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Automatic effects of processing fluency in semantic coherence judgments and the role of transient and tonic affective states

***Abstract**: Recent literature reported that judgments of semantic coherence are influenced by a positive affective response due to increased fluency of processing. The presented paper investigates whether fluency of processing can be modified by affective responses to the coherent stimuli as well as an automaticity of processes involved in semantic coherence judgments. The studies employed the dyads of triads task in which participants are shown two word triads and asked to solve a semantically coherent one or indicate which of the two is semantically coherent. Across two studies in a dual-task paradigm we show that a) attentional resources moderate insight into semantically coherent word triads, whereas b) judgments of semantic coherence judgments are independent of attentional resources. We discuss implications of our findings for how people might form intuitive judgments of semantic coherence.*

Key words: *semantic coherence judgments; automaticity; affect; mood*

Introduction

Judgments are integral part of our everyday life. We are constantly forming impressions about objects, people, or ideas. Such impressions might be made in different ways. On some occasions we are engaging in a deliberate and effortful process of making the decision about which apartment to buy, or what to give our spouse to make him/her happy. But sometimes we are formulating judgments immediately, without much effort and even without enough information to dwell on. The former are called *intuitive* precisely because the reasons for them are difficult and sometimes impossible to verbalise. Although there has been much theorising about the two different kinds of processes underlying judgments (e.g. Lieberman, 2000; Kahneman, 2003), the concept of intuition was rather neglected for its resistance to experimental testing. However, recently a growing number of studies have been published on intuitive processing and its impact on judgment, choice, decision-making and memory (see Gigerenzer, 2008; Kolańczyk, 1991; Newell & Shanks, 2014; Topolinski & Strack, 2009a).

One type of intuitive judgments that have been recently studied is semantic coherence judgments. Using items from the Remote Association Test (Mednick, 1968), Bowers, Regehr, Balthazard, and Parker (1990) showed their participants on each trial two sets of three words each. Each pair of triads contained a coherent one that had a fourth word semantically related to all three within it whereas other triad in each pair was just a random set of words. Bowers et al. (Bowers et al., 1990) reliably demonstrated that participants were able to correctly indicate the coherent triads even though they could not provide their accurate solutions. Thus, despite being unaware of the solution word they could effectively detect a semantic coherence between clue-words within a coherent triad. Bowers et al. (1990) argued that those coherence judgments rely on a spreading activation mechanism within a semantic network (cf. Collins & Loftus, 1975). This account assumes that solution words are activated via their semantic associations with clue-words in triads. Even if solutions are not activated enough to become conscious they may nevertheless facilitate coherence judgments (see Bowden & Beeman, 1998).

The spreading activation account was recently directly tested by Bolte and Goschke (2005) who manipulated

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response-time windows to see whether intuitive judgments of coherence result from an immediate spread of activation. They demonstrated above-chance accurate coherence judgments even when the time between the onset of the trial and the response signal was 1.5 seconds short. Also, Topolinski and Strack (2008) showed that the processing of semantic coherence results in an automatic[1] activation of the triad's solution words. They involved word triads in a lexical decision task in which participants were responding to target words (being either solutions to triads, or control letter strings) presented after triads and by comparing groups instructed to read, memorise, and search for solutions were able to demonstrate that merely reading the triads improved participants performance on coherent triads. This indicates that simple reading of word triads automatically activates their common associates (i.e. solutions).

Affect and Mood in Judgments of Coherence

The crucial feature of automatic activation of semantically related concepts is that because of their relatedness they are processed more fluently. For example, it has been shown that processing fluency leads also to faster processing of coherent triads (Topolinski & Strack, 2009b). High fluency, in turn, is assumed to automatically elicit a subtle positive affect (Winkielman & Cacioppo, 2001). It has been argued therefore that semantic coherence judgments are producing positive affective responses due to an increased processing fluency of semantically coherent material (Topolinski & Strack, 2009b; Topolinski, Likowski, Weyers, & Strack, 2009). The fluency is triggered by semantic coherence automatically – without an intention – and leads to an increase of positive affective response that can be even detected by measuring the activity of facial muscles (Topolinski & Strack, 2008). This positive affect is then used in coherence judgments as convincingly demonstrated by Topolinski and Strack (2009b; see also Balas, Sweklej, Pochwatko, & Godlewska, 2012) as well as in insight into the solutions (Topolinski & Reber, 2010).

Not only subtle positive affect has been shown to affect intuitive coherence judgments but also mood apparently impacts how semantic associations are processed. It has been demonstrated that positive mood increases production of unusual associates (Isen, Johnson, Mertz, & Robinson, 1985), improves solution rates of Remote Association Test items (Isen, Daubman, & Nowicki, 1987; Rowe, Hirsh, & Anderson, 2007), and facilitates the use of broader cognitive structures (Bless et al., 1996; Isen & Daubman, 1984). Bolte et al. (Bolte, Goschke, & Kuhl, 2003) showed that intuitive coherence detection is facilitated in a positive mood compared to a negative mood. As shown by Balas et al. (2012) mood impacts not only on intuitive judgments of semantic coherence but also on the solvability of coherent triads. In our previous study (Balas et al., 2012) we demonstrated that participants in positive mood were accurately solving triads more frequently than those in negative mood. Although mood also affected the accuracy of intuitive judgments this did not reach statistical significance.

Do Affective Influences Require Attentional Resources?

However, the important question is how exactly this positive affect is used. We assume, similarly to Topolinski and Strack (2009b), that the positive affect induced by processing fluency is available to participants in a form of *affective cues* or *cognitive feelings*. Topolinski and Strack (2009b, Study 4) have shown that when those affective cues are mistakenly attributed to some irrelevant sources (other than a coherent triad itself) people cannot discriminate between coherent and incoherent triads anymore. This suggests that one needs to correctly attribute a positive cue to its source in order to use it in coherence judgments. Thus, although semantic associations within a network are processed automatically, the affective cues produced by processing fluency might require some attention to be used in coherence judgments. Therefore, the present studies investigate whether using those affective cues in coherence judgments is automatic in a sense that it does not require attentional resources.

Recently, Rowe et al. (2007) demonstrated that positive mood broadens the scope of visuo-spatial attention by showing increased interference in flanker task. At the same time, as mentioned before, Rowe at al. (2007) also showed that positive mood increases participants' performance on RAT items. Moreover, in the positive mood group the decreased performance in a flanker task correlated with increased solvability of RAT items suggesting that positive mood facilitates retrieval of correct solutions but inhibits selective attention. Although the direct relationship between attention and coherence judgments was not tested the results seem to imply that selective attention is not necessary for intuitive judgments of coherence. However, the other aspect of attention, namely attentional resources (e.g. Ansburg & Hill, 2003) viewed as the amount of processing dedicated to a given task, might intervene in how mood influences either insight or semantic coherence judgments. We also expect that the retrieval of solutions from memory will depend on attentional resources attributed to the task the time of encoding the triads. Since both tasks in the experiment, dyads of triads and a secondary task, are processed in visual modality, a secondary task should at least impair encoding of triads and therefore influence the amount of their further processing. A secondary task should also limit participants' ability to retrieve the solution word.

[1] We are aware the automaticity is a multi-faceted construct (see Moors and De Houwer, 2006), and here it connotes effortlessness (not requiring attentional or cognitive resource).

Experiment 1

Method

Participants

Fifty-seven students (41 women and 16 men) from various educational institutions in Warsaw took part in this experiment as volunteers without any gratification. Their age ranged from 16 to 35 years (M = 25.86, SD = 5.98). They were randomly assigned to either control (No Load) or experimental (Load) group.

Materials and Procedure

Sixty coherent triads were taken from Balas's et al. (Balas et al., 2012) study. All were composed from neutral words. Twenty of them had positively rated solutions (M_{pos} = 1.32, SD_{pos} = .34, e.g. COMPETITION, FINISH, ROUND implying MEDAL), twenty negative (M_{neg} = –.76, SD_{neg} = .31, e.g. CANDLES, NOVEMBER, STONE implying GRAVE), and twenty were neutral (*Mneu* = .30, SD_{neu} = .35, e.g. SCALE, LEGEND, MERIDIAN implying MAP). Those were significantly different with respect to the affective valence of solutions, $F(2, 61) = 212.40$, $p < .001$, η2 = .66, whereas their mean solvability did not differ significantly, $F(2, 61) = 1.34$, *n.s.* (M_{pos} = .42, SD_{pos} = .21, M_{neg} = .38, SD_{neg} = .19, M_{neu} = .37, SD^{neu} = .17). Also, the three different types of triads did not differ on evaluation of words composing them, $F(2, 61) = 1.48$, *n.s.*. Additionally, eighty incoherent triads were generated using a random assignment of neutral words. Three independent judges inspected the incoherent triads in order to eliminate those that could be associated with a plausible solution word. Sixty incoherent triads qualified for the main study. Then, pairs of triads (dyads of triads, henceforth) with one coherent and one incoherent were randomly constructed for each participant.

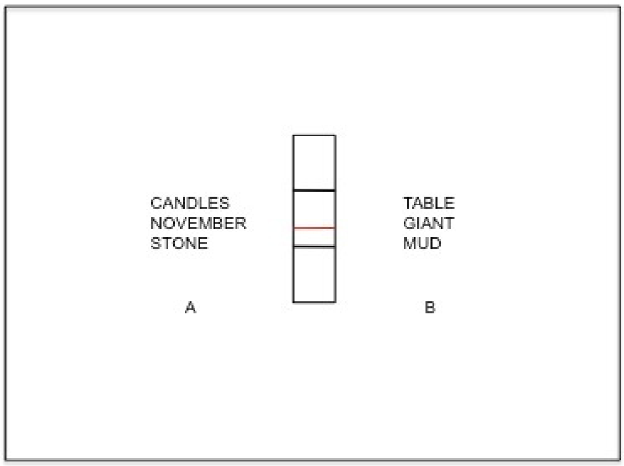

Figure 1. A single dyads of triads trial with a secondary task in-between word triads. Red line represents a moving horizontal bar that had to be kept within the space between thicker horizontal limits.

A secondary task in the experimental group required controlling the position of a stimulus on a computer screen. On each trial a graphical image of a rectangle (480px in height and 210px in width) was presented centrally on the screen between the two triads. A horizontal bar was located inside the rectangle (see Figure 1). Upon the start and throughout of each presentation trial the central bar was automatically moving down within the rectangle. Participants' primary task was to keep the bar within the limits by pressing the mouse key. Each press of the mouse key elevated the bar by a constant distance. The rate of bar's descent varied to prevent participants from adopting a strategy to press the mouse key with regular intervals. If the bar went outside the limits the system beep was set off and a screen turned red focusing participants on the secondary task again.

Procedure

Participants were tested individually in a lab room. The task was computerised. Sixty dyads of triads were presented sequentially in a random order. Whether a coherent triad appeared on the left or right side of a screen was randomized on a trial-to-trial basis. Each trial started with a 500 ms fixation point (a black cross in the centre of a screen) followed by a 500 ms blank screen. Then, the dyads of triads were presented for 5 seconds. The dyads were presented together with the secondary task in the experimental group. After the dyads disappeared, participants were given maximum 3 seconds to indicate which of them (A or B) was solvable by pressing the relevant key on a keyboard. Next, they were instructed to either write the proposed solution word in a textbox or press "I don't know the solution" button.

Standard debriefing procedure revealing the real purpose of the experiment was administered after experiment completion.

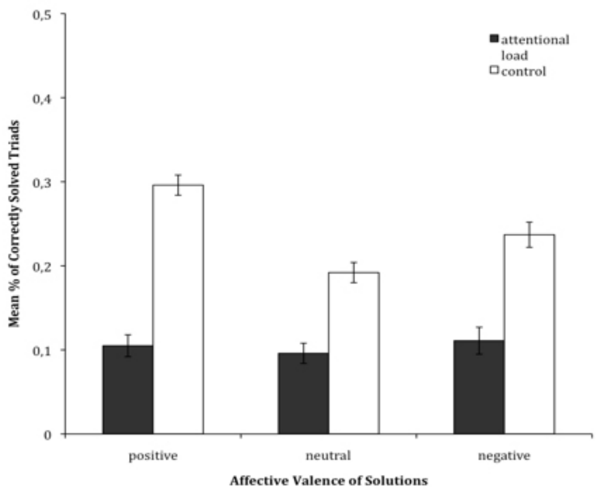

Figure 2. Mean percent of correctly solved triads as a function of attentional load and solutions valence. Whiskers represent standard error of the mean.

Results

Solvability

We classified triads as solved whenever a participant provided an exact solution word or its synonym. Moreover, we made sure that even when participants provided a plausible solution that counted as a correct solution based on a converging opinion from three independent judges. As pointed in Bolte and Goschke (2005) these are rather conservative criteria for determining whether a given coherence judgment was indeed intuitive.

A 2 (Attentional Load) x 3 (Solution Valence: negative vs neutral vs positive) repeated-measures analysis of variance (ANOVA) on the frequency of correct solutions revealed a main effect of attentional load, $F(1, 55) = 53.45$, $p < .001$, $\eta 2 = .73$, as well as a main effect of solution valence, $F(2, 110) = 9.89$, $p < .001$, $\eta 2 = .15$. First, the control group solved more ($M = .24$, $SD = .11$) triads correctly than the experimental group ($M = .11$, $SD = .08$, $t(56) = 4.89$, $p < .01$). Next, triads with neutral solutions ($M = .14$, $SD = .09$) were less frequently solved compared to triads with negative ($M = .17$, $SD = .09$), $t(56) = 2.42$, $p < .05$, as well as to triads with positive ($M = .20$, $SD = .08$), $t(56) = 4.19$, $p < .01$. Also, the triads with positive solutions were solved more frequently than those with negative solutions, $t(56) = 2.23$, $p < .05$.

Further, the analysis also revealed the interaction between attentional load and solution valence, $F(2, 110) = 5.65$, $p < .01$, $\eta 2 = .09$ (see Figure 2). Although the effect of solution valence was significant in the control group, $F(2, 58) = 10.26$, $p < .001$, $\eta 2 = .26$, it failed to reach statistical significance in the experimental group, $F(2, 52) = 1.09$, $p = .31$, $\eta 2 = .41$.

Coherence judgments

We analysed coherence judgments of only those triads that participants did not provided a correct solution to. A 2 (Attentional Load) x 3 (Solution Valence) ANOVA on Hit rates (a proportion of unsolved coherent triads judged as coherent, see Bowers et al., 1990)[2] revealed the main effect of solution's valence, $F(2, 110) = 50.82$, $p < .001$, $\eta 2 = .48$. Triads with positive solution words were judged as coherent more frequently ($M = .71$, $SD = .12$) than triads with neutral ($M = .60$, $SD = .11$), $t(56) = 6.44$, $p < .001$), or negative solutions ($M = .55$, $SD = .08$), $t(56) = 11.34$, $p < .001$). Also, triads with neutral solutions were more frequently judged as coherent than triads with negative solutions, $t(56) = 2.83$, $p < .01$. T-tests against chance probability (.5) revealed above chance Hit rates in case of all types of triads both in control and experimental group (all $ps < .05$). Neither the main effect of attentional load nor its interaction with solution valence was significant, $F(1, 55) = .69$, $p = .41$, $\eta 2 = .01$, and $F(2, 110) = .28$, $p = .76$, $\eta 2 = .01$, respectively.

From this paper's perspective the crucial effect is that attentional load has an impact on solvability, but not coherence judgments. To confirm this, we standardised the accuracy of solution and coherence judgment rates and feed them into 2 (Attentional Load) x 2 (DV: Solutions vs Coherence Judgments) x 3 (Solution Valence) ANOVA. This revealed the main effect of attentional load, $F(1, 55) = 57.83$, $p < .001$, $\eta 2 = .51$, and the interaction between attentional load and the type of judgments, $F(1, 55) = 47.54$, $p < .001$, $\eta 2 = .46$. First, lower rates of accuracy were generally observed in the Load group ($M = -.39$, $SE = .071$) than in controls ($M = .35$, $SE = .067$). Secondly, attentional load did not affect the accuracy of coherence judgments ($M = -.061$, and $M = .55$ in Load and No Load groups, respectively), whereas it did have huge effect on solvability rates ($M = -.72$, and $M = .65$ in Load and No Load groups, respectively). All other effects were not statistically significant (all ps > .29).

Finally, we have also checked for laterality effects in the task. The comparisons between exposure locations (right vs. left) proved insignificant on all dependent variables.

Discussion

Two aspects need our commentary before we start concluding from the data. First, there might be at least two reasons why triads with valence-laden solutions (as compared to neutral solutions) were solved more frequently than in a pre-test. First, participants in a pilot study were solving triads from only one affective category (positive, negative or neutral). Second, triads selected for the study were initially (during a pre-test) embedded in a larger pool of triads that were either very easy or very hard to solve. These procedural differences between a pre-test and the experiment reported here might have contributed to differences in solvability rates between a pre-test and the study and those differences are definitely worth further investigation. However, we think that they do not undermine the interpretation of collected data (see Sweklej, Balas, Pochwatko, & Godlewska, 2014).

Secondly, one would expect that triads with negative solutions would be solved less frequently than those with neutral ones. In fact, we found exactly the opposite pattern. We think that this might be due to the inconsistency between affective responses induced by negative solutions and processing fluency of coherence that led to a more thorough processing of triads with negative solutions and therefore to their higher solvability rates (Roese & Sherman, 2007).

We have demonstrated that a secondary task that demanded participants' attention had a great impact on participant's ability to come up with correct solutions, but did not affect their judgments of coherence. This suggests that the insight to solutions of triads depends on the availability of attentional resources more than forming intuitive coherence judgments does. One reason for that would be that the triads were not processed deeply enough under attentional load to activate the solution concept above retrieval threshold, but enough to elicit fluency variations

[2] In dyads of triads task it is impossible to analyze hit and false alarm rates independently as it is typically done when only one triad is presented at a time (see Topolinski and Strack, 2009a, Bolte and Goschke, 2005, Bolte and Goschke, 2003, Balas et al., 2012) since false alarms rate is 1 - Hit rate. Therefore, we stick to Bowers et al.'s (1990) original "Guiding index" that is comparable to measures of discriminability used in literature (see Baumann et al., 2002).

that inform intuitive coherence judgments. Moreover, although triads with differently valenced solutions did differ in terms of their solvability in general, those differences were present only when attention was not occupied by a secondary task. This in turn, signifies that affective cues from processing the coherence support insight only when one has enough attentional resources to entertain them. However, when attention is directed elsewhere those cues seem to remain "unnoticed". This account is congruent with recently proposed fluency-based account of insight by Topolinski and Reber (2010).

On the other hand, semantic coherence judgments were not affected by limiting attentional resources suggesting that the processes underlying them can be deemed automatic in a sense that they do not require much processing resources. This is also completely in line with a processing fluency account since it assumes semantically coherent material to automatically increase fluency (see Topolinski & Strack, 2009b). This increased processing fluency results in a subtle positive affective response that can be used to mark semantically coherent items (see Topolinski & Strack, 2008). The presented pattern of data converges with this account since it shows more accurate coherence judgments in case of triads with positive solutions and a decreased accuracy on triads with negative solutions. Thus, a positive response from processing fluency can be strengthened or weakened by a positive or negative affect generated by the activation of positive or negative solution words, respectively (see also Balas et al., 2012). Those affective influences do not require attentional resources.

Put it together, the main finding here is that the availability of attentional resources enable insight into solutions, whereas they do not seem to be important in semantic coherence judgments. This suggests that intuitive judgements of semantic coherence result from a resource-free process based on fluency of processing whereas insight seems to depend on attention.

The next experiment sought to reveal whether moods influence both insight and coherence judgments. Dwelling on the fact that positive mood generally broadens the scope of activated associations and negative mood narrows it (Rowe et al., 2007; Bolte & Goschke, 2010), we expect that a positive mood manipulation will generally increase solvability and coherence judgements even under attentional load. Negative mood induction, however, should negatively impact participants' ability to solve triads as well the accuracy of their judgments of semantic coherence. Also, mood should interact with other sources of affective responses in this task, namely processing fluency and the valence of solution words. Therefore, we believe that affective convergence between those sources should magnify previously shown effects. Namely, when positive mood converges with positive affective response from processing fluency and solution's valence we should observe increased proportion of correctly solved triads as well as more accurate judgments of coherence. However, negative mood plus negative response from negatively valenced solutions should lead to the least percentage of correct solutions and accurate coherence judgments.

Experiment 2

Method

Participants

Sixty-four volunteers (36 women and 28 men) from various educational institutions in Warsaw participated in the study with no reward. Their age ranged between 17 and 19 years old (M = 18.16, SD = .44). They were randomly assigned to groups differing with attentional load and mood manipulations.

We used the same set of triads and same secondary task as in Experiment 1. Also, the dyads of triads task was applied exactly in the same manner as previously. Participants were tested individually in a laboratory room. After filling out the first mood measure they were asked to recollect and write down any happy (positive mood induction) or sad (negative mood induction) event(s) that they experienced during last month. A control group was asked to describe a typical student's day. After completing their description, participants were instructed to place it on a table in front of them for a later self-review. The second mood measure was applied straight after mood manipulation and the third upon completion of the dyads of triads task.

To measure mood we adopted an adjective scale from Ohme (1997). It includes 12 positive and 12 negative adjectives referring to positive or negative affective states (e.g. HELPLESS or STRESSED as negative, and RELAXED or SATISFIED as positive). Participants rated how well each of these adjectives described their current emotional state using a 5–point Likert scale (where 1 was "definitely not", 3 - "hard to determine", and 5 - "definitely yes"). Its reliability as assessed with Cronbach's alpha was satisfactory (.922). Because mood was measured three times during the experiment the whole scale was divided into three sets containing 4 positive and 4 negative items each. Adjective assignment to three sets and sets' administration within experiment were randomised. The experiment was run on a standard PC computer with specially designed software.

Results

Mood manipulation check

The mood index was calculated as a sum of self-ratings of adjectives separately before and after mood manipulation as well as after the experiment completion. To make sure that mood manipulation was effective we ran a 3 (Mood Manipulation) x 3 (Measurement Time) repeated-measures analysis of variance (ANOVA) on mood indexes. It revealed the main effect of mood manipulation, $F(2,61) = 12.61$, $p < .001$, $\eta 2 = .29$, main effect of measurement, $F(2,122) = 9.34$, $p < .01$, $\eta 2 = .13$, as well as the interaction between those two factors, $F(4,122) = 6.21$, $p < .01$, $\eta 2 = .17$. The mood manipulation was successful as the mean difference between mood indexes before and after manipulation was positive in a positive mood group (M = 1.24, SD = .89), $t(21) = 3.45$, $p < .05$, and negative in a negative mood group (M = –5.14, SD = 1.78),

$t(21) = 4.31$, $p < .01$. The difference in mood between those groups was significant after the manipulation and after the experiment – $t(42) = -8.96$, $p < .001$, and $t(42) = -2.43$, $p < .05$, respectively – although smaller in the latter case.

Solvability

The frequency of solutions was analysed in a 3 (Mood Manipulation) x 2 (Attentional Load) x 3 (Solution Valence) mixed-design ANOVA. It showed the main effect of attentional load, $F(1, 58) = 40.11$, $p < .001$, η2 = .71, and the main effect of affective valence of solutions, $F(2, 116) = 18.03$, p < .001, η2 = .24. Participants in the experimental group have correctly solved less triads ($M = .09$, $SD = .03$) than the controls ($M = .22$, $SD = .09$). Additionally, triads with positive solutions were solved more frequently ($M = .21$, $SD = .07$) than triads with neutral ($M = .13$, $SD = .05$), $t(63) = 5.35$, $p < .01$, or negative solutions ($M = .14$, $SD = .07$), $t(63) = 4.21$, $p < .01$. However, the solvability of triads did not differ between triads with neutral and negative solutions, $t(63) = -1.39$, $p = .17$. The main effect of mood manipulation proved not to be significant, $F(2,58) = .52$, $p = .59$, η2 = .02.

Also, a marginally significant interaction between attentional load and solutions' valence appeared, $F(2, 116) = 2.84$, $p = .06$, η2 = .09. The difference between control and experimental group was mostly pronounced on triads with negative solutions, $F(1, 62) = 66.43$, $p < .001$, η2 = .51, a little less on triads with positive solutions, $F(1, 62) = 44.97$, $p < .001$, η2 = .42, and was lowest on triads with neutral solutions, $F(1, 62) = 31.62$, $p < .001$, η2 = .32. All other effects, including interactions with mood, were not significant (all ps > .46).

Coherence judgments

The accuracy of coherence judgments (proportion of Hits) was analysed in a 3 (Mood Manipulation) x 2 (Attentional Load) x 3 (Solution Valence) ANOVA. First, it showed a main effect of mood, $F(2, 58) = 19.24$, $p < .001$, η2 = .39. Participants in a positive mood group more frequently correctly judged coherent triads as coherent ($M = .54$, $SD = .09$) than those in a negative ($M = .42$, $SD = .07$) and neutral ($M = .43$, $SD = .09$) group. Also, a main effect of solutions' valence appeared, $F(1, 58) = 34.98$, $p < .001$, η2 = .67. Triads with positive solutions were more frequently judged as coherent ($M = .61$, $SD = .11$) than triads with negative ($M = .32$, $SD = .10$) and neutral ($M = .46$, $SD = .13$) solutions. Additionally, there was a slight influence of attentional load on coherence judgments but it did not reach statistical significance, $F(1, 58) = 2.81$, $p = .09$, η2 = .07. The experimental group showed less accurate coherence judgments than the control one ($M = .45$, $SD = .10$, and $M = .48$, $SD = .09$, respectively).

Because the main focus here was to see whether attentional load has a differential impact on insight and coherence judgments (with possible intervention of affective responses from mood and solution's valence) we standardised the accuracy of solution and coherence judgment rates and feed them into 2 (Attentional Load) x 2 (Mood) x 2 (DV: Solutions vs Coherence Judgments) x 3 (Solution Valence) ANOVA. This revealed the main effects of attentional load, $F(1, 58) = 79.98$, $p < .001$, η2 = .58, and mood, $F(2, 58) = 14.14$, $p < .001$, η2 = .33. First, lower rates of accuracy were generally observed in the Load group ($M = -.39$, $SE = .061$) than in controls ($M = .37$, $SE = .07$). Secondly, participants in neutral mood condition generally scored lower ($M = -.19$, $SE = .07$) than those in negative ($M = -.14$, $SE = .073$) and positive ($M = .31$, $SE = .07$) mood.

Also, both between group factors interacted significantly with the type of DV, $F(1, 58) = 28.21$, $p < .001$, η2 = .33, and $F(2, 58) = 12.28$, $p < .001$, η2 = .29, for attentional load and mood respectively. Attentional load impaired participants ability to correctly retrieve solutions ($M = -.66$, $SE = .079$) as compared to control group ($M = .64$, $SE = .079$) whereas it did not affect the accuracy of coherence judgments ($M = -.13$, $SE = .103$, and $M = .11$, $SE = .103$, for Load and No Load groups, respectively). Also, mood did not have an impact on solvability of triads ($M = -.01$, $SE = .096$, $M = -.06$, $SE = .1$, and $M = .07$, $SE = .096$ in positive, neutral and negative mood induction groups, respectively), whereas participants in positive mood judged triads' coherency more accurately ($M = .65$, $SE = .124$) than those in neutral ($M = -.33$, $SE = .13$) and negative ($M = -.35$, $SE = .124$) mood.

Discussion

In Experiment 2 we have replicated the previous pattern of results in that the attentional load again had a detrimental effect on the solvability of coherent triads but not on the coherence judgments. We also confirmed that unsolved triads with positively valenced solutions are more frequently correctly judged as coherent than triads with either neutral or negative solutions. This again shows that a) insight into solution words seem to require attentional resources, and b) a positive affective response driven by processing fluency interacts with an affective response generated by the activation of solution words (see also Balas et al., 2012).

A puzzling finding is that mood did not have any effect on solvability, although there is ample data showing that positive mood facilitates insight into semantic coherence (e.g. Isen et al., 1987; Rowe et al., 2007). One possible reason would be that, counter to most of the experimental designs in literature, we have presented two triads at the same time. This might diminished mood influence on solvability due to a cognitive load that, in addition to attentional load manipulation, generally strongly inhibited successful retrieval of solutions.

However, we show that mood has a general effect on coherence judgments but does not interact neither with attentional load manipulation nor with the affective valence of solutions. The facilitation of coherence judgments in positive mood due to a broader activation of semantic network is congruent with findings reported in Bolte et al. (2003) and Balas et al. (2012). In addition to that, our data demonstrate also that this facilitatory effect is automatic in a sense that it does not demand attentional resources. However, the fact that positive mood increases the accuracy of coherence judgments does not add up to other sources of facilitation like processing fluency or the activation of affectively valenced solution words. This suggests that mood and subtle affect generated either by processing fluency or the activation of valenced solution words operate differently and are fairly independent.

General Discussion

The purpose of the presented studies was to investigate the nature of how affective processes influence intuitive judgments of semantic coherence. Specifically, we sought to address the automatic nature of those influences as suggested by previous studies as well as theoretical accounts of underlying processes (e.g. Topolinski & Strack, 2008; 2009a). To do that, we manipulated attentional resources available at the time of forming semantic coherence judgments. Additionally, we have manipulated transient and tonic affective states by varying the affective valence of concepts activated through semantic network and inducing moods in participants, respectively.

We have showed that the performance on dyads of triads task in terms of the number of triads correctly solved heavily depends on attentional resources. When participants' attention was occupied by a demanding secondary task they could hardly ever retrieve a correct solution from memory. Moreover, the facilitatory role of positive affect induced by processing fluency and modified by the activated solution words can be entertained only when full attention is devoted to the primary task whereas it disappears under attentional load. This suggests that finding out the correct solution to a given triad requires attentional resources and effort. We argue, contrary to initial claims of Bowers et al. (1990), that the solutions to coherent word triads do not necessarily pop out into one's mind but the process of figuring out the solution is effortful. However, it can still be supported by affective cues that arise from processing fluency (see Topolinski & Reber, 2010) presumably because brief affective states has been shown to modulate activation spread in semantic network (see Topolinski & Deutsch, 2012; Topolinski & Strack, 2009a). But attentional resources are needed to use those cues in the retrieval of common associates from memory. Our claim is then that both the process of gaining insight into the semantically related concepts and the use of affective cues that may support the memory retrieval require attentional resources.

Interestingly enough, mood did not affect the accuracy of solutions. Although previous studies showed increased performance on solving triads when participants were in a good mood (Isen et al., 1987; Rowe et al., 2007), we did not find this effect in our study. This might be due to several reasons. First, the general accuracy of solutions was very low making it difficult to find a significant contrast between groups. Secondly, previous studies used single triads in each trial, whereas here dyads of triads were presented. Showing two triads at the same time in our research surely increased cognitive demands and therefore might hinder participants' ability to retrieve the correct solution.

Although participants' ability to come up with accurate solutions to triads was significantly impaired when their attention was deployed elsewhere, the accuracy of their judgments of semantic coherence remained intact. This indicates that the nature of processes involved in gaining insight into solutions and detecting semantic coherence might be different. Detecting semantic coherence appears to be more automatic and effortless. This converges with previous accounts suggesting that it relies on an automatic activation spread in semantic network. Moreover, the affective cues marking semantic coherence also do not seem to operate in a way that requires attentional resources (see Topolinski & Deutsch, 2012). This fully supports the claim that intuitive judgments of coherence are formed automatically and automatically influence behaviour. Participants seem to use those affective cues spontaneously and automatically.

Apart from a subtle positive affect that marks semantic coherence also positive mood increases the accuracy of intuitive judgments. However, the two sources of enhancement do not seem to interact with each other. We think that this is due to a more general impact of mood on cognitive processing. As mentioned above, positive mood broadens the scope of activated semantic network allowing the activation of more distant associations. Therefore, it allows the semantically related solution to be activated by its associates. Thanks to that, a more fluent processing might occur since positive mood makes more probable that this fluency is generated not only by words in the triad but also by the fourth word that is the solution to it. Thus, positive mood increases the overall positive affective response used in intuitive judgments of semantic coherence. It seems that the modulation of this response by other affective sources, like the valence of an activated solution, is too week to impact judgments.

To sum up, the presented data suggest that affective cues induced by processing fluency might be used in judgments of coherence as well as the retrieval of semantically related concepts from memory. However, those two processes seem to differ in terms of the amount of attentional resources that has to be devoted. On one hand, the memory retrieval of semantically related concepts generally requires cognitive effort and attention is needed to use affect as a cue for this. On the other hand, it seems not to be essential in forming intuitive judgments of semantic coherence that are based on processing fluency. We might be dealing with different types of affective cues, one marking the coherence itself whereas the other indicating a particular concept associated with it. Participants seem to use the former spontaneously and automatically, whereas processing the latter requires cognitive resources. How those two interact remains to be investigated in the future.

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