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The differential similarity of positive and negative information – an affect-induced processing outcome?

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ABSTRACT

People judge positive information to be more alike than negative information. This good-bad asymmetry in similarity was argued to constitute a true property of the information ecology (Alves, H., Koch, A., & Unkelbach, C. (2017). Why good is more alike than bad: Processing implications. *Trends in Cognitive Sciences*, *21*, 69–79). Alternatively, the asymmetry may constitute a processing outcome itself, namely an influence of phasic affect on information processing. Because no research has yet tested whether phasic affect influences perceived similarity among stimuli, we conducted 5 Experiments that also tested whether phasic affect can account for the higher judged similarity among positive compared to negative stimuli. In three experiments, we affectively charged pictures of different Pokemon by pairing them with monetary gains and losses (Exp. 1a, 1b) as well as positive and negative trait words (Exp. 2); yet, the evaluative charge did not differentially influence perceived similarity among the Pokemon. Experiment 3 replicated the basic similarity asymmetry among positive and negative words, and found that it was unaffected by externally induced phasic affect. Experiment 4 showed that phasic affect had no influence on perceived similarity of non-evaluative words either. We conclude that albeit a weak influence of phasic affect on perceived similarity of stimuli cannot be ruled out entirely, it can most likely not account for the typically medium to large sized asymmetry in similarity among positive and negative stimuli.

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Similarity is a major explanatory construct within cognitive models of information processing (e.g. Medin, Goldstone, & Gentner, 1993), and is crucial for understanding processes such as comparisons (Mussweiler, 2003), priming (Neely, 2012), memory (Von Restorff, 1933), or categorisation (Goldstone, 1994). The similarity structure of information strongly determines how it is processed. Importantly, when it comes to evaluative information, the similarity structure of positive and negative information seems to differ systematically. According to the "density hypothesis", positive information is in general more alike than negative information (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008). When participants are asked to judge the similarities of positive and negative stimuli, the average judged similarity between positive stimuli is consistently higher than between negative stimuli (Alves, Koch, & Unkelbach, 2016; Koch, Alves, Krüger, & Unkelbach, 2016).

This density asymmetry has been suggested to account for valence asymmetries in information processing (Alves, Koch, & Unkelbach, 2017a), like the faster processing of positive information (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Unkelbach et al., 2008), or the recognition advantage of negative information (Alves et al., 2015). It thereby constitutes an alternative to established explanations according to which valence asymmetries result from internal affective processes (e.g. Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Taylor, 1991; Wentura, Rothermund, & Bak, 2000). While these two explanations are not mutually exclusive, they place the origin of valence asymmetries at two different locations, namely within the organism (internal

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affect) or the ecology (external information structure). Empirical support for the external explanation stems from regression analyses, showing that similarity of positive and negative information accounts for valence asymmetries above and beyond the mere valence of the information, regarding processing speed (Unkelbach et al., 2008), memory (Alves et al., 2015), and categorisation (Koch et al., 2016).

Despite this evidence there remains a fundamental doubt as to whether the differential similarity of positive and negative information really is a property of the external information ecology. Instead, it remains possible that the similarity asymmetry itself is an outcome of internal affective influences. This alternative explanation was proposed and empirically supported by Topolinski and Deutsch (2013), who found that very brief "phasic" affective reactions modulated reaction times in a lexical decision task. The authors suggested that phasic affect may also influence similarity perceptions and therefore could account for the higher perceived similarity among positive stimuli as described by the density hypothesis (Unkelbach et al., 2008). The possibility that the differential similarity of positive and negative information results from phasic affective modulation therefore constitutes a viable alternative to the ecological assumptions of the density hypothesis, which if true, would also disqualify the density hypothesis as an alternative "external" explanation for valence asymmetries. To address this possibility, the present work tested whether phasic affect influences perceived similarity and whether this can account for the higher perceived similarity among positive stimuli.

In the following, we first introduce the density hypothesis according to which the differential similarity constitutes a true property of the external information ecology along with its implications for valence asymmetries in information processing. Next, we address the competing possibility that the similarity difference results from internal affective reactions. We then present data from 5 Experiments that tested whether perceived similarity of stimuli is altered by phasic affect.

The density hypothesis

The density hypothesis proposes a fundamental asymmetry in the structure of positive and negative information: Positive information is generally more similar to other positive information than negative information is similar to other negative information (Unkelbach et al., 2008). While positive things are rather alike, the world of negative things is highly diverse. An illustrative example is facial-attractiveness. While there are only a few ways to be attractive, there are many different ways to be unattractive. Consequently, attractive faces are on average more similar to one another than unattractive faces (Langlois & Roggman, 1990; Potter, Corneille, Ruys, & Rhodes, 2007; Rhodes, 2006). Relatedly, people generally like stimuli that are similar to a category's prototype (Halberstadt & Rhodes, 2003; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006), which limits the diversity of liked stimuli. While the higher similarity among positive stimuli seems self-evident in cases where positivity results from prototypicality, the density hypothesis claims that it is a general property of the information ecology. For example, recent research in the domain of person perception has shown that people perceive liked individuals and groups as more similar to one another than disliked individuals and groups (Alves et al., 2016; Koch, Imhoff, Dotsch, Unkelbach, & Alves, 2016; Leising, Erbs, & Fritz, 2010). Conversely, people's similarities are more likely to be positive than their differences (Alves, Koch, & Unkelbach, 2017b, 2018). Consequently, people also more strongly agree on the reasons for liking a person or an object (Gershoff, Mukherjee, & Mukhopadhyay, 2008; Leising, Ostrovski, & Zimmermann, 2013).

More generally, Unkelbach et al. (2008) found that positive compared to negative words were judged to be more similar to one another. The authors used pairwise similarity ratings and found that pairs of positive stimuli were judged as being substantially more similar to one another than pairs of negative stimuli. In a graphical presentation based on a multidimensional scaling procedure, the authors showed that positive words were more densely clustered; hence the term "density hypothesis". While the initial illustration of the density hypothesis rested on a set of 40 words, Koch and colleagues (2016) showed that this density asymmetry also holds for large samples of representatively sampled words, real life events, as well as for pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 1997).

This valence asymmetry in similarity is thereby a general, and robust effect, usually of medium or large size, which makes it an intriguing phenomenon in its own right. Further, it has important implications for the processing of positive and negative information.

Implications of the density asymmetry

There are various asymmetries in the processing of positive and negative information that are often summarised under the observation that "bad is stronger than good" (Baumeister et al., 2001). For example, negative information triggers stronger neurological reactions (Ito et al.,1998), grabs more attention (Graziano, Brothen, & Berscheid, 1980; Pratto & John, 1991), is weighted more strongly (Asch, 1946; Fiske, 1980; Skowronski & Carlston, 1989) and is remembered more accurately (Ortony, Turner, & Antos, 1983; Robinson-Riegler & Winton, 1996).

These observable valence asymmetries are usually explained by an affective or motivational reaction within the individual that is elicited when confronted with a positive or a negative stimulus. Accordingly, negative stimuli elicit stronger affective reactions than positive stimuli (Baumeister et al., 2001; Cacioppo, Gardner, & Berntson, 1997; Rozin & Royzman, 2001), which lead to deeper and more elaborate processing (Bless & Fiedler, 2006; Forgas, 2002; Schwarz, 1990; Schwarz & Bless, 1991; Taylor, 1991).

Again, in contrast, the density hypothesis claims that these valence asymmetries may not result from internal affective reactions influencing information processing, but from the similarity structure of the external information itself. Given that information's similarity/diversity strongly influences information processing, the asymmetrical similarity of positive and negative information may account for valence asymmetries in cognitive processing (for an overview, see Alves et al., 2017a). For example, recognition accuracy is usually higher for negative compared to positive words (Inaba, Nomura, & Ohira, 2005; Ohira, Winton, & Oyama, 1998), which has been explained as resulting from affect-induced processing differences, in line with the assumption that negative stimuli undergo deeper processing (e.g. Taylor, 1991). However, recognition memory performance is also highly sensitive to the similarity structure of the stimuli (Brainerd, Reyna, & Mojardin, 1999; Flagg, 1976; Nosofsky, 1991), and Alves et al. (2015) showed that the higher similarity among positive stimuli could fully account for any valence asymmetries in recognition memory.

Similarly, if negative stimuli undergo deeper and more elaborate processing, people should divide negative stimuli into more categories than positive stimuli. However, Koch and colleagues (2016) showed that the more refined categorisation of negative stimuli is also explained by the density asymmetry. Because negative stimuli are less similar to one another than positive stimuli, they are grouped into more categories.

Finally, Gräf and Unkelbach (2016, 2018) showed that because positive traits are more similar to one another than negative traits (see Bruckmüller & Abele, 2013), people more strongly generalise from the presence of one trait to the presence of another trait among positive compared to negative traits. Again, the tendency to more strongly differentiate between negative stimuli seems to reflect the actual diversity of negative stimuli instead of affective influence.

Not all valence asymmetries can in principle be explained by positive information's higher similarity. For example, typical instances of a superiority of positive information include self-relevant domains such as autobiographic recall or self-evaluation (e.g. Alicke & Sedikides, 2009; Sedikides & Gregg, 2008; Hoorens, 1993). In these domains, positive instead of negative information seems to enjoy a processing advantage, which is well explained by motivational accounts. Besides such self-serving biases, the density hypothesis claims that the typical dominance of negative over positive information may result from their differential similarity. However, as we will show below, affective reactions within the individual present a viable alternative explanation.

An ecological explanation vs. an affective explanation of the similarity asymmetry

The density hypothesis assumes stimuli's similarity structure as the causal factor behind processing asymmetries, a variable that lies outside the information-processing individual. In other words, it is assumed that positive stimuli are factually more similar to one another than negative stimuli. Alves et al. (2017a) presented an explanatory model for this ecological phenomenon: On most attribute dimensions, there is one positive range, which is surrounded by two different negative ranges (e.g. too hot or too cold; too tall or too small; too much or too little; see also, Cichocka, Górska, Jost, Sutton, & Bilewicz, 2017; Grant & Schwartz, 2011; Imhoff & Koch, 2017). It necessarily follows that there are more negative than positive attributes and that objects that possess negative compared to positive attributes are on average less similar to one another.

Despite its theoretical plausibility, the claim that the differential similarity of positive and negative information is a property of the external information environment remains speculative at this point. The most apparent alternative explanation is that it results from internal affective reactions that occur when a perceiver encounters positive or negative stimuli. That is, because negative affect triggers more elaborate processing, negative stimuli are *subjectively* more dissimilar to one another than positive stimuli.

This possibility was suggested by Topolinski and Deutsch (2013) who found that even brief (phasic) affective reactions modulate information processing on a trial-by-trial-basis. According to the concept of phasic affective modulation (PAM; Topolinski & Deutsch, 2013), brief variations in affect that can vary from trial to trial influence information processing. Specifically, positive compared to negative affect increases semantic spreading of information, which is in line with research showing that mood influences semantic spread (Corson, 2002; Storbeck & Clore, 2008; for a review see Ashby, Isen, & Turken, 1999). In contrast to mood effects that describe relatively long affective states and are varied between participants, phasic affective states only last for a few seconds. In 5 experiments, Topolinski and Deutsch (2013) showed how phasic affective states influence semantic activation in a lexical decision task. Participants made faster word-non-word decisions on trials that featured a consonant versus a dissonant sound (Experiment 1 and Experiment 5), a positive versus a negative naturalistic sound (Experiment 2), and a picture of a positive versus a negative facial expression (Experiment 3). Furthermore, participants were faster at solving a remote association task under positive versus negative facial feedback induction (Experiment 4). These findings show that phasic affect may modulate semantic spread in priming tasks and subjective stimulus similarity.

The authors also suggested that PAM may constitute an alternative to the density hypothesis for explaining valence asymmetries in evaluative priming. The authors argued that "in contrast to the density hypothesis, the present notion of phasic affective modulation can explain the superiority of positive compared to negative evaluative priming more parsimoniously without a priori assumptions about the hard-to-assess semantic architecture" (Topolinski & Deutsch, 2013, p. 432). Accordingly, when target and prime are positive, the evoked positive affect increases semantic spread leading to a faster evaluative classification as compared to negative prime target combinations. Thus, positive information might have a processing speed advantage not because of its higher density but because of affective modulation. In the original work by Unkelbach et al. (2008), response latencies were shown to be a function of a stimuli's density index that was obtained on the basis of pairwise similarity ratings. However, Topolinski and Deutsch (p. 432) argue that "[…] such a similarity rating may also be biased by word-induced affect itself, with positive compared to negative affect increasing category inclusiveness and thus similarity […]".

Hence, the influence of phasic affect on semantic spread may not only alter response latencies in priming tasks, but also influence the perceived similarity among positive and negative stimuli. If this is true, the density asymmetry may not constitute a true property of the information ecology, but instead be itself the result of affect-induced processing differences. Consequently, the density asymmetry would also be invalidated as an explanation for observable valence asymmetries in information processing.

At the present point, we are left with two competing explanations regarding the nature of observable valence asymmetries in information processing, which are illustrated in Figure 1.

According to the ecological explanation, the similarity asymmetry is a true property of the information ecology. It causally influences processing of positive and negative information and thereby contributes to typical valence asymmetries regarding processing speed, attention, memory, categorisation, and information weighting. While a path of affective influences on information processing may co-exist, stimulus similarity remains an independent cause of valence asymmetries.

According to the affective explanation illustrated in the right part of Figure 1, the similarity asymmetry does not *cause* typical valence asymmetries in processing, but shares a common cause with these, namely the affective reaction of the organism which modulates processing depth. This idea was advocated by Topolinski and Deutsch (2013) who argued that positive and negative information are equally similar in the information ecology, and that this symmetry is only distorted by affect-induced processing differences (e.g. semantic spreading).

In sum, the core question for the present research is whether the valence asymmetry in similarity may be explained by phasic affect. This would invalidate the density hypothesis, which claims that the asymmetry

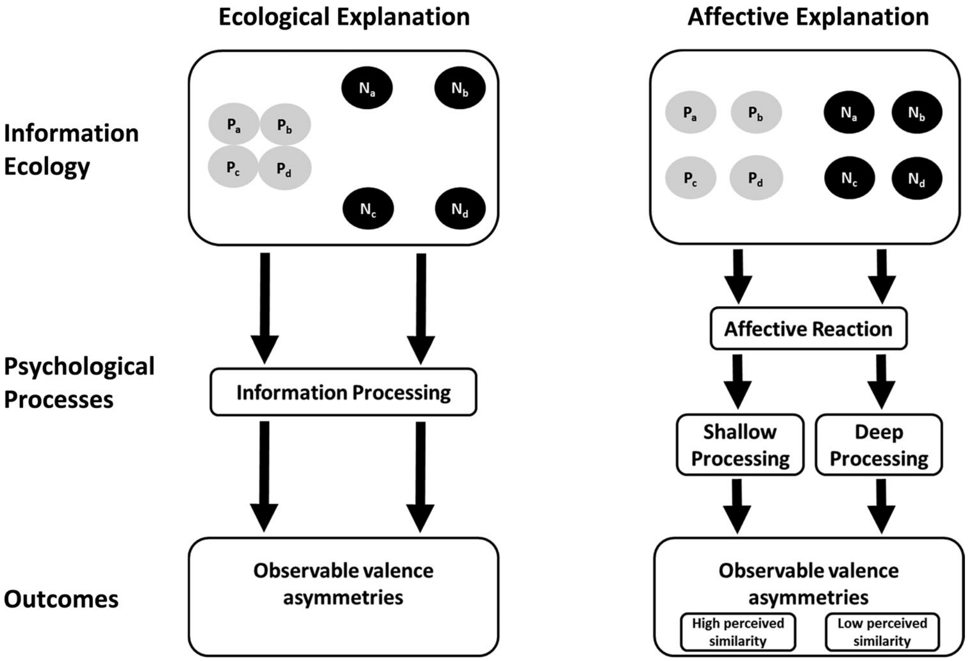

Figure 1. Illustration of the two different explanations of valence asymmetries in information processing. The left part illustrates the ecological explanation, which assumes a similarity asymmetry among positive and negative information in the information ecology, which directly causes observable valence asymmetries. The right part illustrates the affective explanation which does not assume that positive and negative information differ regarding their similarities in the information ecology. Instead it is assume that positive and negative stimuli elicit affective reactions that trigger shallow or deep processing which then lead cause the observable valence asymmetries including the similarity asymmetry.

reflects a true ecological property, as well as the claim that it can serve as an alternative to affective explanations of valence asymmetries. A major precondition for phasic affect to account for the similarity asymmetry is that phasic affect influences explicit similarity ratings, as suggested by Topolinski and Deutsch (2013). So far, there is no empirical evidence regarding this question as Topolinski and Deutsch only investigated the influence of phasic affect on response latencies in priming tasks. Therefore, the present work systematically tests whether (1) phasic affect influences similarity ratings of stimuli and whether (2) this influence can account for the described density asymmetry. In 5 Experiments, we used different strategies to elicit phasic affect during similarity ratings of picture as well as word stimuli.

Overview of empirical tests

In Experiments 1a and 1b, we used an Evaluative Conditioning procedure and affectively charged pictures of Pokemon by pairing them with monetary gains or losses. We then assessed whether the Pokemon's affective potentials influenced their perceived similarities. In Experiment 2, we paired Pokemon with positive and negative trait words, and measured if perceived similarity of Pokemon was influenced by trait valence. In Experiment 3, we conceptually replicated experiments that found the density asymmetry among 20 positive and 20 negative words (Koch et al., 2016; Unkelbach et al., 2008), while we externally induced phasic affect during similarity judgments with positive or negative sounds (Topolinski & Deutsch, 2013). We then tested whether the density asymmetry would persist when similarity judgments were accompanied by sounds of opposite valence. The final Experiment 4 repeated Experiment 3 with non-evaluative words (fruits) to further test whether externally induced phasic affect has any influence on perceived similarity of word stimuli. Data from all experiments can be retrieved via the following link: https://osf.io/jqhf7/?view_only=1cda62d4587f48619e4014da385b146b.

Experiment 1a

To affectively charge stimuli, as stated, Experiment 1a used an Evaluative Conditioning (EC) paradigm that paired Pokemon (CS) with monetary gains or losses. EC is a reliable and frequently used measure to experimentally change the valence of a given stimulus and thereby ideally suited to create evaluative stimuli independent of other potential confounds. Participants were told they played a virtual slot machine and that they would get to keep whatever they won. Some Pokemon were associated with gains and others with losses. Affectively charging the Pokemon allowed us to assess the influence of by and large content-free stimulus-induced valence on pairwise similarity ratings. According to phasic affective modulation, winning Pokemon should be perceived as more similar to one another than losing Pokemon.

Participants and Design. Similarity-related valence asymmetries in the literature are usually medium-to-large sized statistical effects (Alves et al., 2016; Koch et al., 2016; Unkelbach et al., 2008). We therefore aimed at collecting data from 40 participants, providing sufficient statistical power to detect medium sized effects in a repeated measured design with a power of .85 (Cohen, 1988). We collected data from 40 students (20 women and 20 men) of the University of Cologne who participated for 3€ or course credit. All participants were native German speakers. The main experimental factor stimulus valence was manipulated within participants. The EC paradigm used 12 pictures of Pokemon that served as CS. We randomly split the set of 12 Pokemon into two subsets of 6 Pokemon. A second experimental factor then varied which of two Pokemon subsets was paired with monetary gains and which was paired with losses.

Procedure. Participants arrived in the laboratory and were seated in front of a computer. After completing a consent form, the experimenter started a Visual Basic program that presented instructions, stimuli, and recorded the dependent variables. The program informed participants that they would play a virtual slot machine over several trials, in which they could win or lose money on each trial, and that they would receive their overall win at the end of the experiment. Participants were also told that the slot machine featured different Pokemon of which some lead to a winning of 0.5 € while the others lead to a loss of 0.5 €. Participants started with a credit of 3 €. They started each trial by clicking on a button after which a Pokemon appeared in the centre of the screen; after 1000 ms, a textbox appeared next to the Pokemon that told participants whether they had won ("You win 50 ct") or lost ("You lose 50 ct").

The Pokemon and the textbox remained visible for another 1000 ms before the trial was over. Participants played a total of 60 trials so that each of the 12 Pokemon appeared 5 times. The Pokemon were presented in randomised order. As half of the Pokemon were always paired with a win and the other were paired with a loss, the final credit for each participant equalled their starting credit (3 €). This setup is structurally identical to an EC trace-conditioning procedure that reliably changes the evaluation of stimuli over longer periods of time (Förderer & Unkelbach, 2013).

Next, participants provided similarity ratings for all pairwise combinations of the 12 Pokemon resulting in a total of 66 judgments. Similarity ratings were provided on a scale ranging from 1 ("very similar") to 9 ("very dissimilar"). As a measure of valence, participants rated the likeability of each Pokemon on a scale ranging from 1 ("not at all likeable") to 8 ("very likeable"). Finally, participants were thanked, paid, and informed about the purpose of the experiment.

Results

To reiterate, PAM would predict that the positive affect elicited by a given Pokemon makes them more similar; that is, Pokemons in the "winning" category should appear more similar than Pokemons in the "losing" category.

Likeability. We checked the evaluative charge of the Pokemon by comparing the likeability of Pokemon paired with wins to those paired with losses. We conducted a mixed ANOVA that also included the binary between-subjects factor that varied which of the two subsets were paired with gains and which was paired with losses. The mean liking for the Pokemon paired with gains ($M = 5.16$, $SE = 0.18$) was larger than for Pokemon paired with losses ($M = 4.10$, $SE = 0.20$), $F(1,38) = 12.90$, $p = .001$, $\eta_p^2 = .25$. Thus, the evaluative condition procedure was successful. In addition, there was also an interaction between Pokemon valence and subset, $F(1,38) = 7.70$, $p = .009$, $\eta_p^2 = .17$, which indicates that Pokemon in the two subsets differed regarding their likeability.

Similarity. For each participant, we calculated the mean rated similarity among the winning and among the losing Pokemon (sim_{win}, sim_{lose}). These within-valence similarity ratings consisted of 15 winning-winning comparisons and 15 losing-losing comparisons for each participant. We also combined sim_{win} and sim_{lose} to obtain a within-valence similarity index (sim_{within}). We then calculated the mean similarity ratings for the remaining 36 cross-valence comparisons, that is, comparisons that asked participants to compare a winning and a losing Pokemon, thereby arriving at a cross-valence similarity index ($\text{sim}_{\text{cross}}$). Comparing the sim_{win} and sim_{lose} indices provides a test of PAM for explicit similarity ratings. Comparing $\text{sim}_{\text{within}}$ and $\text{sim}_{\text{cross}}$ provides a manipulation check whether participants indeed learned the Pokemons' valence and whether participants used this valence as a basis for explicit similarity ratings.

We first compared the $\text{sim}_{\text{within}}$ and $\text{sim}_{\text{cross}}$ indices using a mixed ANOVA that also included the between-participants factor subset. Participants judged same-valence Pokemon as more similar to one another ($M = 5.95$, $SE = 0.27$) than Pokemon of opposite valence ($M = 6.60$, $SE = 0.20$), $F(1,38) = 7.29$, $p = .010$, $\eta_p^2 = .16$. Thus, participants were sensitive to valence and it influenced their similarity judgments. This effect did not interact with the Pokemon subset.

We then compared the sim_{win} and sim_{lose} to test the PAM prediction. As it turned out, the winning Pokemon ($M = 5.97$, $SE = 0.27$) were not rated as more similar to one another than the losing Pokemon ($M = 5.94$, $Se = 0.30$), $F(1,38) = 0.04$, $p = .852$. However, there was a significant interaction between Pokemon valence and the subset factor, $F(1,38) = 8.55$, $p = .006$, $\eta_p^2 = .18$. Although not intended, this likely indicates that the subsets systematically differed regarding their perceived similarity.

Discussion

In Experiment 1a, we affectively charged pictures of Pokemon by pairing them with financial gains or losses. First, the experiment showed that the EC procedure successfully changed stimulus valence as participants rated winning Pokemon as more likeable than losing Pokemon. Second, participants made meaningful similarity judgments as they judged Pokemons of the same valence (i.e. winning-winning; losing-losing) as more similar than Pokemon of opposite valence (i.e. winning-losing). Third, despite the successful EC and the sensitivity of the similarity judgments, valence did not influence perceived similarity. That is, counter to the phasic affect prediction, winning Pokemon were not perceived as more similar than losing Pokemon. This suggests that similarity judgments are not influenced by participant's phasic affective states elicited by stimulus valence.

One drawback of Experiment 1a is that we created two Pokemon subsets and varied which of the two was paired with gains and which was paired with losses. We did this to counterbalance any stimulus effects; but results from the likability ratings and the similarity ratings indicated that the subsets systematically differed regarding likeability and similarity. It seems unlikely that pre-existing differences in the stimulus subsets overruled an otherwise existent effect of phasic affect; however, ideally, stimuli should have been randomised. Hence, we replicated Experiment 1a and randomised Pokemon assignment to the winning and losing categories for each participant.

Experiment 1b

Experiment 1b again tested whether affectively charging Pokemon stimuli with monetary gains and losses would differentially influence the perceived similarity among them as predicted by PAM. Experiment 1b was similar to Experiment 1a in every aspect expect that Pokemon stimuli were now randomly assigned to the winning and the losing categories.

Participants, Design, and Procedure. We again aimed at collecting data from 40 participants and factually collected data from 43 students[1] (32 women and 11 men) of the University of Cologne who participated for 3€ or course credit. All participants were native German speakers. The only experimental factor was stimulus valence which was manipulated within participants. The only procedural difference was that the computer program in Experiment 1b randomly determined half of the 12 Pokemon as winning Pokemon and the other half as losing Pokemon.

Results

Likeability. We compared the likeability of the Pokemon paired with gains to those paired with losses. Participants rated the winning Pokemon as more likeable ($M = 4.85$, $SE = 0.20$) than the losing Pokemon ($M = 3.77$, $SE = 0.17$), $t(42) = 3.86$, $p < .001$, $d_z = .59$, indicating that the evaluative condition procedure was successful.

Similarity. Participants again judged Pokemon of the same valence as more similar to one another ($M = 6.72$, $SE = 0.21$) than Pokemon of opposite valence ($M = 7.01$, $SE = 0.17$), $t(42) = 2.20$, $p = .033$, $d_z = .33$. Thus, participants were sensitive to the valence of the Pokemon and this influenced their similarity judgments.

However, counter to the PAM prediction, the winning Pokemon ($M = 6.69$, $SE = 0.22$) were not rated as significantly more similar to one another than the losing Pokemon ($M = 6.75$, $SE = 0.22$), $t(42) = -0.54$, $p = .593$.

Discussion

Experiment 1b replicated the findings from Experiment 1a. We affectively charged Pokemon by pairing them with monetary gains and losses. This procedure was successful as participant reported greater liking for the winning Pokemon. Participants also used Pokemon valence as a basis for their similarity judgments as they judged Pokemon of same valence as more similar to one another than Pokemon of opposite valence. Third, we again found no evidence for an influence of phasic affect on perceived similarity; winning Pokemon were not judged as more similar to one another than losing Pokemon.

To quantify the evidence for the null hypothesis that there is no difference between the perceived similarity of winning and losing Pokemon, we combined data from Experiments 1a and 1b and ran a Bayesian analysis (JASP, 2018), using the standard Cauchy prior width .707. A paired Bayesian *t*-test rendered moderate evidence (Lee & Wagenmakers, 2014) for the null hypothesis that participants judged winning and losing Pokemon as equally similar ($BF_{01} = 8.21$).

Experiments 1a and 1b thereby suggest that stimuli's affective potentials resulting from monetary gains and losses have no differential influence on perceived similarity. These findings do not support the PAM explanation of positive information's higher similarity. However, the conclusions that can be drawn from the null effects in Experiments 1a and 1b are naturally limited because null effects may also result from design flaws.

One possibility is that participants misinterpreted the similarity rating task. While they were instructed to rate how similar they thought the given Pokemons were, they may have inferred that they should rate these similarities based on the winning and losing categories only and not focus on the aliens' actual visual features. If participants did not pay attention to the aliens' features in the first place, phasic affect cannot alter the processing of these features. To address this possibility, the following Experiment 2 instructed participants to rate the aliens' similarities based on their visual appearance.

A second possibility is that the monetary valence manipulation is not well-suited to affectively charge the alien stimuli. Even though participants did evaluate the winning Pokemon as more positive than the losing Pokemon, participants may not have perceived the monetary gains and losses as inherent features of the Pokemon. To address this possibility, we used positive and negative traits instead of monetary gains and losses to affectively charge Pokemon in Experiment 2.

Experiment 2

Experiment 2 used an attribute conditioning instead of an evaluative conditioning paradigm (see Förderer & Unkelbach, 2015; Unkelbach & Förderer, 2018) that paired pictures of Pokemon (CSs) with positive and negative traits (USs). Specifically, 6 Pokemon were always paired with the same positive trait and 6 Pokemon were paired with the same negative trait. After the conditioning procedure, participants were again asked to judge the pairwise similarities of the Pokemon, but this time, participants were instructed to base their judgments on the Pokemon's visual features. Experiment 2 again tested whether phasic affect influences the perceived similarity of the Pokemon pictures.

Method

Participants and Design. Because Experiment 2 was not as resource intense as Experiments 1a and 1b in terms of participant compensation, we decided to increase the desired sample size to 110, which enabled us to detect small-to-medium sized effects ($d_z = .35$) in a repeated-measures design with a power of .90 (Cohen, 1988). One-hundred eleven students (77 female, 34 male) of the University of Cologne participated for candy or course credit. All participants were native German speakers. The experimental design manipulated (US) trait valence within participants.

Materials. We took 6 positive trait words ("freundlich" – friendly, "hilfsbereit" – helpful, "nett" – nice, "lieb" – kind, "warmherzig" – warm-hearted, "fürsorglich" – caring) and 6 negative trait words ("aggressiv" – aggressive, "ängstlich" – anxious, "langweilig" – boring, "dumm" – stupid, "abweisend" – dismissive, "unfreundlich" – unfriendly) that were pre-tested for valence. For each participant, one of the positive and one of the negative traits was randomly drawn and these traits than served as the USs which were paired with the Pokemon pictures. The same 12

Pokemon as in Experiments 1a and 1b served as CSs and were randomly paired with one of the traits.

Procedure. Participants arrived in the laboratory and were seated in front of a computer. After completing a consent form, the experimenter started a Visual Basic program that presented instructions, stimuli, and recorded the dependent variables. The program informed participants that the experiment featured several Pokemon that had different traits. Participants' were told that their task was to form an impression about the Pokemon and their traits over several trials. Participants started each trial by clicking a button after which a Pokemon appeared at the centre of the screen; after 1000 ms, a textbox appeared below the Pokemon that displayed the Pokemon's trait. The Pokemon along with its trait remained visible for another 1000 ms before the trial ended. The Pokemon were presented in randomised order. Participants followed a total of 60 trials so that each of the 12 Pokemon-trait-pairs appeared 5 times. Six Pokemon were always paired with the same positive trait word, the other 6 Pokemon were paired with the same negative trait word. Next, participants were asked to judge the Pokemon's similarities on a scale ranging from 1 ("very similar") to 9 ("very dissimilar"), while the instructions stated that similarity judgments should be made based on the Pokemon's visual appearances. Participants judged the similarity of all pairwise combinations of the 12 Pokemon, resulting in a total of 66 judgments. Finally, participants rated the likeability of each Pokemon on an 8-point scale before they were thanked, paid, and informed about the purpose of the experiment.

Results

Likeability. We compared the likeability of Pokemon paired with positive traits to those paired with negative traits within participants. As expected, participants liked positively charged Pokemon more ($M = 5.05$, $SE = 0.11$) than negatively charged Pokemon ($M = 4.46$, $SE = 0.11$), $t(110) = 4.24$, $p < .001$, $d_z = .40$, indicating that the conditioning procedure was successful.

Similarity. Similar to the previous experiments, participants judged Pokemon paired with the same valence as more similar to one another ($M = 5.90$, $SE = 0.14$) than Pokemon paired with opposite valences ($M = 6.13$, $SE = 0.12$), $t(110) = 2.44$, $p = .016$, $d_z = 0.23$. Crucially, the perceived similarity among Pokemon paired with positive traits ($M = 5.91$, $SE = 0.15$) was not statistically higher than the perceived similarity among Pokemon paired with negative traits ($M = 5.89$, $SE = 0.14$), $t(110) = 0.30$, $p = .764$, $d_z = 0.03$. In order to quantify the evidence for the present null hypothesis, we ran a Bayesian paired samples t-test (JASP, 2018), using the standard Cauchy prior width .707. The test rendered moderate evidence (Lee & Wagenmakers, 2014) in favour of the null hypothesis that perceived similarity among positively paired and negatively paired Pokemon was equal ($BF_{01} = 9.09$).

Discussion

Experiment 2 again found no evidence for an influence of phasic affect on perceived similarity among stimuli. Affectively charging Pokemon pictures with positive and negative traits did not lead to asymmetric similarity judgments as would be expected by PAM. These results render it further unlikely that the higher perceived similarity among positive information as described by the density hypothesis is due to phasic affective modulation.

However, there remain two important limitations at this point, which prevent us from concluding that the density asymmetry is not due to affect-induced processing differences. First, the stimuli that were affectively charged in the previous experiments were pictures. Even though the existence of the density asymmetry has been shown for (IAPS) pictures (see Koch et al., 2016), most of the evidence for the density asymmetry concerns word stimuli (see Alves et al., 2017a, for an overview). Hence, in the following experiment, we collected similarity ratings for word stimuli instead of picture stimuli. Second, it is possible that affectively charging stimuli by means of evaluative conditioning does not elicit affective reactions that are strong enough to alter information processing during similarity judgments. Therefore, we moved away from conditioning as affect induction and instead adopted the methodology used by Topolinski and Deutsch (2013), who externally induced phasic affect during information processing by means of positive and negative sounds. While Topolinski and Deutsch found that the thereby induced phasic affect influenced response latencies in semantic priming tasks, we tested whether they also influence similarity ratings.

Experiment 3

Topolinski and Deutsch (2013) used different manipulations of positive and negative phasic affect; one manipulation presented participants with consonant and dissonant triad chords played over headphones during semantic priming trials. We obtained the respective sound files from the first author and used them as manipulations of phasic affect in Experiment 3. As stimuli, we used the original 40 sub-set of stimulus words by Fazio, Sanbonmatsu, Powell, and Kardes (1986) that were initially used to show the density asymmetry (Unkelbach et al., 2008). That is, the 20 positive words were judged as more similar to one another than the 20 negative words.

The goal of Experiment 3 was to obtain pairwise similarity ratings for the 40 words, while during the similarity judgments, positive or negative sounds are played over participants' headphones. Specifically, in one condition, the valence of the sounds was congruent with the valence of the given word pair, while in the other condition, sound valence was opposite to that of the word pair. Experiment 3 thereby aimed at conceptually replicating the basic density asymmetry (see Koch et al., 2016; Unkelbach et al., 2008) with the addition of a phasic affect manipulation.

This design enables us to observe the density asymmetry as present among the 40 word stimuli and to assess whether this asymmetry is altered by a phasic affect manipulation. If the density asymmetry is the result of PAM, perceived similarity of words should not merely be a function of word valence but also of sound valence.

Method

Participants and Design. One-hundred and ten students of the University of Cologne participated for 3€ or course credit. We did not record data on gender, and all participants were native German speakers. The independent variable word valence varied within participants while congruency between audio and word valence varied between participants. Pairwise similarity ratings served as the dependent variable.

Stimulus Materials. The word set contained the 20 most positive and the 20 most negative words from a word set frequently used in experimental social psychological research (Fazio et al., 1986; Klauer & Musch, 1999; Unkelbach et al., 2008). In addition, we obtained two sound files from Topolinski and Deutsch (2013) that were shown to elicit trial-based phasic affect in semantic priming (see also Heycke, Aust, & Stahl, 2017; Sollberge, Rebe, & Eckstein, 2003; Topolinski & Deutsch, 2012). The sound files consisted of one consonant (positive) and one dissonant (negative) triad chord.

Procedure. Participants arrived in the laboratory and were seated in front of a computer. After completing a consent form, the experimenter instructed participants to put on the provided headphones before a Visual Basic program was started that presented instructions, stimuli, and recorded the dependent variables. The program informed participants that their task was to sequentially rate the similarities of several word pairs and that they would hear different noises over the headphones while rating the similarities. Participants started each trial by clicking on a button after which two words appeared at the centre of the screen along with the instruction to rate how similar/dissimilar the words were to each other. Participants rated the similarity using a scale from 1 ("very dissimilar") to 9 ("very similar").

Compared to the previous experiments, the similarity scale was now reversed. We implemented this change because some participants had reported in the past that it would be more intuitive to pair similarity with large numbers and dissimilarity with low numbers. After each word pair appeared, the positive or negative audio clip was played over the headphones. The audio files were edited so that the sound would start after a delay of 350 ms so that it was played when participants just started reading the word pair. This ensured that the sound was associated with the current word pair and not with the rating of the previous word pair. The word set consisted of 20 positive and 20 negative words, which results in a total of 190 positive and 190 negative pairs. From these, the computer randomly drew 45 positive and 45 negative pairs, hence, participants provided a total of 90 similarity ratings. The order of these 90 word pairs was also randomised. For half of participants, the valence of the sound was always congruent with the valence of the word pair, while for the other half of participants, sound valence was always incongruent with word valence. At the end of the experiment, participants were thanked, paid, and debriefed about the purpose of the experiment.

Results

For each participant, we calculated the mean rated similarity among the positive and among the negative word pairs, respectively among the words paired with positive sounds and among the words paired with negative sounds. In order to analyze the influence of both within factors (words valence and sound valence) simultaneously, we submitted the data to a linear regression analysis that included the fixed factors words and sound valence and that also specified the random subject factor with error components for the intercept.[2] Replicating the basic density effect, this model revealed a significant effect of word valence, $b = 0.34$ ($SE = 0.05$), $t(108) = 6.54$, $p > .001$. As shown in Figure 2, the positive words were rated as more similar to one another than the negative words. Counter to the PAM prediction, sound valence had no significant influence on perceived word similarity, $b = 0.08$ ($SE = 0.05$), $t(108) = 1.58$, $p = .117$ (see Figure 2).

In order to estimate the evidence for an actual absence of sound valence on perceived similarity among words, we performed a Bayesian repeated t-test in JASP that compared the mean rated similarity among words paired with positive sounds with the mean rated similarity among words paired with negative sounds, using the standard Cauchy prior = 0.707. This analysis found the H0 (means do not differ) 3.95 (BF_{01}) more likely than the H1 (means do differ), which corresponds to moderate evidence in favour of the H0 (Lee & Wagenmakers, 2014).

Discussion

Experiment 3 replicated the density asymmetry, as participants perceived positive words as more similar to one another than negative words. At the same time, externally-induced phasic affect by means of positive and negative sounds had no effect on perceived similarity. We need however to be careful in concluding that phasic affect had no effect at all on perceived similarity as the Bayesian analysis found only moderate evidence in favour of this null hypothesis. This means, that it remains possible that phasic affect had a small influence on perceived similarity that was not detectable given degree of power.

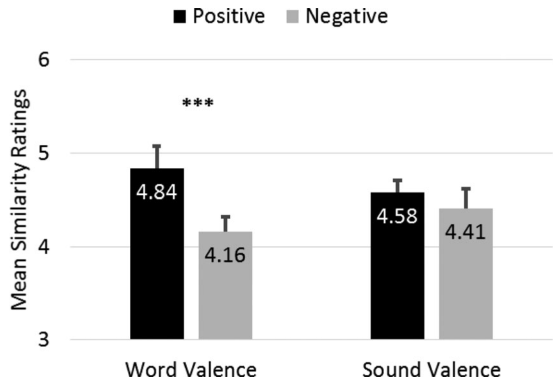

Figure 2. Mean perceived similarity among words as a function of word valence and sound valence. Error bars represent standard error of the mean. *** $p < .001$

Nevertheless, it is highly unlikely that such a small influence can account for the density asymmetry, which usually constitutes a medium or large seised effect, as was also the case in the present experiment ($\eta_p^2 = .28$). As this density asymmetry persisted even beyond an incongruent phasic affect manipulation, we conclude that the differential similarity between positive and negative stimuli is most likely not caused by phasic affective modulation.

Nevertheless, because Experiment 3 did not provide an answer if phasic affect may *in principle* influences perceived similarity, we conducted a final experiment to answer this remaining question. In order to isolate the influence of externally induced phasic affect, the final Experiment 4 removed the factor word valence and used non-evaluative words while the only manipulation was phasic affect induced by sound valence.

Experiment 4

To measure the principal influence of externally-induced phasic affect on perceived similarity, Experiment 4 used fruits as non-evaluative word stimuli. For half of the fruits, the positive sound was played during pairwise similarity comparisons and for the other half, the negative sound was played. The fruit category is ideal as it is possible to see fruits both as very similar (e.g. sweet, vitamin-rich) or as very different (e.g. shape, colour).

Method

Participants and Design. One-hundred students of the University of Cologne participated for candy or course credit. We did not record data on gender, and all participants were native German speakers. The only independent variable was sound valence varied within participants. Pairwise similarity ratings served as the dependent variable.

Stimulus Materials. Sixteen fruit names served as word stimuli (apple, orange, pear, tangerine, pineapple, banana, coconut, cherry, grape, melon, kiwi, plum, mirabelle, grapefruit, peach, strawberry). The same consonant and dissonant triad chords used by Topolinski and Deutsch (2013) again served as manipulations of phasic affect.

Procedure. The procedure was highly similar to Experiment 3. The program instructed participants that their task was to sequentially rate the similarities of several fruit pairs and that they would hear different noises over the headphones while rating the similarities. The program then randomly split the fruit set into a "positive-sound" and a "negative-sound" set, each consisting of 8 fruits. Pairwise similarity ratings of the former set were accompanied by the positive sound being played over the headphones, while similarity ratings of the latter were accompanied by the negative sound. Participants rated the similarity of all same-valence fruit pairs, resulting in a total number of 56 trials. Order of the fruit pairs was randomised. At the end of the experiment, participants were thanked, paid, and debriefed about the purpose of the experiment.

Results

For each participant, we calculated the mean rated similarity among the "positive sound" and among the "negative sound" fruits. Descriptively, participants perceived the "positive-sound" fruits as somewhat more similar then the "negative-sound" fruits ($M_{\text{pos}} = 3.25$, $SE_{\text{pos}} = 0.11$ vs. $M_{\text{neg}} = 3.14$, $SE_{\text{neg}} = 0.11$), but a paired t-test found this difference to be non-significant, $t(99) = 1.40$, $p = .165$. A Bayesian paired t-test revealed moderate evidence (Lee & Wagenmakers, 2014) in favour of the null hypothesis ($\text{BF}_{01} = 3.52$; H0: pos = neg; H1: pos $\neq$ neg).

Discussion

Participants rated fruits paired with positive sounds as more similar to one another than fruits paired with negative sounds. However, this effect was not significantly different from chance and the Bayesian analysis found moderate evidence in favour of the null hypothesis that phasic affect did not influence perceived similarity of word stimuli. Even though Experiment 4 can again not fully rule out *any* influence of phasic affect on perceived similarity, this influence, if existing, would be small and could therefore not account for the density asymmetry.

General discussion

The valence asymmetry in similarity (i.e. the density hypothesis) describes the phenomenon that people perceive positive information as more alike than negative information. This asymmetry holds for a variety of stimuli as well as for different measures of perceived similarity (Koch et al., 2016). We have previously argued that the density asymmetry constitutes a true property of the information ecology (see Alves et al., 2017a; Koch et al., 2016; Unkelbach et al., 2008), that is, positive information in fact is on average more alike than negative information. Here, we tested an alternative explanation for the density asymmetry that was suggested by Topolinski and Deutsch (2013). Accordingly, the higher perceived similarity of positive information may constitute a perceptual distortion that itself results from affect-induced processing differences. Topolinski and Deutsch (2013) based this reasoning on their finding that very brief (phasic) affective reactions that are elicited on a trial-by-trial basis modulate semantic spread. While positive phasic affect widens semantic spread, negative affect narrows it, which is visible in response latencies during semantic priming tasks. Consequently, when participants provide similarity judgments for positive and negative stimuli, the stimuli's valence may elicit phasic affect that alters the perceived similarity and results in the perception that positive stimuli are more similar.

Even though this is a viable alternative explanation for the density asymmetry, in 5 Experiments, we could not find supporting evidence for an influence of phasic affect on perceived similarity. In Experiments 1a and 1b, we affectively charged Pokemon pictures by pairing them with monetary gains or losses, but the positive ("winning") Pokemon were not perceived as more similar to one another than the negative ("losing") Pokemon. Similarly, Experiment 2 found that Pokemon paired with positive traits where not judged as more similar to another than Pokemon paired with negative traits. Experiment 3 conceptually replicated previous experiments that had demonstrated the density asymmetry among sets of positive and negative words. In addition, we used the original sound stimuli from Topolinski and Deutsch (2013) to induce phasic affect during pairwise similarity ratings, which did not significantly influence the perceived similarity of the word stimuli. Consequently, positive words were judged as more similar to one another than negative words, regardless of phasic affect (sound valence). The final Experiment 4 again found that phasic affect induced by sounds had no significant influence on the perceived similarity of (non-evaluative) word stimuli.

However, the conclusion that phasic affect has *no* influence at all on explicit similarity ratings cannot be drawn from the present results. First, logically, it is impossible to verify the non-existence of an effect. Second, descriptively, we also found effects in the direction of the PAM prediction in 3 out of 5 Experiments. In order to estimate the average effect size for the PAM prediction that positive phasic affect triggers higher similarity ratings, we conducted a meta-analysis in which the mean effect sizes were weighted by sample size (Goh, Hall, & Rosenthal, 2016). The resulting PAM effect size was small ($d = .12$), and a Stouffer's Z test (Mosteller & Bush, 1954) found it to be non-significant ($z = 0.99$, $p = .322$). Hence, the present results suggest that either phasic affect has no effect on explicit similarity ratings, or a very small one, which in order to be detected by a paired t-test with a power of .90, would require a very large sample size ($N = 732$; for $d = .12$; Cohen, 1988).

Regardless of the question whether PAM in principle has any influence on similarity ratings, this influence is certainly not large enough to account for the density asymmetry, which typically constitutes a medium-to-large sized effect. We therefore suggest that the higher perceived similarity of positive information is not due to an affective reaction within the individual triggered by the positive and negative words, which then widens or narrows semantic spread.

It is also important to note that the present results do not invalidate the PAM account in principle, as introduced by Topolinski and Deutsch (2013). The available evidence for an influence of brief, phasic affect on semantic spread that the authors found has exclusively concerned response latencies in semantic priming tasks. Priming tasks are obviously quite different from explicit similarity ratings in various ways. First, semantic priming tasks ask the participant for binary classifications of target stimuli, while explicit similarity ratings ask for a similarity judgment. Second, the dependent variable in priming tasks is a response latency, while similarity ratings are a Likert-like measure. Thus, while phasic affect may have a considerable effect on semantic spread in priming tasks, it does not have a corresponding effect on explicit similarity ratings.

The present data by and large rule out the possibility that the density asymmetry itself results from affective reactions. Thus, the idea that higher similarity among positive compared to negative information constitutes a true property of the information ecology is not invalidated and may be open for further tests. While we suggest that the density asymmetry is a general phenomenon that applies to many if not all information domains, it is difficult to provide supporting evidence for the claim that it is a true property of the external world. For example, while attractive and unattractive faces can be compared objectively by physically measuring their visual features, an objective measure for the similarity between words is not available. As a result, the density asymmetry still remains a density hypothesis at this point (Unkelbach et al., 2008).

Nevertheless, the present work provides support for an important, because necessary condition for the density hypothesis, namely that it does not result from internal affective reactions itself. While there is ample empirical evidence that people's affective reactions such as emotional states, moods, and even brief phasic affective reactions influence cognitive processing (Bless et al., 2006; Forgas, 1995; 2008; Schwarz, 2011; Schwarz & Clore, 1983), the density asymmetry seems to exist independent and beyond such affective influences. Hence, the differential similarity among positive and negative information may well serve as an alternative explanation for various known valence asymmetries in information processing regarding processing speed, attention, information weighting, categorisation, and memory (Alves et al., 2017a).

Notes

1. The fact that we collected data from more participants than intended was due to procedural constraints in our lab. Sometimes participants who are recruited on campus show up at the lab later than they intended, and we then allow them to participate even if the desired sample size has already been reached.
2. Note that this analysis is factually equivalent to an ANOVA with one between and one repeated factor, but it prevents us from expressing one of the two factors (word and sound valence) as an interaction term, which may create confusion.

Disclosure statement

No potential conflict of interest was reported by the authors.

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