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ORIGINAL ARTICLE

The differential effects of fluency due to repetition and fluency due to color contrast on judgments of truth

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Abstract Two experiments contrast the effects of fluency due to repetition and fluency due to color contrast on judgments of truth, after participants learn to associate high levels of fluency with falseness (i.e., a reversal of the fluency–truth link). Experiment 1 shows that the interpretation of fluency as a sign of truth is harder to reverse when learning is promoted with repetition rather than with perceptual fluency. Experiment 2 shows that when color contrast and repetition are manipulated orthogonally, the reversal of the truth effect learned with color contrast does not generalize to repetition. These results suggest specificities in the processing experiences generated by different sources of fluency, and that their influences can be separated in contexts that allow the contrast of their distinctive features. We interpret and discuss these results in light of the research addressing the convergence vs. dissociation of the effects elicited by different fluency sources.

Introduction

Is the statement "The ice cream cone was invented in the USA in 1924" true or false? Most of us would be uncertain about the correct answer. However, if we hear it repeatedly we will most probably consider it true. This phenomenon is known as the *illusion of truth effect*, which shows that repeated statements have a higher truth value than new statements (Bacon, 1979; Hasher, Goldstein, & Toppino, 1977). This effect has been observed under many different conditions, both in laboratorial and more ecological contexts, and also with different types of statements (trivia facts, personal opinions, product-related claims; see Dechêne, Stahl, Hansen, & Wänke, 2010, for a meta-analytic review).

Illusions of truth are explained as the product of the processing fluency that is associated with repeated stimuli (e.g., Begg, Anas, & Farinacci, 1992; Jacoby & Dallas, 1981). But why should repeated (and thus, fluently processed) statements be truer than new ones? For Begg and colleagues (1992), "there is no logical reason for repetition to affect rated truth or for earlier information to be trusted more than later information" (p. 447). However, a number of arguments favoring a real correspondence between repetition and truthfulness can be put together (see Herzog & Hertwig, 2013; Reber & Unkelbach, 2010; Unkelbach, 2007; Unkelbach & Stahl, 2009). For one thing, it is more likely that we are repeatedly exposed to true information than to false information. This may happen because when individuals communicate with others they tend to present mostly information they consider true, following a maxim of interpersonal communication (Grice, 1975). Additionally, while there are numerous false versions about a fact, there is only one true version of it. So, there is a higher probability that the one true fact about the ice cream cone debuting in the USA in 1924 is encountered more often than every false version of it (e.g., that it was invented in 1955, 1936, etc.).

The link between truth and fluency is corroborated by the fact that individuals are faster to respond to true statements than to false ones (Unkelbach & Stahl, 2009;

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response latencies are often taken as an objective measure of processing fluency, see Reber, Wurtz, & Zimmermann, 2004; Wurtz, Reber, & Zimmermann, 2008). Also, the process of accepting a given fact as true seems to be cognitively fluent and effortless, while the categorization of information as false is a lot more demanding (Gilbert, 1991; Gilbert, Krull, & Malone, 1990). One can thus suppose that repetition and the experience of fluency that accompanies it are tightly connected with truthfulness in the real world. This makes its use as cue for judging the truth status of a statement valid and rather adaptive.

However, truth judgments are also susceptible to the influence of other (seemingly inappropriate) fluency sources. For example, statements are considered more probably true when presented in high contrast rather than in low contrast to the background (e.g., Hansen, Dechêne, & Wänke, 2008; Reber & Schwarz, 1999), in a rhyming rather than a non-rhyming form (McGlone & Tofighbakhsh, 2000), or when words are primed by semantically related concepts vs. not primed (Kelley & Lindsay, 1993). Similar to Begg et al. (1992), one can argue that there is no logical reason for why statements that are easily perceived should be more valid than their perceptually disfluent version. One suggestion is that this occurs due to a misattribution of processing fluency to familiarity (e.g., Begg, Duft, Lalonde, Melnik, & Sanvito, 1989; Begg et al., 1992). Congruently, Reber and Schwarz (1999) suggested that even in the occasions where fluency is not promoted by repeated exposure, illusions of truth may still be rooted in familiarity with information. These authors reasoned that "statements that are easy to process are experienced as familiar (e.g., Whittlesea, Jacoby, & Girard, 1990), thus leading participants to feel that they have heard or seen this before, suggesting that it is probably true" (p. 342; see also Hansen et al., 2008).

The hypothesis that fluency effects on truth judgments are dependent on fluency being attributed to familiarity finds support in studies analyzing truth judgments as a function of statements being perceived as old (i.e., previously encountered) or new. For example, Bacon (1979) found that statements that were recognized as repeated were rated truer than statements judged new, and this occurred independently of the statements' real repetition status (see also Begg & Armour, 1991). Parks and Toth (2006) present convergent evidence in experimental settings in which fluency was associated with the statements' graphic style (making them easy vs. difficult to read). They found substantial positive correlations between participants' ratings of familiarity with statements and judgments of truth (the more familiar a claim was considered, the higher its perceived validity). Thus, "feelings of familiarity drive judgments of truth even in the absence of episodic memory manipulation" (Parks & Toth, 2006, p. 239).

A relevant feature of perceptual fluency truth effects is that they are usually associated with smaller effect sizes than repetition-based effects. Dechêne and collaborators' (2010) meta-analysis of 70 studies showed the repetition truth effect to be medium sized ($d = 0.49$). In comparison, in Reber and Schwarz's (1999) study perceptual fluency was associated with an effect size of only $d = 0.13$. Similarly, Parks and Toth (2006) found an effect size of $d = 0.12$ for an interaction involving perceptual fluency (and the main effects were not significant). In addition, although Hansen and colleagues' (2008) study testing a discrepant-fluency hypothesis showed perceptual fluency to be associated with an effect size of $d = 0.51$, in Dechêne, Stahl, Hansen and Wänke's (2009) study with a repetition manipulation the effect size rose to $d = 1.13$. Contradicting this evidence, Unkelbach (2007, Experiment 2) found perceptual fluency effects ranging from $d = 1.09$ to $d = 1.65$.

But if some researchers recognize that perceptual fluency is associated with smaller effects (e.g., Parks & Toth, 2006; Unkelbach, 2007), this fact is also frequently devaluated, leading to the belief that no differences are expected between the fluency elicited by different sources. Their effects are simply assumed to reflect a unitary construct (Alter & Oppenheimer, 2009) and result in the same general subjective experience of processing ease (e.g., Reber et al., 2004; Wurtz et al., 2008).

Supporting this "unitary view", Unkelbach's (2007) work on the reversal of truth effects shows evidence of equivalence between perceptual fluency and repetition. The author asked participants to categorize a set of easy statements (e.g., "Aristotle was a Japanese philosopher", or "Sunlight contains ultraviolet radiation") as true or false, and gave feedback about their answers. To reverse the fluency–truth link, true statements were always presented in low-contrast colors and false statements always in high-contrast colors. The effectiveness of the reversal was visible in a subsequent phase, when participants judged neutral (difficult) statements (i.e., difficult to know if true or false, such as "Methuselah was the grandfather of Noah") without feedback: participants continued to judge low-contrast statements more probably true than high-contrast ones, showing evidence of having learned the fluency = falseness association. But the most relevant finding was that the learning that occurred with perceptual fluency was generalized to fluency generated by repetition. That is, after learning that low contrast was a sign that a statement was true, participants applied the same logic to old vs. new statements and took novelty as a sign of truth. So, the fluency induced by perceptual features or repetition was experienced and interpreted in the same way. This idea matches Reber and collaborators' (2004) (see also Wurtz et al., 2008) data that although different sources of perceptual fluency have their objective impacts (measured in response times) in different stages of the perceptual process (e.g., color

contrast influences the speed of stimuli-detection, while letter font influences the speed of identification), they produce similar effects on the subjective judgment of how easily a stimulus is perceived.

This evidence suggests "fluency exerts the same influence on judgments independently of how it is generated" (Alter & Oppenheimer, 2009, p. 220). But does it mean that people are "unable to dissociate processing fluency stemming from different sources, for example, previous experiences and perceptual features" (Reber & Unkelbach, 2010, p. 566)? Not necessarily. Take for example the study conducted by Whittlesea (1993), showing that conceptual judgments (e.g., deciding whether a target word is semantically related to words presented in a previous list) are affected by conceptual fluency manipulations (e.g., presenting the target word in a predictive context: the word "boat" following "The stormy seas tossed the") but not by perceptual fluency manipulations (e.g., visual clarity of the words). This suggests some domain specificity in the use of fluency as a cue for our judgments, and so different fluency manipulations may not always lead to the same effects (see Topolinski, 2013, for possible mechanisms underlying fluency-specificity). Similar data are provided by Lanska, Olds and Westerman (2014) with recognition judgments: perceptual fluency of the target words (repetition priming) facilitated verbatim recognition but not recognition of the targets as synonyms of previously presented words (which is more influenced by the conceptual features of the stimuli); by opposition, a conceptual fluency manipulation (presenting the target words in a predictive vs. not predictive context) facilitated meaning-based recognition but not verbatim recognition. Olds and Westerman (2012) provide further evidence of dissociation. The authors showed that the reversal of fluency effects found in the context of memory judgments (i.e., fluency = novelty, Unkelbach, 2006) was not generalized from one fluency manipulation to another (learning the reversal with fluency due to visual contrast was not generalized to fluency due to repetition priming). The reversal also did not generalize across different memory judgments (learning with recognition judgments did not generalize to frequency judgments), suggesting some specificity regarding the task and context in which the new association is learned and then applied.

In sum, while much of the research on fluency shows convergent effects of different fluency manipulations across many judgment domains (for a review see Alter & Oppenheimer, 2009), a set of studies in the context of memory judgments demonstrates that individuals are sensitive to the adequacy of the fluency cue to the task or judgment they are performing. However, there is no data suggesting that this is the case also with truth judgments. But given the arguments claiming for the ecological validity of repetition as cue for truth (see above), a similar effect should be expected.

We tested this hypothesis in two experiments contrasting the effects of fluency due to figure-ground contrast and fluency due to repetition within the paradigm designed by Unkelbach (2007) to reverse the truth effect via a learning mechanism. Assuming that the association of the two fluency sources to truth may be rooted in different processes (e.g., ecological validity vs. misattribution processes) we expect differences regarding relearning and reversal of that association. The ecological validity in repetition's link to truth may strengthen that association in a way that is not necessarily present in misattribution processes. Thus, repetition's association with truth should be harder to reverse than is the case with perceptual fluency, as a short, isolated training episode may not be strong enough to counteract a relation that has been reinforced for a lifetime. This was tested in Experiment 1. In addition, we tested whether the generalization effects that were found between the two fluency sources (Unkelbach, 2007) relied on conditions that favored the confounding of the two fluency sources. In Experiment 2, after a learning block designed to make high perceptual fluency predictive of falseness, repetition and color contrast were manipulated simultaneously and orthogonally. If no generalization effects are observed under these conditions (i.e., the reversal learned with perceptual fluency is not transferred to repetition), then there are grounds to believe that the two sources of fluency are not necessarily equivalent, and that individuals can discriminate among them and their meanings.

Experiment 1

This experiment tested if the association between repetition and truth can be reversed after a learning block where the opposite association (repetition = falseness) is trained. To do this, we replicated the feedback-learning procedure used by Unkelbach (2007, exp. 2) to reverse illusions of truth due to perceptual fluency, but introduced another condition in which repetition was manipulated. So, different from Unkelbach, part of our participants trained the fluency = falseness link with statements with varying levels of repetition (0 vs. 1). Thus, our aim with this experiment was to test whether the feedback-learning procedure used to reverse the truth effect is as effective with repetition as it was shown to be with perceptual fluency.

Method

Participants and design[1]

Forty-five undergraduate students (40 women; $M_{age} = 21.56$ years, SD = 7.11) participated in the

[1] Across the two experiments, participants had normal or corrected-to-normal eye vision and color acuity. All participants gave their informed consent upon registering for the experiments.

experiment for course credit. They were randomly assigned to the cells of a 2 (fluency level: high vs. low fluency) × 2 (fluency source: repetition vs. color contrast) factorial design, with fluency level manipulated within participants.

Material[2]

A set of 80 neutral and 90 easy statements about various topics was used. Neutral statements consisted of items that in previous pre-tests showed an equal probability of being considered true or false (e.g., "It takes 60 days for a house fly to become great-grandmother"; see Garcia-Marques, Silva, Reber, & Unkelbach, 2015); easy statements were assertions that individuals can clearly identify to be true or false (e.g., "A guitar is a string instrument" or "February is the first month of the year"). Half of the statements in each category were true and half were false. Color contrast was manipulated by varying RGB values, a well-established manipulation of perceptual fluency (e.g., Hansen et al., 2008; Reber & Schwarz, 1999; Unkelbach, 2007). Thus, following the combinations of values used by Unkelbach (2007), a low-contrast and a high-contrast version of blue and red colors was created (high-contrast blue: 110, 110, 225; low-contrast blue: 220, 220, 255; high-contrast red: 255, 110, 110; low-contrast red: 255, 220, 220). Statements were written in Arial (size 18) and were always presented against a white background.

Materials and responses were presented and registered using *e-prime* software (Schneider, Eschman, & Zuccolotto, 2002). HP 72 17-inch monitors with 800 × 600 pixel resolution were used to display the materials. Statements were always presented in the center of the screen. Participants saw the stimuli from a distance of ≈45 cm. Size of statements was consistent throughout the experiment (width: 8.84 cm; height: 3.97 cm). These experimental apparatus and material characteristics were common for the two experiments reported in this paper.

Procedure

Participants were invited to take part in a study involving the reading of sentences in different colors and the evaluation of images. The experiment consisted of four phases: (1) exposure phase, (2) filler task, (3) learning phase and (4) test phase.

Exposure phase Only participants in the repetition condition were subjected to the exposure phase. They read 60 easy and 30 neutral statements (half true, half false). They were told that half of the statements were true and half were false. Statements were presented one at a time, in high-contrast black letters with a 500 ms blank screen between them (order of the statements was randomly determined for each participant). A rapid presentation time of 3 s per statement was used to minimize chances of profound encoding and processing operations (see Unkelbach, 2007, Experiment 3).

Filler task To eliminate statements from working memory, participants performed an unrelated filler task lasting approximately 10 min, in which they had to rate the pleasantness of 35 images (e.g., objects, food, people).

Learning phase Sixty easy statements (half true, half false) were presented and participants were instructed to decide whether they were true or false as quickly as possible. Statements (randomly ordered for each participant) were presented individually and remained on the screen until participants pressed either the "S" or the "L" key to indicate whether the statement was "True" or "False", respectively. The labels "S—True" and "L—False" were presented with the statements, close to the lower left and lower right corners of the screen, respectively. Each response received veridical feedback, with the words "correct" or "wrong" appearing above the statement for 2 s. A 1-s blank screen separated each trial. Participants in the color contrast conditions judged only new statements, while participants in the repetition condition judged 30 new and 30 repeated statements (from the exposure phase). As the focus of the experiment is whether a reversal of truth effects occurs, the learning phase implemented one condition reinforcing the fluency = falseness link, i.e., a reversed learning condition (Unkelbach, 2007; see Olds & Westerman, 2012, for a similar approach). Thus, to promote reversed learning in the repetition condition all false items were repeated from the exposure phase and all true statements were new (in this condition all statements were written in black letter). In the color contrast condition, all false statements were presented in high-contrast blue and red (15 in each color) and all true statements were presented in the colors' low-contrast version.

Test phase Participants were told they would continue with the previous task with another set of stimuli. They were again informed that half of the statements were true and half were false, but now no feedback would be provided. They were also instructed to answer as fast as possible. The procedure of the test phase was in everything similar to the learning phase, with the

[2] Table 9 in "Appendix" provides a list of the original pool of statements used for all the experiments. We only gathered information about the RGB values that were used to manipulate color contrast, as this is the most common information provided in other studies investigating color contrast effects on truth (e.g., Hansen et al., 2008; Unkelbach, 2007). However, in future studies measured color should also be provided (i.e., a measure of the colors at the surface of the display), in order to know exactly how the colors looked like in the computer screens and not only the contrast that researchers intended to create.

exception of the statements presented for judgment and the absence of feedback. For participants in the repetition condition 60 neutral statements were presented, 30 repeated from the exposure phase and 30 completely new (all statements were again written in black). Half of the repeated and of the new statements were true and half were false. For participants in the color contrast condition, 40 new neutral statements were presented (half true, half false), half in high-contrast and the other half in low-contrast colors. Half of the statements in each contrast level were presented in blue and half in red letters. This combination resulted in 10 statements being presented in high-contrast blue; 10 statements in low-contrast blue; 10 statements presented in high-contrast red; 10 statements in low-contrast red. In each contrast × color combination, 5 statements were true and 5 were false.

Dependent measures

Using the proportions of "True" responses to true statements—hit rate, and to false statements—false alarms (FA) rate, we derived signal detection theory (SDT) estimates of d' (discrimination ability; higher values represent better discrimination between true and false statements) and C (criteria for answering "True"; $C = 0$ represents a unbiased respondent; negative values indicate a bias to answer "True", and positive values indicate a bias to answer "False") both for the learning and the test phase. Participants' response times (RTs) were also analyzed to measure processing speed (an objective measure of processing fluency).

Results and discussion

Learning phase

Mean hit rates, FA rates, and SDT d' and C estimates are provided in Table 1. For parsimony, we report only the analyses of the SDT measures, entered as dependent measures in t tests comparing the two fluency source conditions.

Table 1 Mean (SD) hits, false alarm rates, and SDT estimates in the learning phase of Experiment 1, by fluency source (repetition vs. color contrast)

	Hits	FA	d'	C
Repetition ($n = 25$)	0.96 (0.04)	0.09 (0.07)	3.16 (0.57)	−0.17 (0.25)
Color contrast ($n = 20$)	0.96 (0.02)	0.07 (0.07)	3.38 (0.56)	−0.11 (0.21)

Discrimination estimates (d') Corroborating that the statements' truth status was very clear, d' estimates were high in both conditions (both d's > 3.00). Although there was a slight tendency for worse discrimination in the repetition condition, the effect of fluency source did not reach significance, $t(43) = 1.32$, $p < 0.193$.

Criteria estimates (C) Mean C estimates show that overall participants adopted liberal criteria for their responses (both Cs < -0.10). No significant difference emerged between the two fluency manipulations, $t < 1$.

Response Times (*RTs*) The main effect of fluency source shows that overall RTs[3] in the repetition condition were faster than in the color contrast condition ($M_{\text{repetition}} = 2625$, SD = 696 and $M_{\text{color-contrast}} = 3907$, SD = 1157), $F(1, 43) = 22.61$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.34$. However, the effect of fluency level did not achieve standard levels of significance, $F(1, 43) = 2.87$, $p = 0.098$ ($M_{\text{high-fluency}} = 3252$, SD = 1284 and $M_{\text{low-fluency}} = 3138$, SD = 960). This is because the processing advantage associated with high-fluency statements is only clearly detected in the color contrast condition ($M_{\text{high-contrast}} = 3734$, SD = 954 and $M_{\text{low-contrast}} = 4079$, SD = 1358, $t(43) = 2.85$, $p = 0.007$, $d = 0.29$) and not in the repetition condition ($M_{\text{repeated}} = 2590$, SD = 731 and $M_{\text{new}} = 2660$, SD = 660, $t < 1$), promoting a significant interaction between the fluency level and fluency source factors, $F(1, 43) = 6.52$, $p < 0.014$, $\eta^2_{\text{partial}} = 0.13$. This pattern of results may suggest that for participants in the repetition condition to provide the same level of correct responses as participants in the color contrast condition (as shown by the analysis of d' and C estimates), repeated statements lost their processing advantage. That is, it seems that the elimination of the bias to categorize repeated statements as being true is achieved at the cost of longer RTs.

Test phase

Table 2 presents mean hit and FA rates, and SDT d' and C estimates by fluency source. SDT estimates were analyzed with ANOVAS associated with our experimental design (fluency source × fluency level).

Discrimination estimates (d') d' estimates were low across all conditions, what corroborates that the neutral

[3] Following Unkelbach (2007) procedure, we also analyzed RTs after winsorizing the values (see Ratcliff, 1993) at 1000 ms and 5000 ms in the learning phase (i.e., latencies greater than 5000 ms were set to 5000 ms, and latencies less than 1000 ms were set to 1000 ms) and at 1000 ms and 7000 ms in the test phase (i.e., latencies greater than 7000 ms were set to 7000 ms). Results were unchanged.

Table 2 Mean (SD) hits, false alarm rates, and SDT estimates in the test phase of experiment 1, by fluency source (repetition vs. color contrast)

	Hits	FA	d'	C
Repetition ($n = 25$)				
Repeated	0.59 (0.14)	0.65 (0.16)	−0.17 (0.44)	−0.32 (0.35)
New	0.57 (0.16)	0.51 (0.10)	0.19 (0.60)	−0.10 (0.45)
Color contrast ($n = 20$)				
High contrast	0.38 (0.23)	0.53 (0.20)	−0.45 (0.72)	0.16 (0.58)
Low contrast	0.53 (0.19)	0.49 (0.20)	0.12 (0.57)	−0.01 (0.52)

statements used in this phase of the experiment were hard to categorize as true or false. Results of the ANOVA revealed only a main effect of fluency level: participants were better discriminating low-fluency than high-fluency statements ($M_{\text{high-fluency}} = -0.29$, SD = 0.59 and $M_{\text{low-fluency}} = 0.16$, SD = 0.58), $F(1, 43) = 11.40$, $p = 0.002$, $\eta^2_{\text{partial}} = 0.21$. No other effects were significant [fluency source: $F(1, 43) = 2.41$, $p = 0.126$; interaction: $F < 1$].

Criteria estimates (*C*) To understand whether the learning phase was successful in reversing the truth effect elicited by repetition and perceptual fluency, *C* estimates were analyzed. A successful reversal of repetition and perceptual fluency effects should result in the use of a more liberal criterion (i.e., a higher bias to answer "True") for new or low-contrast statements than for repeated or high-contrast statements. A main effect of fluency source was found, showing that criteria were more liberal in the repetition than in the color contrast condition ($M_{\text{repetition}} = -0.21$, SD = 0.40 and $M_{\text{color-contrast}} = 0.08$, SD = 0.55), $F(1, 43) = 7.08$, $p = 0.011$, $\eta^2_{\text{partial}} = 0.14$. But most informative for understanding the effectiveness of the reversed learning procedure in the two conditions, the fluency source × fluency level interaction was significant, $F(1, 43) = 4.51$, $p = 0.039$, $\eta^2_{\text{partial}} = 0.09$. As can be seen in Table 2, in the color contrast condition the bias to judge statements "True" was higher for low-contrast than for high-contrast statements, congruently with the association that was trained before. However, the same is not true in the repetition condition. Here, the typical truth effect pattern is found, with a higher bias to consider statements true when they are repeated rather than false. Given the pattern of this interaction, the effect of fluency level was not significant ($F < 1$). These results suggest that even if the learning procedure eliminated the bias to associate repetition to truth in the learning phase, it did not translate into a reversal of the truth effect in the test phase.

Response times (*RTs*) The analysis of RTs (Table 3) revealed several effects of our manipulations on objective processing speed. First, participants in the repetition condition were in general faster to make their judgments than participants in the color contrast condition

Table 3 Mean (SD) response times (in ms) to high- and low-fluency statements in the test Phase of Experiment 1, by fluency source (repetition vs. color contrast)

	High-fluency statements (repeated/high contrast)	Low-fluency statements (new/low contrast)
Repetition ($n = 25$)	2871 (823)	3533 (891)
Color contrast ($n = 20$)	4536 (1266)	4535 (1366)
Total ($n = 45$)	3611 (1328)	3979 (1221)

($M_{\text{repeated}} = 3201$, SD = 857 and $M_{\text{color-contrast}} = 4535$, SD = 1316), $F(1, 43) = 17.57$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.29$, which is not surprising since they were activating a well-learned association. Second, responses were faster to high-fluency statements than low-fluency statements ($M_{\text{high-fluency}} = 3610$, SD = 1328 and $M_{\text{low-fluency}} = 3978$, SD = 1221), $F(1, 43) = 23.73$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.36$. However, the significant interaction between the two factors, $F(1, 43) = 23.90$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.36$, shows that the faster responses to high-fluency statements hold only in the repetition condition [faster RTs to repeated than to new statements, $t(43) = 7.32$, $p < 0.001$, $d = 0.77$]. Participants in the perceptual fluency condition showed no difference in the RTs to high-contrast vs. low-contrast statements ($t < 1$), possibly because the effects of processing fluent items were diluted by the reversal of the response.

In sum, Experiment 1 indicates that repetition-based truth effects are harder to reverse than when the effect anchors on perceptual fluency. This is supposedly because the association of repetition with truth is somewhat stronger than that of perceptual fluency. An assumption of a stronger association implies that individuals will need to exert effort in its correction. This should interfere with the time taken to make correct judgments, which is exactly what we found for the repetition condition in the learning phase of the experiment. Being differently connected to the inference of truth, the effects of the two fluency sources

may be open to dissociation and individuals may be able to differentiate them under specific circumstances. We tested this hypothesis directly in Experiment 2.

Experiment 2

Previous studies showed that the reversal of the truth effect learned with fluency due to color contrast is generalized to a repetition manipulation in the test phase (Unkelbach, 2007). This generalization provides evidence that the two sources of fluency generate a processing experience with convergent effects on subjective judgments of truth. In those experiments generalization occurred in a testing context where only repetition was manipulated, a context that favors the confounding between the fluency source used during learning and the fluency source used at test. However, the existence of a confound (which is needed for a misattribution to occur) does not necessarily imply that the effects of the two fluency sources cannot be dissociated. It just stresses that the fluency experience they promote is similar enough so that what is learned with one fluency source is transferred to the other one. To understand whether the effects of the two fluency sources can be dissociated, participants should experience the fluency induced by repetition and color contrast simultaneously after training the reversal of the truth effect with color contrast. Such context allows assessing whether both sources of fluency will still exert convergent effects, or if their impact is dissociated due to their opposite associations with truth. This is what we did in Experiment 2, replicating Unkelbach (2007) Experiment 3, while introducing that small but relevant factor in the test phase (i.e., the manipulation of color contrast orthogonal to repetition). In addition, we introduced a recognition test in the end of the experiment to understand how memory mechanisms might contribute to the expected reversal effects, and explore how the learning procedure affects the truth judgments of statements perceived as familiar or new (e.g., Bacon, 1979; Begg & Armour, 1991).

Method

Participants and design

Fifty-three undergraduate students (42 women; $M_{age} = 20.58$ years, SD = 4.61) participated in the experiment in exchange for course credit. They were randomly assigned to the conditions of a 2 (learning condition: classic vs. reversed) × 2 (repetition: repeated vs. new statements) × 2 (color contrast: high vs. low) factorial design, with the last two factors manipulated within participants.

Material

Ninety-six neutral and 60 easy statements were used.[4] Half of the statements in each category were true and half were false. Color contrast was manipulated as in Experiment 1, but two colors were added: green (RGB combination for high contrast: 110, 255, 110; low contrast: 220, 255, 220) and orange (high contrast: 255, 180, 0 and low contrast: 255, 255, 101). In this experiment, different colors were used in the learning phase (blue and red) and in the test phase (green and orange) to increase the dissociation between the colors used in the two phases.

Procedure

Exposure phase Exposure was done as in Experiment 1, but with 48 neutral statements (half true and half false; easy statements were not used in this phase of the experiment). The same filler task followed.

Learning phase Sixty easy statements were again used for the learning trials. Different from Experiment 1, the learning procedure occurred only with color contrast and a classic learning condition (i.e., fluency = truth) was introduced. In this condition, true statements were all presented in high-contrast blue and red, and all false statements were presented in the colors' low-contrast version so that the link fluency–truth was established. By opposition, in the reversed learning condition all true statements were presented in low contrast and all false statements in high contrast.

Test phase The procedure of the test phase was similar to the previous experiment, but repetition and color contrast were manipulated orthogonally. Ninety-six neutral statements were presented, all 48 from the exposure phase (half true, half false) and 48 totally new ones. Half of the repeated and of the new statements were presented in high contrast and the other half in low contrast. Thus, of the 48 repeated and new statements, 12 were presented in high-contrast green and 12 in low-contrast green, 12 in high-contrast orange and 12 in low-contrast orange. In each contrast × color combination, 6 statements were true and 6 were false.

Recognition test In the end of the experiment, 48 statements were presented (16 old items from the exposure

[4] Because the learning procedure occurred only with color-contrast, the 30 easy statements of the exposure phase were not needed, reducing the learning material to 60 easy items. The number of neutral statements was increased to assure a sufficient number of statements in each contrast × color × repetition combination in the test phase.

Table 4 Mean (SD) hits, false alarm rates, and SDT estimates in the learning phase of Experiment 2, by learning condition (classic vs. reversed)

Learning condition	Hits	FA	d'	C
Classic learning ($n = 26$)	0.93 (0.06)	0.09 (0.07)	3.06 (0.73)	−0.04 (0.24)
Reversed learning ($n = 21$)	0.95 (0.03)	0.08 (0.07)	3.32 (0.54)	−0.07 (0.29)
Total ($n = 47$)	0.94 (0.05)	0.08 (0.07)	3.18 (0.66)	−0.05 (0.26)

phase, 16 of the items presented as new on the test phase, and 16 totally new statements, all randomly selected; participants were not aware of the number of each type of statement), and participants were asked to indicate whether they recognized them from the exposure phase (an exclusion recognition instruction, e.g., Jacoby 1991). Care was taken to make these recognition instructions very clear, repeating twice that the response "Old" should be given only to items from the exposure phase. Statements were written in black and the question "Was this statement presented in the first exposure phase of the experiment?" appeared on top. Participants used the "S" key to signal that a statement had been presented in the exposure phase ("Old" responses), and the "L" key to signal that it had not ("New" responses). A 1-s blank screen separated the trials. After the recognition test, participants were thanked and debriefed.

Dependent measures

d' and C estimates were again calculated and participants' RTs were also analyzed. For the recognition test we considered only the proportions of "Old" responses to the three types of statements—old (hits), "new" items from the test phase (FA-test phase), and new statements (FA).[5]

Results and discussion

Learning phase

Table 4 presents mean hits and FA rates and d' and C estimates in all conditions.[6]

Discrimination estimates (d') Indicating that both learning groups clearly understood which statements were true and which were false (all d's > 3.00), analysis of d' estimates showed no differences between the two conditions, $t(45) = 1.37$, $p = 0.177$.

Table 5 Mean (SD) response times (in ms) to high- and low-contrast statements in the learning phase of Experiment 2, by learning condition (classic vs. reversed)

Learning condition	High contrast	Low contrast
Classic learning ($n = 26$)	2967 (584)	3336 (706)
Reversed learning ($n = 21$)	3065 (652)	2848 (563)
Total ($n = 47$)	3016 (611)	3092 (684)

Criteria estimates (C) Mean values of C reflected unbiased decisions in both conditions (both Cs ≈ 0) and no differences were found between the two groups ($t < 1$).

Response Times (*RTs*) Results of the ANOVA revealed no significant main effects [color contrast: $F(1, 45) = 1.22$, $p = 0.276$; learning condition: $F(1, 45) = 1.28$, $p = 0.263$]. However, the interaction between the two factors was significant, $F(1, 45) = 18.03$, $p < 0.001$, $\eta_{\text{partial}}^2 = 0.29$. While in the classic learning condition participants were faster responding to high-contrast statements than to low-contrast ones, the opposite occurred in the reversed learning condition (Table 5), manifesting the a priori advantage that true statements have over false ones in terms of objective processing fluency (e.g., Unkelbach, 2007; Unkelbach & Stahl, 2009).

Test phase

Mean hits and FA rates and d' and C estimates for the test phase can be found in Table 6.

Discrimination estimates (d') Mean d' estimates were very low across all conditions (Table 5), suggesting that it was highly difficult to distinguish true from false facts. Congruently, an ANOVA yielded no significant main effects or interactions on d' estimates (all Fs < 1, except the three-way interaction, $F(1, 45) = 1.70$, $p = 0.199$). Only the interaction between repetition and color contrast was marginally significant, $F(1, 45) = 3.51$, $p = 0.069$, $\eta_{\text{partial}}^2 = 0.07$, showing a tendency for new statements to be discriminated better when presented in high rather than in low contrast ($M_{\text{high-contrast}} = 0.08$, SD $= 0.62$; and $M_{\text{low-contrast}} = -0.11$, SD $= 0.48$), while the opposite happened for repeated statements ($M_{\text{low-contrast}} = 0.09$, SD $= 0.48$; and $M_{\text{high-contrast}} = 0.01$, SD $= 0.57$).

[5] Two sets of SDT estimates were computed for this data and their analysis did not bring any advantage to comparing the differences between the three proportions themselves. Thus for the sake of clarity they are not here presented.

[6] Only the data of 47 participants were analyzed, as 6 participants could not be considered due to (a) having participated in a similar experiment in the previous semester ($n = 2$), (b) not finishing the experiment ($n = 2$), and (c) interrupting the viewing of the exposure phase to complain about the rate at which stimuli were presented ($n = 2$).

Table 6 Mean (SD) hits, FA rates, and SDT estimates in the test phase of Experiment 2, by learning condition (classic vs. reversed), repetition (repeated vs. new) and color contrast (high vs. low) level

Learning condition	Hits	FA	d'	C
Classic learning ($n = 26$)	0.56 (0.20)	0.55 (0.20)	0.02 (0.57)	−0.17 (0.53)
Repeated—high contrast	0.64 (0.23)	0.61 (0.21)	0.10 (0.57)	−0.40 (0.61)
Repeated—low contrast	0.57 (0.23)	0.55 (0.18)	0.06 (0.46)	−0.18 (0.55)
New—high contrast	0.55 (0.18)	0.53 (0.21)	0.03 (0.68)	−0.14 (0.48)
New—low contrast	0.47 (0.17)	0.51 (0.21)	−0.11 (0.55)	0.03 (0.48)
Reversed learning ($n = 21$)	0.65 (0.18)	0.66 (0.16)	0.01 (0.50)	−0.48 (0.47)
Repeated—high contrast	0.67 (0.20)	0.73 (0.19)	−0.13 (0.57)	−0.63 (0.59)
Repeated—low contrast	0.79 (0.16)	0.76 (0.13)	0.13 (51)	−0.86 (0.46)
New—high contrast	0.56 (0.19)	0.53 (0.15)	0.14 (0.54)	−0.15 (0.38)
New—low contrast	0.58 (0.17)	0.62 (0.16)	−0.12 (0.37)	−0.29 (0.44)

C estimates (C) Suggesting a successful reversal of the perceptual fluency experience, participants used a more liberal criterion for low-contrast statements than high-contrast ones in the reversed learning condition, whereas the opposite occurred in the classic learning [interaction between color contrast and learning condition, $F(1, 45) = 10.16$, $p = 0.003$, $\eta^2_{\text{partial}} = 0.18$]. So, in the classic learning condition, the typical illusion of truth emerged and participants showed a higher bias for truth for high-contrast than low-contrast statements ($M_{\text{high-contrast}} = -0.27$, SD = 0.55 and $M_{\text{low-contrast}} = -0.07$, SD = 0.51), $t(45) = 2.46$, $p = 0.018$, $d = 0.38$. This pattern inverted in the reversed learning condition, and the higher bias for truth emerged for low-contrast rather than high-contrast statements ($M_{\text{high-contrast}} = -0.57$, SD = 0.45 and $M_{\text{low-contrast}} = -0.39$, SD = 0.49), $t(45) = 2.08$, $p = 0.044$, $d = 0.38$. The key question is now if such reversal was extended and generalized to repetition. However, the main effect of repetition and its moderation by the learning condition do not support such generalization. The main effect reflects the typical truth effect pattern: the criteria to judge a statement "True" was a lot more liberal for repeated statements than for new ones ($M_{\text{repeated}} = -0.49$, SD = 0.61 and $M_{\text{new}} = -0.13$, SD = 0.46), $F(1, 45) = 37.78$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.46$. Additionally, the interaction shows that the truth effect was larger in the reversed learning condition (difference between repeated and new items = 0.52) than in the classic one (difference between repeated and new items = 0.29), $F(1, 45) = 5.61$, $p = 0.022$, $\eta^2_{\text{partial}} = 0.11$. This is exactly the opposite of what was expected if a generalization occurred. The ANOVA also revealed a main effect of learning condition, with participants in the reversed learning condition showing a higher bias to judge statements "True" than participants in the classic condition, $F(1, 45) = 7.59$, $p = 0.008$, $\eta^2_{\text{partial}} = 0.14$. All other effects were not significant ($F < 1$).

Response times Analysis of participants' RTs (Table 7) validate that both repetition and high contrast increased statements' processing fluency. Participants were faster to answer to repeated than to new statements ($M_{\text{repeated}} = 3699$, SD = 1042, and $M_{\text{new}} = 4396$, SD = 1081), $F(1, 45) = 87.08$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.66$, and faster to answer to high-contrast than to low-contrast statements ($M_{\text{high-contrast}} = 3909$, SD = 1070 and $M_{\text{low-contrast}} = 4186$, SD = 1053), $F(1, 45) = 15.45$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.26$. No other effects were significant [all Fs < 1, except the three-way interaction, $F(1, 45) = 1.31$, $p = 0.26$].

Table 7 Mean (SD) response times (in ms) in the test phase of Experiment 2, by learning condition (classic vs. reversed), repetition (repeated vs. new) and color contrast (high vs. low) level

Learning condition	High contrast	Low contrast
Classic learning ($n = 26$)	3998 (1146)	4232 (1096)
Repeated	3584 (1143)	3950 (1112)
New	4412 (1148)	4513 (1080)
Reversed learning ($n = 21$)	3803 (984)	4130 (1018)
Repeated	3457 (942)	3774 (952)
New	4149 (1025)	4486 (1083)
Total ($n = 47$)	3909 (1070)	4186 (1053)

Recognition test

Proportions of "Old" responses in the recognition test (Table 8) were analyzed with an ANOVA, having learning condition (classic vs. reversed) and type of statement (old vs. "new" items of the test phase vs. new items; repeated measures) as independent factors. As Table 7 shows, participants had good memory for the information that had been presented in the exposure phase. This is evidenced by the main effect of type of statement, $F(2, 90) = 97.68$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.69$, showing a high mean proportion of hits and a very low proportion of FA (associated with totally new items). This means that even though statements in the exposure phase were presented rapidly, participants were still able to register the information they were

Table 8 Mean (SD) hits, FA and FA-test rates in the recognition test of Experiment 2, by learning condition (classic vs. reversed)

Learning condition	Hits	FA	FA-test phase
Classic learning ($n = 26$)	0.80 (0.21)	0.07 (0.08)	0.48 (0.39)
Reversed learning ($n = 21$)	0.85 (0.21)	0.11 (0.18)	0.38 (0.38)
Total ($n = 47$)	0.82 (0.21)	0.09 (0.13)	0.43 (0.38)

exposed to and later recognize it. However, the proportion of FA-test phase (FA to the "new" items of the test phase) was at chance level (t test comparing this FA rate with chance level of 0.50, $t(46) = -1.17$, $p = 0.250$). Because the higher SDs associated with these responses are unlikely to be attributed to participants not fully comprehending the (exclusion) instructions of the recognition test (instructions were presented twice before the test started), these results seem to inform that participants were relying on familiarity to make their recognition decisions (e.g., Jacoby, 1991).

Conditional analysis

Results of C estimates in the test phase indicate the absence of a reversal of the truth effect associated with repetition, suggesting that participants did not reverse the meaning of the subjective experience of familiarity. This implies that the correspondence between familiarity and truth was not altered by the learning procedure. In this case, any statement perceived as familiar (independently of its objective status) should be also perceived as true. That is, an association between *perceived familiarity* and truth should also be observed and be independent of learning conditions. We tested this hypothesis by comparing the proportion of "True" responses to the statements that participants perceived as familiar ("old") and those they considered "new", independently of their real repetition status. The ANOVA with learning condition (classic vs. reversed) as between-participants factor and recognition status of the statements ("old" vs. "new") as repeated measures revealed only a main effect of the items' recognition status. Congruently with previous studies (e.g., Bacon, 1979; Begg & Armour, 1991), the proportion of "True" responses was higher for statements that participants considered old than for those they considered new ($M_{old} = 0.65$, SD = 0.17 and $M_{new} = 0.46$, SD = 0.26), $F(1, 45) = 16.94$, $p < 0.001$, $\eta^2_{partial} = 0.27$. Neither the effect of learning condition, $F(1, 45) = 1.76$, $p = 0.19$, nor the interaction between the two factors, $F(1, 45) = 1.63$, $p = 0.21$, was significant. This result, together with the fact that participants were quite accurate in recognizing repeated statements, suggests that the experience of familiarity and the link familiarity–truth underlay participants' judgments in both learning conditions.

The high memory accuracy could indicate that participants merely followed a recognition heuristic (e.g., Gigerenzer & Goldstein, 2011; Goldstein & Gigerenzer, 2002) in the test phase and did not base their responses on the experience of fluency due to repetition at all. Despite the fact that no differences were found between the RTs in the perceptual fluency and repetition conditions (with high-fluency statements being faster to process than low fluency ones in both conditions), suggesting that the same kind of fluency-based processes were occurring in the two conditions, the hypothesis that a recognition rule was in use (participants judged repeated statements as true simply because they remembered them) should be considered and addressed more systematically in the future.

In sum, results of this experiment suggest that the generalization of the effects associated with perceptual fluency to repetition is less prone to happen in a context where their distinctive features can be contrasted. When the two fluency sources are put side by side with opposing signs regarding truth, their effects are dissociated.

General discussion

Our goal in this study was to contrast perceptual fluency and repetition effects on subjective judgments of truth. We wanted to test whether the two fluency sources encompass specificities that can be disentangled by our cognitive system. Experiment 1 suggests that even if the bias to associate repetition with truth is eliminated in the learning phase with easy statements, it does not translate into a reversal of the repetition truth effect when feedback is no longer given and statements are ambiguous/neutral regarding truth (i.e., the test phase). In addition, results of Experiment 2 corroborate that different sources of fluency can be dissociated. When repetition and color contrast were manipulated orthogonally and had opposing signs regarding the association with truth, they were differentiated and their effects dissociated.

Results of Experiment 1 fit well with the fact that in the literature the truth effect associated with repetition is usually of a higher magnitude than when perceptual fluency manipulations are used (e.g., Hansen et al., 2008; Parks & Toth, 2006; Reber & Schwarz, 1999; but see Unkelbach, 2007, for an exception). Given the difficulty that our participants demonstrated in associating repeated statements with the response "False", even though they were clearly false (only easy statements were used in those experiments), it seems that repetition has a stronger

connection to truth, which is also less malleable than in the case of perceptual fluency. This apparently stronger link of repetition to truth may have its root in the ecological validity of that association (see Herzog & Hertwig, 2013; Reber & Unkelbach, 2010; Unkelbach, 2007), while truth effects due to perceptual fluency are likely to have another origin, as attribution processes for example (e.g., misattribution to familiarity, e.g., Parks & Toth, 2006).

Yet, one other characteristic of repetition may contribute to its strong impact on truth judgments. Repetition aggregates different levels of fluency. Besides the perceptual fluency that comes from reprocessing the wording and phrase structure of the statements, repetition also increases conceptual fluency due to the reprocessing of the semantic content and meaning of the stimuli. As discussed earlier, there seems to be a certain domain specificity in the use of fluency as cue for judgments—several studies show conceptual fluency to selectively influence more conceptual judgments and perceptual fluency to influence more perceptual judgments (e.g., Lanska et al., 2014; Whittlesea, 1993). Truth judgments are by nature conceptual judgments in which the validity of an assertion about reality is evaluated. Thus, there should be a higher equivalence and adequacy in the use of repetition-based fluency to inform about truth value than the fluency elicited at the perceptual level.

Our arguments are anchored in the results obtained within a response-reversal paradigm (e.g., Unkelbach, 2006, 2007). Coutanche and Thompson-Schill (2012) theoretical analysis of these paradigms suggests that the response reversal observed after a block of training does not necessarily mean that the primary association (e.g., fluency–truth) itself has changed. The two associations (i.e., the original and its reversal) may co-occur. Being so, a training block aiming at reversing the typical response to stimulus turns that association ambiguous. That is, after training there are two possible interpretations for the stimulus—the original and the reversed one. And just like for any ambiguous stimulus, the choice between the two available responses can be cued/supported by the context an individual is in. Therefore, the new response is most likely to be selected in the specific context where it was developed. However, the exhibition of the response reversal cannot be taken as a clear sign that the original association has been changed. Rather, it probably remained unaltered and is just not being activated in that specific context because individuals learned that it is not the appropriate one. Thus, it is possible that the generalization effects previously found between perceptual fluency and repetition effects are not translating the effective reversal of their association with truth, but rather that individuals learned that in that specific context they should respond according to the reversed pattern to be correct.

This hypothesis fits our data showing that as soon as repetition and perceptual fluency are manipulated simultaneously, the reversal is manifested only for perceptual fluency—the variable with which the reversal was learned to produce correct responses. This result is also reminiscent to what the Rescorla–Wagner model of conditioning predicts in a case of blocking (e.g., Rescorla & Wagner, 1972; Wagner & Rescorla, 1972; for an overview of the model see Miller, Barnet, & Grahame, 1995), in which the previous pairing of color contrast with falseness in the learning phase blocks the same association with repetition when the two fluency instances are presented together. However, for this to happen, it is always necessary that the fluency promoted by repetition is dissociated from the fluency promoted by color contrast (otherwise participants would not be able to have two different patterns of response, one for each fluency source). Thus, our results challenge the idea of fluency as a unified experience that has the same effect on subjective judgments independently of how it is promoted (e.g., Alter & Oppenheimer, 2009). And in a way, we extend Reber and collaborators' (2004) (Wurtz et al., 2008) conclusions, by showing that the impact of different fluency experiences can also be dissociated in subjective judgments, such as truth judgments, and not only in objective measures of cognitive processing (RTs).

But even though different fluency manipulations may result in different (objective and subjective) effects, the fact is that certain evaluative contexts lead to confounds between them, suggesting that the experiences they elicit share important characteristics. For example, it seems that the processing experience promoted by diverse fluency sources is positive and hedonically marked (e.g., Winkielman, Schwarz, Fazendeiro, & Reber, 2003). This, or other shared features of different fluency sources, can lead to one being taken by another when the context does not allow the comparison of their distinctive attributes. A reason that contributes for the confound is the diffuse nature of fluency (e.g., Mandler, Nakamura, & Van Zandt, 1987), which results in no clear borders between the experiences elicited by different manipulations, or between them and the judgments they affect.

By showing a dissociation of perceptual fluency and repetition effects on truth judgments, our results evidence that, in this context, the fluency elicited by the two different sources can be disentangled and does not necessarily promote the same output. Additionally, these results highlight the relevance of the contexts in which individuals make their judgments. When the evaluative context allows the simultaneous experience of the fluency generated by different factors, their influences on subjective judgments can be separated. However, in this work we only contrasted repetition and color contrast as sources of fluency. It is relevant

that future research explores whether the dissociations found are a specific case of repetition, or if they would also emerge with other stimuli's features that impact processing ease. Another question to be addressed is whether these dissociations are also found for other types of judgments, especially those addressing directly the subjective experience of ease.

In conclusion, like Alter and Oppenheimer (2009) suggested, there is no doubt that fluency is a ubiquitous metacognitive cue in our subjective judgments and that the many forms of processing fluency exert convergent effects on those judgments. But our results suggest that the tribes forming the metacognitive nation of fluency may not be so united after all, and may at times be at war.

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Compliance with ethical standards

Ethical standards The research was conducted in compliance with all APA Ethical Guidelines for the treatment of human participants, and we believe it presents new relevant data. Neither the manuscript nor the data have been published previously, nor are they under consideration for publication elsewhere, and its publication is approved by all authors.

Appendix

See Table 9.

Table 9 Pool of statements

Statement	True/false	Type of statement
A medalha do Prémio Nobel da Paz tem 3 homens com as mãos pousadas nos ombros uns dos outros	True	Neutral
A construção da Casa Branca foi iniciada em 1792 e estava pronta para habitar em 1800	True	Neutral
O número de rotações de uma máquina de lavar roupa pode ir de 500 a 1100 por minuto	True	Neutral
São necessários 20 dias para que uma mosca doméstica seja bisavó	True	Neutral
O organismo humano sintetiza metade da quantidade de vitamina K necessária	True	Neutral
As balizas do polo aquático têm 2 metros de largura	True	Neutral
A expressão "peste negra" tem a sua origem no aspecto físico do doente, visto que a pele seca e escurece assinalando a morte	True	Neutral
Os cornos da Camurça apresentam nas extremidades uma curvatura em gancho dirigida para traz	True	Neutral
Os pássaros têm cerca de 175 músculos diferentes	True	Neutral
Nenhum lugar na terra está livre de tempestades eléctricas	True	Neutral
A infecção com maior prevalência no mundo é a malária	True	Neutral
O maior lago do mundo situa-se na América do Norte	True	Neutral
A tenista Steffi Graf anunciou a sua retirada do desporto no dia 13 de Agosto de 1999	True	Neutral
Os ratos domésticos atingem velocidades aproximadamente de 15 km/hora	True	Neutral
Um feto começa a desenvolver os dedos das mãos às 8 semanas de gestação	True	Neutral
O tempo de vida de uma pestana é aproximadamente 150 dias	True	Neutral
Mozart era o mais novo de 7 irmãos	True	Neutral
O primeiro campeão dos Jogos Olímpicos da era moderna foi James B. Connolly	True	Neutral
D. Pedro e D. Inês de Castro tiveram três filhos	True	Neutral
Uma cria de urso ao nascer pesa apenas cerca de 5,5 kg	True	Neutral
Matusalém era o avo de Noé	True	Neutral
O maior glaciar da europa é o Vatnajökull, na Islândia	True	Neutral
O primeiro fóssil de dinossauro foi descoberto por William Buckland	True	Neutral
Um ergofóbico é uma pessoa que tem fobia do trabalho	True	Neutral
O pombo tem um tempo de vida superior ao de um coelho	True	Neutral
Os selos de via aérea foram pela primeira vez emitidos em 13 de Maio de 1918	True	Neutral
A língua de uma baleia azul pesa mais do que um elefante	True	Neutral
O primeiro semáforo foi colocado nos EUA e era apenas vermelho e verde	True	Neutral
O coração de uma cobra chega a bater 24 horas após se ter separado a cabeça do seu corpo	True	Neutral
O batimento cardíaco pode subir 30 % durante um bocejo	True	Neutral
A baleia azul, pesando cerca de 100 toneladas, necessita de cerca de 40 kg de alimento diário	True	Neutral

Table 9 continued

Statement	True/false	Type of statement
O sangue do corpo humano completa um circuito de 23 em 23 segundos	True	Neutral
Um gato tem 32 músculos em cada orelha	True	Neutral
Uma joaninha recém-nascida é amarela e vermelha	True	Neutral
Os dentes dos roedores crescem continuamente até ao final de vida do animal	True	Neutral
As traças têm cerca de 1 centímetro de comprimento	True	Neutral
As beringelas, de forma ovoide, têm cor roxa ou branca	True	Neutral
Uma ervilha não mastigada deixará vestígios nas fezes	True	Neutral
O presidente John Taylor dos EUA adoptou 14 crianças	True	Neutral
O Central Park, em Nova Iorque, tem quase duas vezes o tamanho do Mónaco	True	Neutral
A graduação do vinho da Madeira situa-se entre os 20 e 22 graus	True	Neutral
O corpo humano tem cerca de 100 000 km de veias	True	Neutral
A fritura em óleo consiste na criação de uma película de glícidos coagulados e colorados	True	Neutral
O preço mais elevado alguma vez pago por uma orquídea foi de 50 contos, em 1960	True	Neutral
A planta de sésamo têm flores em forma de dedal	True	Neutral
O basquetebol foi inventado nos EUA em 1891	True	Neutral
O metropolitano de Lisboa foi inaugurado pelo cardeal Cerejeira	True	Neutral
O menor satélite natural do planeta Neptuno foi baptizado Psámata	True	Neutral
Os primeiros 3 países a terem televisão foram a Inglaterra, os Estados Unidos e a Alemanha	True	Neutral
Existem cerca de 6000 espécies de borboletas nas florestas tropicais da América do Sul	True	Neutral
A maior árvore do mundo é uma sequoia que mede 115,56 metros	True	Neutral
Um piscar de olhos dura entre 300 e 400 milissegundos	True	Neutral
Um rinoceronte pode viver até 50 anos	True	Neutral
O número de rotações de uma máquina de lavar roupa pode ir de 500 a 1100 por minuto	True	Neutral
O sangue das aranhas é transparente	True	Neutral
Os inventores do primeiro balão tripulado foram os irmãos Joseph e Jaques Montgolfier	True	Neutral
É da ordem das centenas de milhares o número de espermatozoides expelidos durante o orgasmo masculino	False	Neutral
Os ratos podem sobreviver até 40 dias sem comida	False	Neutral
Napoleão casou por procuração com Maria Luísa, filha do imperador da Áustria	False	Neutral
O Egipto tem apresentado nos últimos anos as taxas mundiais mais baixas de suicídio	False	Neutral
O coelho pode ter entre 3 e 12 crias num intervalo de 2 a 3 meses	False	Neutral
Lord Byron, após se separar da mulher, saiu de Inglaterra e nunca mais lá voltou	False	Neutral
O maior rio da Europa é o rio Danúbio, com 3 688 km de comprimento	False	Neutral
A árvore que consome 10 litros de água por dia é a Faia	False	Neutral
O primeiro filme de desenhos animados é inglês	False	Neutral
O Departamento de Estado americano reconhece 201 países independentes no Mundo	False	Neutral
A estátua do Cristo Rei tem 38 m de altura	False	Neutral
Os limpa para-brisas foram inventados em 1923	False	Neutral
A altura média da mulher americana é de 1,69 cm	False	Neutral
A flor mais pequena do mundo encontra-se no Brasil e mede 1 milímetros	False	Neutral
A cólera apenas desapareceu da Europa no século XIX	False	Neutral
Na Croácia acenar a cabeça para cima e para baixo significa não	False	Neutral
A maior distância a que uma bola de basebol foi lançada é cerca de 130 metros	False	Neutral
O gelado de cone surgiu nos EUA em 1924	False	Neutral
O primeiro cão-guia para cegos foi apresentado a um cego em 1948	False	Neutral
O nome original da cidade de Xangai era Edo	False	Neutral
A velocidade do som é independente da temperatura	False	Neutral
A capital de Madagáscar é Toamasina	False	Neutral
O Lego surgiu numa empresa familiar na década de 1940	False	Neutral

Table 9 continued

Statement	True/false	Type of statement
O primeiro jornal português iniciou a sua publicação em 1710	False	Neutral
Uma mão direita e esquerda juntas eram o símbolo da amizade para os romanos	False	Neutral
O eclipse solar total mais longo de que há registo durou 12 minutos	False	Neutral
O último prisioneiro a deixar Alcatraz foi Alan Wilson	False	Neutral
Os crocodilos dormem de olhos abertos	False	Neutral
Uma dona de casa lava em média 2,5 milhões de artigos de vestir na sua vida	False	Neutral
O maior rubi do mundo pesa 5634 gramas	False	Neutral
O plasma representa cerca de 45 % do volume total do sangue circulante	False	Neutral
Desde o início da exploração do espaço, 14 homens já foram à lua	False	Neutral
A primeira fotografia com cor permanente foi conseguida em 1900 por um físico escocês	False	Neutral
Por segundo, são recicladas cerca de 350 latas	False	Neutral
A máxima velocidade atingida por um réptil em terra é de 46 km/hora	False	Neutral
A dinastia Chinesa Ching é anterior à dinastia Chang	False	Neutral
O primeiro piano foi construído em Itália em 1709	False	Neutral
O território de Marrocos está dividido em 12 regiões	False	Neutral
Para congelar álcool puro é necessária uma temperatura abaixo de 90 graus negativos	False	Neutral
A primeira bandeira da Confederação nos EUA designava-se "Antiga Glória"	False	Neutral
O cravo da Índia é a especiaria mais cara do mundo	False	Neutral
Carlos Magno foi coroado Imperador do Ocidente, pelo Papa, no dia de Páscoa	False	Neutral
As unhas dos dedos das mãos crescem mais rapidamente que as dos pés	False	Neutral
A mais alta barragem da Europa encontra-se na Suíça e tem 385 metros	False	Neutral
A escritora Grazia Deledda foi a primeira mulher a receber o prémio Nobel da literatura	False	Neutral
O urubu é a ave de rapina mais comum na europa	False	Neutral
O primeiro presidente da Nicarágua foi Patricio Rivas	False	Neutral
Os Antrópodes são seres vertebrados	False	Neutral
Os macacos fêmea reconhecem as suas crias pela altura e peso	False	Neutral
O cantor Frank Sinatra não queria gravar o tema "My Way", mas a sua editora forçou-o a fazê-lo	False	Neutral
O nosso cabelo cresce mais rápido durante a manhã do que em qualquer outra altura do dia	False	Neutral
A força exercida pela dentada de um crocodilo pode chegar aos 20 000 pascais	False	Neutral
O planeta Marte gira ao contrário dos outros planetas do sistema solar	False	Neutral
O nosso cabelo cresce mais rápido durante a manhã do que em qualquer outra altura do dia	False	Neutral
A altura do dia em que é mais frequente os patos porem ovos é à tarde	False	Neutral
São precisos 5 minutos e 40 segundos para a luz do Sol chegar à Terra	False	Neutral
O amarelo, o verde e o azul fazem parte do arco-íris	True	Easy
A Bíblia é composta pelo Antigo Testamento e pelo Novo Testamento	True	Easy
Um triângulo equilátero tem os lados todos iguais	True	Easy
O símbolo da paz é uma pomba branca	True	Easy
Quando é cortada, a cauda de uma lagartixa volta a crescer	True	Easy
O Natal celebra-se em Dezembro	True	Easy
Um oceano é maior que um lago	True	Easy
O leite é uma bebida e tem cor branca	True	Easy
1 hora tem 60 minutos	True	Easy
As formigas são animais mais pequenos que os ratos	True	Easy
A lã das ovelhas pode ser usada para fabricar roupas	True	Easy
Portugal e Espanha fazem parte da Península Ibérica	True	Easy
Uma ilha é uma porção de terra rodeada de água por todos os lados	True	Easy
É preciso usar-se uma raquete para jogar Ténis	True	Easy
As maçãs pertencem à classe dos frutos	True	Easy

Table 9 continued

Statement	True/false	Type of statement
Angola e a Etiópia são dois países africanos	True	Easy
Os ursos polares são brancos e os ursos pardos castanhos	True	Easy
As motas são veículos motorizados de duas rodas	True	Easy
Um século tem 100 anos	True	Easy
Pablo Picasso é um dos grandes nomes da pintura espanhola	True	Easy
A guitarra é um instrumento musical de cordas	True	Easy
Os cavalos têm quatro patas	True	Easy
Fernando Pessoa foi um grande poeta português	True	Easy
Luís de Camões escreveu a obra "Os Lusíadas"	True	Easy
O papel e o plástico são materiais que podem ser reciclados	True	Easy
As laranjas são frutos ricos em vitamina C	True	Easy
O Canadá não fica no continente Europeu	True	Easy
Actualmente não existem notas de 1 euro	True	Easy
O período normal de gestação de um bebé humano é de 9 meses	True	Easy
A cidade do Porto fica a norte da cidade de Faro	True	Easy
No exército, o cargo de General está acima do de soldado	True	Easy
O rádio foi inventado antes do computador	True	Easy
Lisboa é conhecida como a cidade das 7 colinas	True	Easy
Um relógio habitualmente tem 12 números para indicar as horas	True	Easy
Elvis Presley foi uma famosa estrela de rock dos EUA	True	Easy
Palhaços e trapezistas são dois tipos de artistas que se podem encontrar no circo	True	Easy
Os arquipélagos dos Açores e da Madeira situam-se no Oceano Atlântico	True	Easy
O estado da Argentina fica na América do Sul	True	Easy
Os Beatles foram uma banda Inglesa	True	Easy
A China fica situada no continente Asiático	True	Easy
Os ursos polares são animais de climas frios	True	Easy
O principal componente do café é a cafeína	True	Easy
Paris é a capital de França	True	Easy
A cobra é um animal rastejante	True	Easy
Um cronómetro serve para contar o tempo	True	Easy
A Expo 98 decorreu em Lisboa	True	Easy
Neil Armstrong foi o primeiro homem a pisar a lua	True	Easy
O primeiro Rei de Portugal foi D. Afonso Henriques	True	Easy
O vinho é produzido a partir da uva	True	Easy
As constelações são agrupamentos de estrelas	True	Easy
O fado é um género musical Português	True	Easy
O xadrez é um jogo jogado entre duas pessoas	True	Easy
As girafas são animais conhecidos por terem o pescoço comprido	True	Easy
Na Índia, a vaca é considerado um animal sagrado	True	Easy
As iniciais ONU referem-se a Organização das Nações Unidas	True	Easy
A Praça Vermelha fica situada na Rússia	True	Easy
As toupeiras são animais que vivem debaixo de terra	True	Easy
Uma biografia é um género literário sobre a história de vida de uma pessoa	True	Easy
A árvore mais associada ao Natal é o pinheiro	True	Easy
A cidade-estado do Vaticano fica situada em Itália	True	Easy
O coco é uma fruta que cresce num arbusto rasteiro ao chão	False	Easy
A 9ª sinfonia é a obra mais emblemática de Chopin	False	Easy
Para além do Rato Mickey, Walt Disney criou também os desenhos animados de Tintin e o seu cão Milú	False	Easy

Table 9 continued

Statement	True/false	Type of statement
Os dentes do siso nascem em todas as pessoas	False	Easy
O violeta é a mistura de todas as cores	False	Easy
Por ter sido uma colónia Inglesa, a língua oficial da Índia é o inglês	False	Easy
Toda a gente consegue lamber o seu próprio cotovelo	False	Easy
O Apartheid foi um regime que esteve em vigor na Nova Zelândia	False	Easy
O primeiro cão a viajar para o espaço chamava-se Sophie	False	Easy
O alfabeto português é constituído por 20 letras	False	Easy
O Sol é um cometa	False	Easy
As galinhas conseguem voar grandes distâncias	False	Easy
Paris é a cidade capital da Alemanha	False	Easy
Portugal entrou para a União Europeia no ano de 2007	False	Easy
O uso da pimenta na culinária passou de moda em 1860	False	Easy
Os oceanos ocupam cerca de 15 % da superfície do planeta Terra	False	Easy
O museu do Louvre está situado no centro de Londres	False	Easy
A Princesa Diana de Gales era de nacionalidade Japonesa	False	Easy
A cerimónia de entrega dos Óscares realiza-se todos os anos numa cidade asiática	False	Easy
Os peixes são mamíferos	False	Easy
O primeiro mês do ano é Fevereiro	False	Easy
O animal associado à cidade de Barcelos é o elefante	False	Easy
Os sinais de proibição são habitualmente verdes	False	Easy
Uma pessoa vegetariana é alguém que só come carne	False	Easy
Albert Einstein foi um escultor famoso	False	Easy
O vinho é uma bebida não-alcoólica	False	Easy
O euro é a moeda oficial dos EUA	False	Easy
Os espinafres são vegetais duros e de cor laranja	False	Easy
No nosso sistema solar, o planeta que está mais longe do Sol é Mercúrio	False	Easy
A fórmula química da água é CO2	False	Easy

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