Consciousness and Cognition 29 (2014) 230–234

Contents lists available at ScienceDirect

Consciousness and Cognition

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

Subliminal primes for global or local processing influence judgments of vehicular traffic

Stefanie Hüttermann [a,*], Otmar Bock [b], Daniel Memmert [a]

[a] Institute of Cognitive and Team/Racket Sport Research, German Sport University Cologne, Germany
[b] Institute of Physiology and Anatomy, German Sport University Cologne, Germany

ARTICLE INFO

Article history:
Received 13 January 2014

Keywords:
Subliminal priming
Attentional breadth
Local attention
Global attention

ABSTRACT

Previous studies on semantic priming show that briefly presented words can unconsciously manipulate subjects' mental states, behaviors, and attitudes. Here we evaluated whether semantic primes can also manipulate the breadth of subjects' visual attention. We primed participants with briefly presented words that indicate either broadness or narrowness; each prime was followed by either a large or a small picture of a street intersection with vehicles, and participants had to indicate in which order the vehicles were legally allowed to pass the intersection. Participants responded to large pictures faster when primed with words denoting broadness, and to small pictures faster when primed with words denoting narrowness. From this we concluded that semantic priming can be effectively applied to manipulate the breadth of attention, which could be exploited in real-world scenarios.

© 2014 Elsevier Inc. All rights reserved.

1. Introduction

In everyday life, we often have to distribute our attention across our whole visual field while at other times it must be merely focused on a limited area of space (Nideffer, 1976). It is well-established that humans can flexibly change between global and local attention (e.g., Eriksen & St. James, 1986; Kinchla, Solis-Macias, & Hoffman, 1983) in dependence on spatial (e.g., Shulman & Wilson, 1987) and temporal (e.g., Lamb & Yund, 1996) characteristics of a displayed scene but also scene-independent (e.g., Gasper & Clore, 2002). A variety of researchers (e.g., Förster & Higgins, 2005; Förster, Liberman, & Kuschel, 2008; Navon, 1977; Schwarz & Bless, 2007) have documented – mostly by using perceptual tasks – that a person's preference for processing global versus local information can be experimentally manipulated. Our study examined for the first time whether the direction and scope of the attentional focus can be controlled and affected by semantic priming, too.

In recent years, the phenomenon of semantic priming has been proven in an increasing number of studies (for reviews see Hutchison, 2003; Lucas, 2000; Maxfield, 1997). Commonly, prime words were presented so briefly that they escaped subjects' awareness but nevertheless affected their responses to subsequent target words (cf. Meyer & Schvaneveldt, 1971). This finding is typically interpreted as evidence for a lexical network in the brain which stores semantically related information in adjacent locations: a prime word would activate a given location for some time, and thus facilitate the response to a subsequent, semantically congruent target (Collins & Loftus, 1975; Kiesel, Kunde, & Hoffmann, 2007; Klauer & Musch, 2003). In the present study, we experimentally manipulated at the semantic level a person's preference for processing of global versus

* Corresponding author. Address: Institute of Cognitive and Team/Racket Sport Research, German Sport University Cologne, Am Sportpark Müngersdorf 6, 50933 Köln, Germany. Fax: +49 221 4982 8260.
E-mail address: s.huettermann@dshs-koeln.de (S. Hüttermann).

http://dx.doi.org/10.1016/j.concog.2014.08.007
1053-8100/© 2014 Elsevier Inc. All rights reserved.

local information. Participants were primed with words denoting either a wide or a narrow focus (e.g., "universal" or "compressed"). We hypothesized that primes denoting a global or a local focus not only modify the semantic analysis of subsequent words, but also change the subsequent processing of spatially distributed information: priming with words such as "universal" would therefore facilitate the processing of large (congruent condition) rather than small (incongruent condition) visual scenes, while the opposite would hold for priming with words such as "compressed". This means, in sum, we hypothesized that congruent primes would shorten response times and incongruent trials would result in longer response times compared to neutral primes.

2. Methods

Altogether, 20 participants (7 female, 13 male) aged 18–24 years (M_{age} = 21.30 years, SD = 1.38 years) took part in the study. Data from four additional participants were excluded because they did not achieve the performance minimum of 75% accuracy across all trials (cf. Sloutsky, Kloos, & Fisher, 2007). All participants reported normal vision without the need for corrective lenses. Written informed consent was obtained from each participant. The study was carried out in accordance with the Helsinki Declaration of 1975.

Participants sat at a distance of about 45 cm from a 15″ PC monitor, so that the visual angle of the display was about 34° horizontal × 27° vertical. Primes – successfully used in pilot studies (e.g., Hüttermann, Memmert, & Bock, 2012) – were adopted from a set of 20 adjectives describing a narrow attentional focus and 20 adjectives describing a broad focus of attention (word set 1: *close, strict, accurate, special, sole, subtle, compressed, thorough, intense, enclosed, linear, direct, small, exact, detailed, slim, precise, specific, short, limited;* word set 2: *far, approximate, global, universal, multiple, broad, open, general, common, spacious, distant, long, big, blanket, comprehensive, allround, distributed, large, rough, total*). The prime words were presented on the screen in lowercase letters (average height 0.8 cm), in black on a white background. Primes were extended to a length of 13 letters by adding "+" characters to the left and to the right so that all primes had the same length. Two non-word letter strings (either "npxqh" or "npxlh", cf. Kiesel, Kunde, Pohl, & Hoffmann, 2006) were additionally used as neutral primes. Each prime was displayed for 32 ms, and was followed by a mask of 13 "#" characters for 50 ms.

Targets were illustrations of traffic scenarios similar to those used in drivers' license tests. Sixteen different scenarios were created with the software E-Prime®, each depicting an intersection with "yield" and/or priority signs and with two or three vehicles (cars, trucks, and/or motorcycles in light or dark gray). The scenarios were displayed across the whole screen ("global targets", see Fig. 1, top panel), or only within the central quarter of the screen area ("local targets" see Fig. 1, bottom panel).

The order of events on each trial is illustrated in Fig. 1. A black fixation cross appeared for 500 ms, followed by prime and mask, which were again followed by the target. Participants were instructed to first fixate the cross and then to use the computer mouse to touch the displayed vehicles one after the other, in the order in which they were allowed to pass through the intersection according to the traffic rules; they were asked to complete the task as quickly as possible. (An experimenter ensured that participants actually clicked on the vehicles and did not click two or three times in row in order to be faster). The next trial started immediately after the last (2^{nd} or 3^{rd}) vehicle was touched. Each subject completed four practice trials followed by 60 experimental trials with six combinations of prime type (local prime – local target, global prime – local target, neutral prime – local target, local prime – global target, global prime – global target, and neutral prime – global target) each randomly varying ten times. Target difficulty (2 or 3 vehicles) as well as the prime word from the set of semantically similar words were also selected randomly.

Response times from target onset to the first vehicle touch were averaged within the prime types congruent (prime and target both global or both local), incongruent (one of prime or target global, the other local), and neutral (prime neutral) in respective of target size. The outcome was submitted to a 3 × 2 × 2 ANOVA with repeated measures on the factors Prime type (congruent, incongruent, neutral), target Size (global, local), and task Complexity (two vehicles, three vehicles). When the assumption of sphericity was violated, p-values were adjusted by the conservative Greenhouse–Geisser method.

2.1. Prime visibility test

Subsequent to the main experiment, we conducted a prime visibility test[1] with 13 new participants (8 female, 5 male) aged 19–26 years (M_{age} = 21.85 years, SD = 1.77 years). They were submitted to the same procedures as in the main experiment, but in addition, they were informed about the presence of prime words. As in the main experiment, participants had to indicate the order in which vehicles were allowed to pass through the intersection. Afterwards, they were asked whether the masked prime words described a narrow or a broad attentional focus, or a non-word letter string. They were encouraged to make the best guess if they were unsure about the correct answer.

[1] The prime visibility test was conducted after the main experiment because we collected these data in response to a reviewer's suggestion.

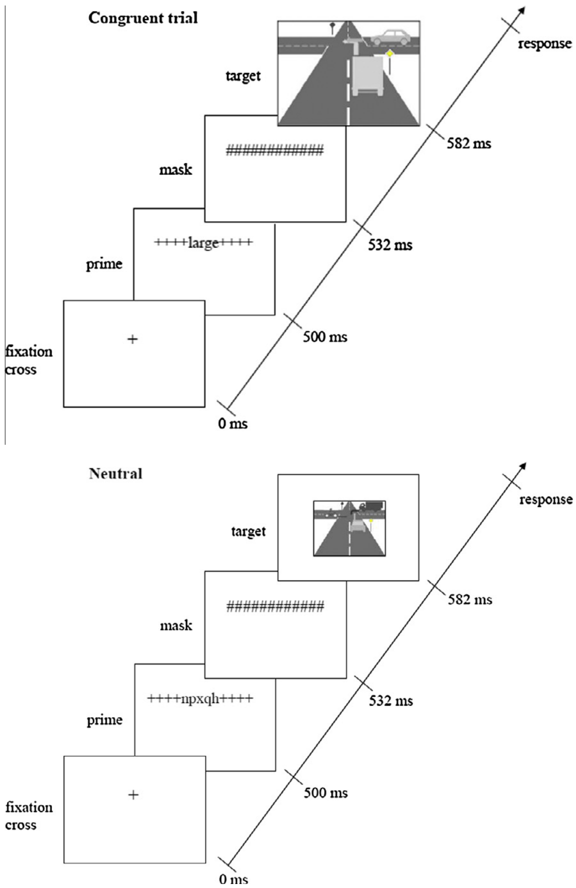

Fig. 1. Sequence of events in one trial from the congruent condition at low complexity (top panel: two vehicles) and the neutral condition at high complexity (bottom panel: three vehicles). The congruent condition is depicted with a global target, and the neutral condition with a local target.

3. Results

3.1. Priming judgments

The ANOVA yielded significant main effects of Prime, $F(1.468, 27.885) = 5.467$, $p = .016$, $\eta_p^2 = 0.223$, Greenhouse–Geisser $\varepsilon = 0.734$, and Size, $F(1,19) = 6.217$, $p = .022$, $\eta_p^2 = .247$, but not of Complexity, $F(1,19) = 1.458$, $p = .242$, $\eta_p^2 = .071$; none of the interactions was significant. Fig. 2 illustrates that overall, response time was smallest in the congruent ($M = 624.03$ ms, $SD = 192.32$ ms), higher in the neutral ($M = 678.59$ ms, $SD = 210.54$ ms), and highest in the incongruent ($M = 737.10$ ms, $SD = 235.10$ ms) condition (congruent vs. incongruent: $t(19) = -4.426$, $p < .001$; congruent vs. neutral: $t(19) = -1.714$, $p = .103$; incongruent vs. neutral: $t(19) = 1.363$, $p = 1.89$; Bonferroni corrected post hoc comparisons had an adjusted alpha of 0.017). Furthermore, Fig. 2 implicates a higher condition-sensitivity of global ($M = 704.95$ ms, $SD = 226.88$ ms) compared to local ($M = 654.86$ ms, $SD = 167.40$ ms) targets, although the interaction term was not statistically significant.

3.2. Prime visibility test

The proportion of correct answers was 35.13%, which is not significantly different from the chance level of 33.33%, $t(12) = 0.633$, $p = .538$. This indicates that participants were not aware of the prime stimuli, even if – unlike in the main experiment – they had been informed about their presence.

4. Discussion

The main goal of this study was to examine the influence of subliminal priming on the scope of people's attentional focus. According to past research investigating the effect of subliminal priming on people's mental states or decision making (e.g.,

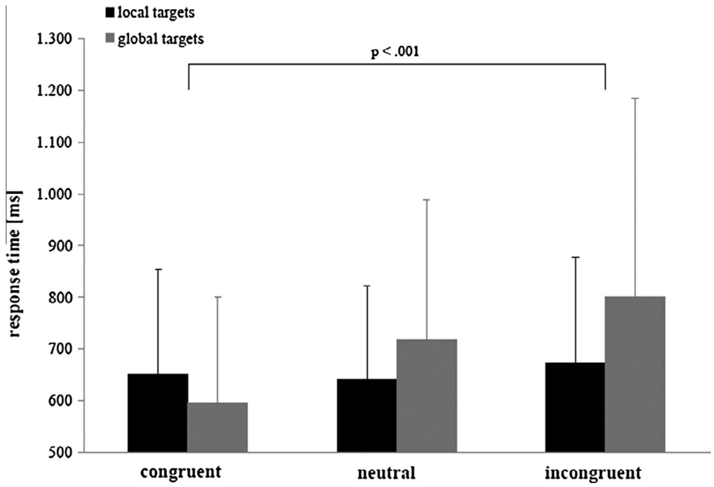

Fig. 2. Response times of correct responses to traffic situations presented globally or locally in the congruent, neutral, and incongruent condition. Symbols represent across-subject means irrespective of task complexity, and error bars show standard deviations.

Fenske & Eastwood, 2003; Förster, Friedman, Özelsel, & Denzler, 2006; Zemack-Rugar, Bettman, & Fitzsimons, 2007), we expected that priming with words that denote narrowness would facilitate the processing of small visual scenes, while priming with words that denote broadness would facilitate the processing of large scenes. This is indeed what we found: participants' right-of-way judgments were fastest when primes and targets were congruent (i.e., both associated with broadness or both with narrowness), slowest when primes and targets were incongruent (i.e., one associated with broadness but the other with narrowness), and intermediate when the primes were neutral.

Past research showed that the breadth of visual attention can be influenced by verbal instructions (e.g., Furley, Memmert, & Heller, 2010; Memmert & Furley, 2007) and emotional (e.g., Fredrickson & Branigan, 2005) as well as motivational states (e.g., Förster et al., 2006; Hüttermann & Memmert, 2014). To our best knowledge, the current findings represent the first experimental evidence that attentional breadth can also be influenced by semantic priming: this technique therefore not only activates the postulated semantic network (Kiesel et al., 2007; Klauer & Musch, 2003), it also seems to modify the breadth of spatially distributed processing in accordance with the prime's meaning. Hence the effect of semantic priming is not limited to the semantic level, but rather extends to other cognitive levels.

In his seminal work, Navon (1977) assumed that any visual scene represents a hierarchical network of sub-scenes that is interrelated by spatial relationships (Kimchi, 1992), and that our visual system prioritizes global over local levels. We therefore expected the mean response times across all prime categories to be shorter with large than with small traffic pictures. Congruent prime types confirmed our expectations, but both, the neutral and the incongruent prime type as well as the averaged experimental data across prime types yielded just the opposite effect. We have three potential explanations for this discrepancy: our targets were about five times larger than those of Navon (1977), they were preceded by small stimuli (fixation cross, prime, and mask) which possibly biased the breadth of visual attention, and our small targets were not embedded in a more complex scene. Further examination is needed to confirm these explanations.

The present work has potential applications in several areas of everyday life. Semantic priming could be used to broaden drivers' attention when approaching a busy intersection and to narrow it when approaching a residential area. Among others, it could also be used to direct the attention of customers towards global or local characteristics of a product. Other forms of subliminal priming were already explored in marketing research (e.g., Karremans, Stroebe, & Claus, 2006; Klink, 2009). The different areas (e.g., road traffic, marketing) that seem to be suitable for using the effects of semantic priming on the attentional focus point out the practical relevance of the topic and plead for further research and development in this research area.

It should be concluded that semantic priming can be effectively applied to manipulate the breadth of subjects' visual attention. Briefly presented words that indicate either broadness or narrowness affect global and local processing and might be highly relevant and applicable in several real-world scenarios.

References

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review, 82*, 407–428.
Eriksen, C. W., & St. James, J. D. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Perception & Psychophysics, 40*, 225–240.
Fenske, M. J., & Eastwood, J. D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. *Emotion, 3*, 327–343.
Förster, J., Friedman, R. S., Özelsel, A., & Denzler, M. (2006). Enactment of approach and avoidance behavior influences the scope of perceptual and conceptual attention. *Journal of Experimental Social Psychology, 42*, 133–146.

Förster, J., & Higgins, E. T. (2005). How global versus local perception fits regulatory focus. *Psychological Science, 16*, 631–636.
Förster, J., Liberman, N., & Kuschel, S. (2008). The effect of global versus local processing styles on assimilation versus contrast in social judgment. *Journal of Personality and Social Psychology, 94*, 579–599.
Fredrickson, B. L., & Branigan, C. A. (2005). Positive emotions broaden the scope of attention and thought–action repertoires. *Cognition and Emotion, 19*, 313–332.
Furley, P., Memmert, D., & Heller, C. (2010). The dark side of visual awareness in sport – Inattentional blindness in a real-world basketball task. *Attention, Perception, & Psychophysics, 72*, 1327–1337.
Gasper, K., & Clore, G. L. (2002). Attending to the big picture: Mood and global versus local processing of visual information. *Psychological Science, 13*, 33–39.
Hutchison, K. A. (2003). Is semantic priming due to association strength or feature overlap? A micro-analytic review. *Psychonomic Bulletin and Review, 10*, 785–813.
Hüttermann, S., & Memmert, D. (2014). The influence of motivational and mood states on visual attention: A quantification of systematic differences and casual changes in subjects' focus of attention. *Cognition and Emotion*. in press.
Hüttermann, S., Memmert, D., & Bock, O. (2012). Semantic priming of attention focus: Evidence for short- and long-term effects. *Psychology, 3*, 128–131.
Karremans, J. C., Stroebe, W., & Claus, J. (2006). Beyond Vicary's fantasies: The impact of subliminal priming and brand choice. *Journal of Experimental Social Psychology, 42*, 792–798.
Kiesel, A., Kunde, W., & Hoffmann, J. (2007). Mechanisms of subliminal response priming. *Advances in Cognitive Psychology, 3*, 307–315.
Kiesel, A., Kunde, W., Pohl, C., & Hoffmann, J. (2006). Priming from novel masked stimuli depends on target set size. *Advances in Cognitive Psychology, 2*, 37–45.
Kimchi, R. (1992). Primacy of wholistic processing and global/local paradigm: A critical review. *Psychological Bulletin, 112*, 24–38.
Kinchla, R. A., Solis-Macias, V., & Hoffman, J. (1983). Attending to different levels of structure in a visual image. *Perception & Psychophysics, 33*, 1–10.
Klauer, K. C., & Musch, J. (2003). Affective priming: Findings and theories. In J. Musch & K. C. Klauer (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion* (pp. 7–50). Mahwah, NJ: Lawrence Erlbaum.
Klink, R. R. (2009). Gender differences in new brand name response. *Marketing Letters, 20*, 313–326.
Lamb, M. R., & Yund, E. W. (1996). Spatial frequency and interference between goals and local levels of structure. *Visual Cognition, 3*, 193–219.
Lucas, M. (2000). Semantic priming effects without association: A meta-analytical review. *Psychonomic Bulletin and Review, 7*, 618–630.
Maxfield, L. (1997). Attention and semantic priming: A review of the prime task effects. *Consciousness and Cognition, 6*, 204–218.
Memmert, D., & Furley, P. (2007). "I spy with my little eye!" – Breadth of attention, inattentional blindness, and tactical decision making in team sports. *Journal of Sport & Exercise Psychology, 29*, 365–381.
Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology: General, 90*, 227–234.
Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology, 9*, 353–383.
Nideffer, R. M. (1976). Test of attentional and interpersonal style. *Journal of Personality and Social Psychology, 34*, 394–404.
Schwarz, N., & Bless, H. (2007). Mental construal processes: The inclusion/exclusion model. In D. A. Stapel & J. Suls (Eds.), *Assimilation and contrast in social psychology* (pp. 119–142). New York: Psychological Press.
Shulman, G. L., & Wilson, J. (1987). Spatial frequency and selective attention to local and global information. *Perception, 16*, 89–101.
Sloutsky, V. M., Kloos, H., & Fisher, A. V. (2007). When looks are everything: Appearance similarity versus kind information in early induction. *Psychological Science, 18*, 179–185.
Zemack-Rugar, Y., Bettman, J. R., & Fitzsimons, G. J. (2007). The effects of nonconsciously priming emotion concepts on behavior. *Journal of Personality and Social Psychology, 93*, 927–939.