiment 1: neutral graspable vs. dangerous objects in teenagers and adults

Method

Participants. Fourteen teenagers (4 males and 10 females; 12 years old) and twelve undergraduate students from the University of Bologna (6 males and 6 females; mean age: 21 years, range: 19 - 26) took part in the experiment. All subjects were right-handed and had normal or corrected-to-normal vision. All were naive as to the purpose of the experiment and they or their parents, as for teenagers, gave informed consent.

Materials and Procedure. Participants sat in front of a 17-inc. colour monitor (the eye-to-screen distance was approximately 50 cm). E-Prime 1.1 software was used.

The task was a computerized version of the line bisection task. Participants were required to indicate the midpoint of a line flanked by two pictures of objects (object-line distance: 4 px, 0.1 cm). Participants indicated the midpoint with the help of a mouse cursor (a vertical arrow, size: 17 x 7 px, 0.5 x 0.2 cm). The arrow cursor shifted only horizontally under the line. The line was centrally presented on the horizontal axis, but its vertical position (centre, up or down from the screen centre) and the arrow cursor initial position (left or right under the line) were randomized across trials and not considered as variables of interest. Two line lengths were presented (short: 288 px, 7.6 cm; long: 432 px, 11.4 cm).

The objects-flankers consisted of sixteen black and white pictures of common graspable objects, half of the objects were neutral (mean pixel 125 x 166, mean cm 3.3 x 4.4), e.g. a tomato, and half dangerous (mean pixel 120 x 165, mean cm 3.2 x 4.4), e.g. a cactus (see Table 1). The set of objects was the same used in other studies (Anelli et al. 2012a, 2012b), in which we asked an independent group of forty-three participants to rate on a five-points Likert scale objects dangerousness.

In each trial the objects-flanker pairs could belong to two conditions depending on the objects positions: neutral left + dangerous right (Neutral Dangerous, ND) or dangerous left + neutral right (Dangerous Neutral, DN).

Instructions indicated the presence of a line flanked by two objects, emphasizing the importance to correctly indicate the line midpoint without considering the objects.

The experiment consisted of one practice block of 16 trials and one experimental block of 96 trials. In each block, half of the trails belonged to the ND condition and half to the DN condition. Objects positions conditions (ND, DN) and line lengths (long, short) were presented in a randomized order, for a total of 112 trials.

Each trial began with a white screen displayed for 100 ms. Then, a line flanked by two objects was shown, followed after 100 ms by the arrow cursor. Stimuli remained on the centre of the screen until response. Then a white screen was presented for 1000 ms, before the next trial(see Figure 1).

(Figure 1 about here)

At the end of the experiment, participants rated the dangerousness of the sixteen objects presented during the experiment on a five-points Likert scale (with 1 = not dangerous and potentially painful object, and 5 = extremely dangerous and potentially painful object).

The experiment consisted of a 20-min session, and then participants were informed about the aims of the experiment.

Scoring and Analysis. Our dependent variable was the accuracy in the bisection task, obtained subtracting the real line midpoint (the line centre) from the subjective line midpoint (i.e., participant's bisection). In this way, accuracy is referred to the line centre, and positive values correspond to rightward bias while negative values correspond to leftward bias. Accuracy is expressed in pixel, similarly to previous studies adopting this paradigm (Ranzini et al. 2011; Ranzini and Girelli 2012).

Statistical analyses were conducted by means of an ANOVA on accuracy, with three factors: *Group* (teenagers and adults) as between-subjects factor, and *Objects Order* (ND and DN) and *Line Length* (long and short) as within-subjects factors.

In addition, an ANOVA on dangerousness ratings was carried out, with three between-subjects factors: *Group* (teenagers and adults), *Typology* (neutral and dangerous), and *Category* (artifact and natural).

Results

The accuracy analysis revealed two significant main effects, *Objects Order* [F (1, 24) = 14.1, MSe = 3.02, n^2_p = 0.37, p = .001] and *Group* [F (1, 24) = 5.9, MSe = 64.9, n^2_p = 0.20, p = .02]. There was a larger leftward bias in ND condition (mean = - 2.5, SEM = 0.8) than in DN condition (mean = - 1.2, SEM = 0.8), (Figure 2). Post-hoc analyses revealed that the leftward bias was significant only in the ND condition (t-test vs. 0: ND, t(25) = -2.7, p < 0.05; DN, t(25) =, p > 0.2). In addition, only adults showed a leftward bias (adults mean = - 3.7, SEM = 1.2); teenagers mean = 0.1, SEM = 1.1). Post-hoc analyses revealed that the leftward bias was significant only in adults (t-test vs. 0: adults, t(11) = -4.2, p < 0.01; teenagers, t(13)= 0.9, p > 0.9). There were no other significant main effect or interaction (ps > 0.05).

The ratings analysis revealed the main effect of *Typology* [F (1, 24) = 187.1, MSE = 0.2, $p < .001$] showing a significant difference between neutral (mean = 1.4) and dangerous objects (mean = 3.4). There were no other significant main effect or interaction (ps > 0.05).

(Figure 2 about here)

Discussion

Experiment 1 demonstrated that bisection performance was influenced by the type of flanker objects: participants significantly shifted the midpoint toward the neutral object. This pattern of results might suggest that the neutral graspable object evokes an affordance effect, biasing the motor response toward it. Alternatively, or in addition, the dangerous graspable object might generate avoidance/repulsion effects, thus inducing an “escape” from it.

Despite a classical leftward bias characterized the adult group only (differently to the decreasing of pseudoneglect in function of age observed in previous studies: see Jewell and McCourt 2000), adults’ bias due to object typology did not significantly differ from the teenagers’ one. Therefore, teenagers and adults were similarly sensitive to the difference between dangerous and neutral objects.

Experiment 2: dangerousness and graspability in adults

Experiment 1 showed that, when required to indicate the midpoint of a line flanked by pictures of neutral and dangerous graspable objects, younger and adult participants bisected the line toward the neutral object. This demonstrates the human ability to automatically discriminate object properties – here object affordances, whether of graspability or avoidance – even when the object is not relevant for the task. However, this finding can originate from the neutral object, inducing graspable affordances, or it can be an “escape” from the dangerous one, inducing aversive affordances. Experiment 2 was conducted to clarify if the previous result was linked to an affordance effect evoked by the neutral graspable object or to an avoidance of the dangerous graspable one, by presenting ungraspable objects that, by their nature, should not evoke affordances linked to graspability. The line was flanked by two objects matched on graspability and differing on dangerousness (Experiment 2a), or matched on dangerousness and differing on graspability (Experiment 2b). If the effect observed in Experiment 1 was due to the tendency to reach the graspable object, we would observe an effect toward it also when coupled with an ungraspable one. On the other hand, if it was due to an escape from the dangerous graspable object, we would observe a bias opposed to it also when coupled with an ungraspable one.

Due to the lack of influence of different age classes reported in Experiment 1, only adults participated to Experiment 2.

Experiment 2a

Method

Participants. Twelve undergraduate students from the University of Bologna (3 males and 9 females) with a mean age of 19.8 years (range: 19 - 23) took part in Experiment 2a for course credits. All subjects had normal or corrected-to-normal vision. All were naive as to the purpose of the experiment and gave informed consent.

Materials and Procedure. Apparatus, stimuli, and procedure were the same of Experiment 1 except for the following. Half of the participants carried out a block on dangerousness (Experiment 2a) and half a block on graspability (Experiment 2b). Since Experiment 2a was focused on dangerousness, objects differed for their dangerousness, but were matched on graspability. Thus, we compared neutral graspable vs. dangerous graspable objects and neutral ungraspable vs. dangerous ungraspable objects.

The objects-flankers consisted of thirty-two black and white pictures of objects. Sixteen objects were the same ones employed in Experiment 1. The other sixteen objects were new, half were neutral ungraspable objects (mean pixel 122 x 162, mean cm 3.2 x 4.3), e.g. a mountain, and half were dangerous ungraspable objects (mean 123 pixel x 163, mean cm 3.3 x 4.3), e.g. a volcano (see Table 1).

In each trial the objects-flanker pairs could belong to four conditions depending on the objects positions: neutral + dangerous graspable (NDG) or dangerous + neutral graspable (DNG) and neutral + dangerous ungraspable (NDU) or dangerous + neutral ungraspable (DNU).

The experiment consisted of one practice block of 16 trials and one experimental block of 96 trials (for a total of 112 trials, as in Experiment 1). Only long lines were presented, since in Experiment 1 no differences emerged between short and long lines.

At the end of the experiment, participants were required to rate both the dangerousness and the graspability of the thirty-two objects presented during the experiment on a five-points Likert scale (rating on dangerousness: 1 = not dangerous and potentially painful object, and 5 = extremely dangerous and potentially painful object; rating on graspability: 1 = ungraspable object, and 5 = graspable object). Object graspability was evaluated on the basis of whether it was possible or not to lift the object with the hands and move it from one place to another (for a similar procedure, see Ranzini, Lugli, Anelli, Carbone, Nicoletti, & Borghi, 2011).

The experiment consisted of a 25-min session, and then participants were informed about the aims of the experiment.

Scoring and Analysis. We analyzed the accuracy as in Experiment 1.

Statistical analyses were conducted by means of an ANOVA on accuracy, with two factors: *Typology* (dangerous and neutral) and *Objects Order* (graspable left and ungraspable right / graspable right and ungraspable left) as within-subjects factors.

In addition, for each block two ANOVAs on ratings concerning dangerousness and graspability were carried out, with the between-subjects factor *Typology* (neutral and dangerous) or *Graspability* (graspable and ungraspable), respectively.

Results

The accuracy analysis showed a significant interaction *Objects Order* x *Typology* [F (1, 11) = 37.5, MSe = 0.8, n^2_p = 0.8, p < .001], (Figure 3, panel a). With graspable objects participants indicated the midpoint of the line toward the neutral object/far from the dangerous one (NDG condition: mean = -3.2, SEM = 1.7; DNG condition: mean = -1.8, SEM = 1.8; t(11) = -3.4, p < 0.01), exactly as observed in Experiment 1. With ungraspable objects, instead, participants indicated the midpoint of the line toward the dangerous object/far from the neutral one (NDU condition: mean = -2.7, SEM = 1.8; DNU condition: mean = -4.2, SEM = 1.7; t(11) = 3.2, p < 0.01). The leftward bias was significant only in the UDN condition (t test vs. 0: t(11) = -2.4, p < 0.05; in the GND condition: p = 0.08).

The ratings analysis on dangerousness revealed the main effect of *Typology* [F (1, 30) = 48.4, MSE = 0.8, p < .001], with a significant difference between neutral (mean = 1.4) and dangerous objects (mean = 3.6).

The rating analysis on graspability revealed the main effect of *Graspability* [F (1, 30) = 119.1, MSE = 0.5, p < .001], with a significant difference between graspable (mean = 4.2) and ungraspable objects (mean = 1.4).

(Figure 3 about here)

Discussion

Experiment 2a showed two interesting results. First, with graspable objects participants shifted the midpoint toward the neutral objects and far from the dangerous ones, confirming the finding of Experiment 1. As in Experiment 1, the results do not allow clarifying whether the effect is due to an affordance effect induced by the neutral object or an avoidance effect induced by the dangerous one. Experiment 2b will give further hints on this issue. Second, data on ungraspable objects extended the previous ones revealing the opposite pattern of results, since in this case participants indicated the midpoint of the line toward the dangerous object and far from the neutral one. We interpret this last effect as a pure effect of attention toward the dangerous stimulus (e.g., Blanchette 2006) when no grasping affordance is involved.

Experiment 2b

Method

Participants. Twelve undergraduate students from the University of Bologna (1 male and 11 females) with a mean age of 20.3 years (range: 19 - 24) took part in Experiment 2b for course credits. All subjects had normal or corrected-to-normal vision. All were naive as to the purpose of the experiment and gave informed consent.

Materials and Procedure. Apparatus, stimuli, and procedure were the same of Experiment 1 except for the following. Since Experiment 2b was focused on graspability, objects differed for their graspability, but were matched on dangerousness. We compared neutral graspable vs. neutral ungraspable objects and dangerous graspable vs. dangerous ungraspable objects.

In each trial the objects-flanker pairs could belong to four conditions depending on the objects positions: graspable + ungraspable neutral (GUN) or ungraspable + graspable neutral (UGN) and graspable + ungraspable dangerous (GUD) or ungraspable + graspable dangerous (UGD).

Scoring and Analysis. We analyzed the accuracy as in Experiment 2a except for the following.

Statistical analyses were conducted by means of an ANOVA on accuracy, with two factors: *Typology* (graspable and ungraspable) and *Objects Order* (dangerous left and neutral right / dangerous right and neutral left) as within-subjects factors.

Results

The accuracy analysis showed the main effect of *Objects Order* [F (1, 11) = 75.2, MSe = 4.4, n^2_p = 0.9, $p < .001$], with a bias toward the ungraspable object (graspable-ungraspable condition: mean = 1.8, SEM = 1.3; ungraspable-graspable condition: mean = - 3.4, SEM = 1.0). Importantly, the interaction *Objects Order* x *Typology* [F (1, 11) = 24.3, MSe = 0.8, n^2_p = 0.7, $p < .001$] was significant (Figure 3, panel b). The interaction indicated that the effect toward the ungraspable object was larger with dangerous objects (GUD condition: mean = 2.3, SEM = 1.6; UGD condition: mean = -4.2, SEM = 1.2; $t(11) = 8.9$, $p < 0.001$) than with neutral ones (GUN condition: mean = 1.3, SEM = 1.2; UGN condition: mean = -2.7, SEM = 1.0; $t(11) = 6.9$, $p < 0.001$). The left bias was significantly different from 0 in both in the UGN ($t(11) = -2.8$, $p < 0.05$) and in the UGD condition ($t(11) = -3.6$, $p < 0.01$).

The ratings analysis on dangerousness revealed the main effect of *Typology* [F (1, 30) = 42.4, MSE = 0.8, $p < .001$]. As in Experiment 2a, this result showed a significant difference between neutral (mean = 1.5) and dangerous objects (mean = 3.6).

The rating analysis on graspability revealed the main effect of *Graspability* [F (1, 30) = 173.6, MSE = 0.4, $p < .001$], with a significant difference between graspable (mean = 4.2) and ungraspable objects (mean = 1.4).

Discussion

Experiment 2b demonstrated that when objects differed in graspability, participants shifted significantly the midpoint toward the ungraspable object rather than toward the graspable one. Albeit we do not have a clear understanding of the reasons underlying the effect of attraction toward the ungraspable neutral object, it is important to underline that this effect is not supporting the view that the bias toward the dangerous object when both are graspable is due to an effect of affordance toward the neutral object (hypothesis 1). On the contrary, together with results of Experiment 2a, this finding is in line with the view that dangerous graspable objects may evoke aversive affordances (hypothesis 2). The fact that the bias toward the ungraspable object was larger when the objects were dangerous rather than neutral can be due to a conjoint effect of avoidance of graspable dangerous object and attraction toward the ungraspable dangerous one.

General Discussion

The present study investigated the mechanisms underlining the processing of dangerous objects. In two experiments we measured participants' sensitivity to the distinction between neutral and dangerous objects during cued line bisection (e.g., Ranzini et al. 2011). In Experiment 1, the line was flanked by neutral and dangerous graspable objects. Both teenagers and adults performed the task allowing us to investigate whether the ability to distinguish dangerous and neutral objects increases with age. The bisection bias was considered as an indicator of underlying mechanisms of objects processing.

Firstly, we found that participants systematically mis-bisected the line toward the neutral graspable object in Experiment 1, i.e. in the opposite direction of the dangerous object side. This effect was similarly observed in teenagers and adults. This result demonstrates that participants were sensitive to dangerous objects and that this sensitivity is maintained across lifespan, possibly as it is necessary for survival (see also Anelli et al. 2012a, 2012b). These results are in line with a large body of evidence indicating that perceiving danger modulates/involves visual attention. For instance, in visual search tasks dangerous stimuli are more efficiently detected than neutral ones (threat-superiority effect: e.g., Blanchette 2006, Öhman et al. 2001). The present study is in line with these studies: first, it confirms that threat modulate the allocation of visuospatial attention, as the orienting of attention is crucially involved while performing the bisection task (see Toba et al. 2011). Secondly, we observed danger sensitivity in a task not requiring SRC and where the object stimuli were completely task irrelevant (i.e., they did not need to be processed to perform line bisection), suggesting a certain degree of automaticity in the processing of danger (Öhman et al. 2001).

Moreover, differently from previous behavioural and TMS studies (e.g., Anelli et al. 2012a, 2012b; Avenanti et al. 2005; Morrison et al. 2007b), the objects were not presented in interaction with a hand, permitting us to attribute the observed bias to a pure effect of object processing and not to the presence of motor resonance mechanisms.

The systematic misplacement of the subjective line midpoint toward the neutral graspable object/against the dangerous object, however, had two possible explanations: it could be due to the activation of graspable objects affordances; alternatively, it could be due to an aversive affordance inducing "escaping" from the dangerous objects.

Experiment 2 clarified whether the effect obtained in Experiment 1 was due to affordances activation by neutral graspable objects or to interference effects generated by dangerous objects. In Experiment 2a, lines were flanked by objects matched on graspability (graspable or ungraspable) and differing on dangerousness (neutral or dangerous). In Experiment 2b, lines were flanked by objects matched on dangerousness (neutral or dangerous) and differing on graspability (graspable or ungraspable). Results of Experiment 2a confirmed the finding of Experiment 1 by revealing that, when participants were faced with graspable objects, they bisected the line relatively toward the neutral object, and thus far from the dangerous one. However, data highlighted new and unexpected evidence as for ungraspable objects: participants shifted the subjective midpoint toward the dangerous object. Notice that the paradigm here adopted involved the planning and execution of a precise hand action (i.e., doing a mark on the line). In this sense, the effects of graspable stimuli are in line with an interpretation that takes into account the interplay between object affordance, attention and action planning and execution (Ranzini et al. 2011). However, with ungraspable stimuli, the manual task seemed to be less influenced by the objects' dangerousness given that, by their nature, ungraspable objects should not evoke affordances related to graspability. The effect of ungraspable dangerous stimuli was opposite to the one obtained with graspable ones, probably due to attentional factors. Indeed, an ungraspable dangerous object seemed to be more salient than an ungraspable neutral one, capturing the participants' attention and thus inducing the bisection bias (in line with the attentional account, e.g., Öhman et al. 2001). Importantly, Experiment 2b showed that ungraspable objects were more attractive than graspable ones, either dangerous or neutral, even if this effect was larger with dangerous stimuli than with neutral ones. Albeit we do not have a clear explanation of the bias toward the ungraspable object when coupled with graspable ones, this effect favours the idea that dangerous graspable objects evoke some kind of avoidance effect (Anelli et al. 2012a, 2012b), which in turn cause an "escape". This allows excluding the hypothesis 1. As graspable objects trigger the affordance of grasping, participants moved away from the object when perceived it as graspable and potentially dangerous.

Moreover, the bias toward dangerous stimuli when ungraspable underlines the importance of taking into account the dimension of graspability when investigating the processing of danger, as opposite results can emerge depending on this dimension.

The paradigm we chose allows us to speculate about the possible neural mechanisms underlying the processing of neutral and dangerous graspable objects. Previous studies on pain investigated the relationship between a hand and an object (e.g., Anelli et al. 2012a, 2012b; Avenanti et al. 2005; Morrison et al. 2007b), highlighting the role of the mirror neuron system (i.e., neurons involved in both the agent's own actions and the visual observation of such actions performed by others; for a review, see Rizzolatti and Craighero 2004) as the possible underlying basis of a resonant mechanism activated while observing hands interacting with painful stimuli. In the present research we presented only objects. Therefore the probable subtended neural basis is the canonical neuron system (e.g., Raos et al. 1996), active during both the execution of object-directed actions and the mere observation of the same objects (Rizzolatti and Craighero 2004). Whether this system underlies only the affordance effect we found or whether it is involved in the mechanism of avoidance in act during dangerous object processing should be object of future research.

In conclusion: albeit this study is pioneer in the contest of object dangerousness representation, as well as in the contest of studies using line bisection with flankers objects, the observed results permitted us to confirm and clarify the following points. First, humans are sensitive to objects affordances, in the sense that representation of objects includes in itself the motor codes activated during the interaction with objects. This may be the case also for dangerous objects, as recently suggested also by Coello et al. (2012) who found that the dangerousness of everyday manipulable objects influenced the boundary of peripersonal space. The bias we observed is in line with the claim of sensitivity even to dangerous affordances. In this sense, our results could represent an additional contribute to the literature about the influence of emotion on domains of cognition such as attention and perception (for a review, see Dolan, 2002). Second, this finding adds to previous studies on danger processing indicating that graspability is an important aspect of dangerous objects.

Future studies will shed light on the properties and the time-course of the mechanisms of avoidance elicited by dangerous object affordances.

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Figures Captions

Fig. 1 Design of the experiments. In the two experiments, participants were required to indicate the midpoint of a line flanked by two pictures of objects. Each trial started with a white screen displayed for 100 ms. Then, a line flanked by two objects was shown followed after 100 ms by the arrow cursor under the line. The stimuli remained on the centre of the screen until a response had been made. After stimulus offset a white screen was presented for 1000 ms, and then the next trial began.

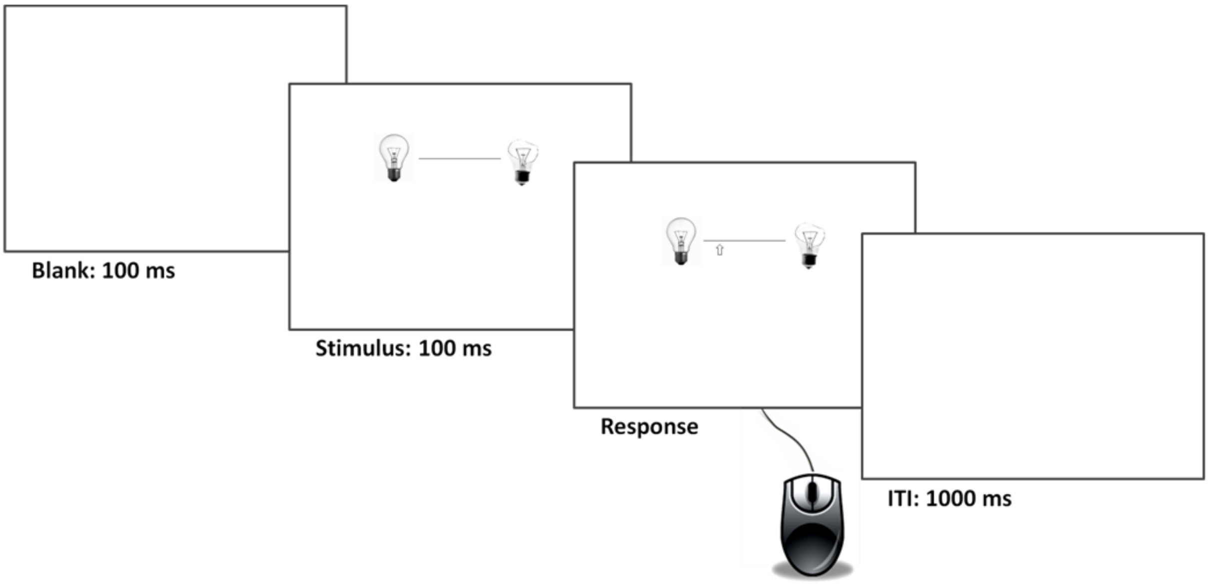

Fig. 2 Significant *Objects Order* effect for the bisection bias in Experiment 1, values are in pixels and bars are SEM. Negative and positive values correspond to shifts toward the left or right from the center, respectively. Participants (teenagers and adults) shifted the midpoint toward the neutral object when the line was flanked by dangerous and neutral objects.

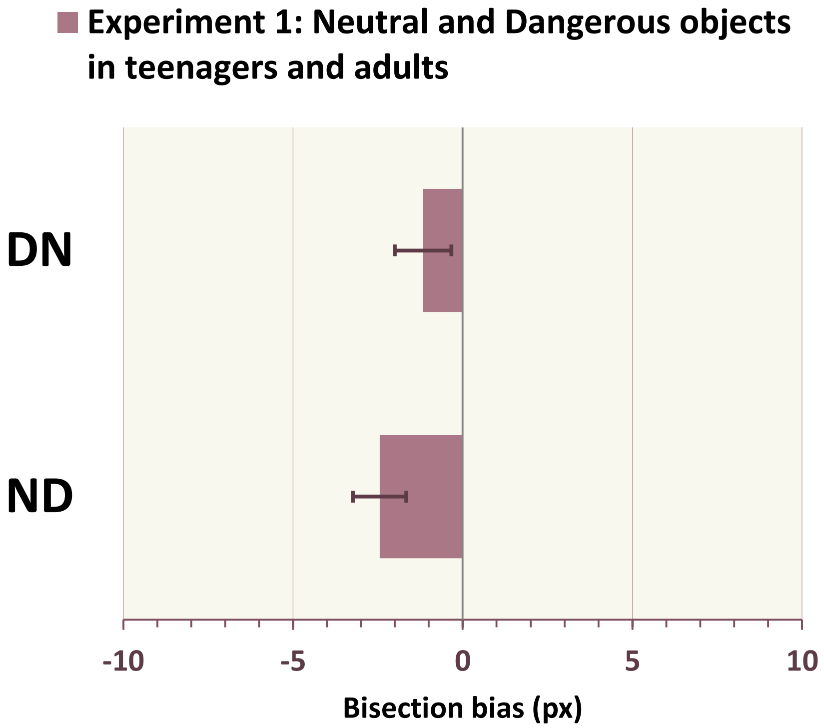

Fig. 3 Significant interaction *Object Order* x *Typology* for the bisection bias in Experiment 2. Values are in pixels and bars are SEM. Negative and positive values correspond to shifts toward the left or right from the center, respectively.

Panel a: Significant interaction between *Typology* and *Objects Order* for the bisection bias in Experiment 2a. Participants shifted the midpoint toward the neutral graspable object, but also toward the dangerous ungraspable one.

Panel b: Significant interaction between *Typology* and *Objects Order* for the bisection bias in Experiment 2b. Participants shifted the midpoint toward the ungraspable object, but this effect was larger with dangerous stimuli.

Panel A **Panel B**

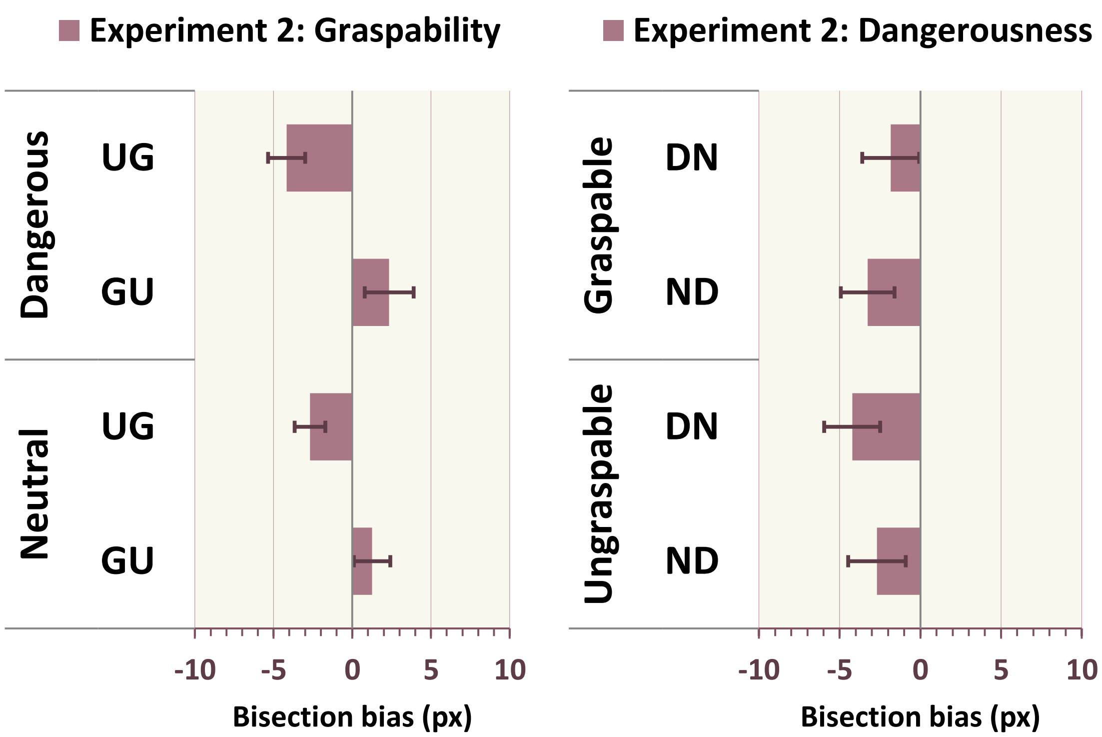

Table 1. Experimental stimuli.

		Neutral Graspable Objects (exp 1, 2, and 3)	Dangerous Graspable Objects (exp 1, 2, and 3)	Neutral Ungraspable Objects (exp 3)	Dangerous Ungraspable Objects (exp 3)
1	**Natural**	Cat	Porcupine	Elephant	Crocodile
2		Chick	Scorpion	Dolphin	Shark
3		Plant	Cactus	Tree	Prickly pear
4		Tomato	Husk	Mountain	Volcano
5	**Artifact**	Bulb	Broken bulb	Bell	Atomic bomb
6		Glass	Broken glass	Skyscraper	Collapsing skyscraper
7		Lighted out match	Lighted match	Semaphore	Warning road sign
8		Spoon	Knife	Home	Collapsing home