Published in final edited form as:

Addict Behav. 2007 December ; 32(12): 3077–3082.

Enhanced Identification of Smoking-Related Words During the Attentional Blink in Smokers

Andrew J. Waters, Ph.D.¹, Stephen J. Heishman, Ph.D.², Caryn Lerman, Ph.D.³, and Wallace Pickworth, Ph.D.^{2,4}

¹The University of Texas M. D. Anderson Cancer Center

²National Institute on Drug Abuse - Intramural Research Program

³University of Pennsylvania

Abstract

The attentional blink (AB) occurs when ongoing processing of one target (T1) in a series of rapidly presented stimuli impairs processing of a subsequently presented second target (T2), such that T2 cannot be consciously perceived or reported. There is evidence that the AB can be influenced by the emotional or motivational salience of T2. We examined whether the AB could be attenuated by smoking-related stimuli in smokers. Heavy smokers (N = 55) performed an AB task on two occasions, once following 12-hr of abstinence and once following ad libitum smoking. T2s were either smoking-related or neutral (household-related) words, and lagged T1 by 0 to 7 distracter words. T1s were all neutral words. Each word was presented for 130 ms. Subjects were required to recall T1 and T2 immediately after each trial. There was a significant word type by lag interaction, whereby smoking-related T2s were recalled better than neutral T2s at early, but not late, lags. The word type effect at early lags was significantly associated with attentional bias assessed on the smoking Stroop task, but was not significantly moderated by abstinence. These data indicate that, in heavy smokers, smoking-related stimuli are more likely to engage conscious awareness than neutral words under conditions of limited attentional resources.

Keywords

Attentional Blink; Attentional Bias; Smoking Cues

1. Introduction

Much recent research has examined drug users' attentional responses to drug-related cues in the belief that these responses are theoretically and clinically important (Waters & Leventhal, 2006). Fine-grained information on the time course of attention to stimuli can be derived from rapid serial visual presentation (RSVP) tasks. In RSVP tasks, a series of stimuli such as letters, words, or digits are presented rapidly (e.g., 100 ms per item). One of the stimuli is presented in a distinct color and is a designated target (T1) whose identity must be reported. T1 is followed by a second target (T2) after a variable number of intervening stimuli (distracters). Typically, participants are accurate at recalling T1. When T2 follows T1 by more than 500 ms, participants

Corresponding Author: Andrew J. Waters, Department of Behavioral Science, UT M. D. Anderson Cancer Center, Houston, TX 77030; Telephone: 713-745-5614; Fax: 713-794-4730; e-mail: ajwaters@mdanderson.org.

⁴Battelle Centers for Public Health Research and Evaluation

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

are also accurate at recalling T2. However, when T2 follows T1 within 500 ms, identification of T2 is impaired, as if the attentional mechanisms underlying visual identification “blink”.

Various theories have been advanced to account for the AB (Shapiro, Arnall, & Raymond, 1997). These theories all assume that allocating attention to T1 leaves less attention for T2. A critical finding is that, even when T2 is not identified during the AB, T2 undergoes a significant degree of perceptual and semantic processing. The AB is also influenced by the emotional and personal salience of the T2. For example, individuals do not experience an AB when T2 is their own name, but do so when T2 is another name (Shapiro et al., 1997). Anderson & Phelps (2001) showed that the AB is markedly attenuated when T2 is a negative word (e.g., rape) compared with when T2 is a neutral word. Keil & Ihssen (2004) reported that the AB was attenuated when T2 was an emotionally arousing positive (e.g., win) or negative verb (e.g., murder), compared with when T2 was a neutral verb (e.g., label). However, few studies have examined the AB in drug-users (though see Munafo et al., 2005). Here, in a population of smokers, we investigated whether the AB was attenuated for smoking vs. neutral T2s. We also examined whether the AB is moderated by abstinence from smoking, and explored associations with attentional bias assessed on the smoking Stroop task.

2. Method

2.1 Participants

Participants were 55 smokers recruited from the Baltimore metropolitan area via newspaper and radio advertisements. They were a subset of a larger sample ($n = 203$) recruited to a study examining individual differences in acute tobacco withdrawal. Participants were on average 37.1 years old ($SD = 10.2$), smoked 21.7 cigarettes/day ($SD = 6.4$), and scored 6.53 on the FTND ($SD = 1.76$) (see Leventhal et al. 2007 for further details).

2.2 Procedure

Participants completed a battery of physiological, subjective, and cognitive measures, including the smoking Stroop task, at two (order-counterbalanced) 60-min laboratory sessions 3.73 days apart ($SD = 6.65$) (see Leventhal et al., 2007 for details). The AB task was administered at the end of the session. At a non-abstinent session, participants were asked to smoke ad libitum before the session (mean reported time since previous cigarette = 15.7 min ($SD = 10.7$); mean breath CO = 26.6 ppm, range = 11 - 53). For the abstinent session, participants were asked to refrain from smoking for at least 12 hours before the session (mean breath CO = 6.5 ppm, range = 3 - 10).

2.3 Attentional Blink Task

Each trial consisted of 16 words: T1 (red), T2 (red), and 14 distracters (black). The participants' task was to monitor the stream of words (presented in New York Times font, point-size 18) and to subsequently report the two red targets (T1, T2) by typing them on the keyboard after the trial ended. They were told they could ignore all of the black words. Following Anderson & Phelps (2001), each word was presented for 130 ms (8 refreshes of the computer screen), and immediately followed the previous word. Eight lags between T1 and T2 were used ranging from lag-1 (T2 immediately followed T1) to lag-8 (seven distracters between T2 and T1). There were 3 trials (T1 at serial position 4, 5 or 6) for each combination of Lag (1 - 8) and T2 Word Type (smoking vs. neutral), giving a total of 48 trials. On each trial, T1 was selected randomly (without replacement) from a pool of 48 T1 words. The distracters were selected randomly (without replacement) from a pool of 100 distracter words. During each assessment (48 trials), each T2 word was presented once at “early” lags (defined as lags 1-4, corresponding to the time period of the AB (520ms)) and once at “late” lags (defined as lags 5-8, corresponding to the time period beyond the AB). The sequence of trials was randomized for each participant.

The smoking T2 words were: Tobacco, Drag, Cigarette, Nicotine, Puff, Craving, Smoke, Pack, Ashtray, Urge, Lighter, Matches. The (categorized) neutral T2 words were: Blanket, Garage, Shampoo, Handle, Sofa, Curtain, Switch, Bathroom, Vase, Hallway, Broom, Lounge. The mean word-lengths of two word sets were identical (6.08 letters), and the mean frequencies (in the Kucera and Francis (1967) count) were similar (13.4, 16.8 for smoking, neutral sets respectively). T1 words were uncategorized neutral words that were: nouns; 5-8 letters; judged to be unrelated to the categories of “Smoking” or “Household Objects/Features”; and judged to be emotionally neutral. Distracters were similar but 10-13 letters in length (to ensure adequate masking of T1, T2 words).

2.4 Data Reduction and Analysis

For each response, two independent judges (blinded to state, lag) were asked: “Does this entry look like the target word, or, if vocalized, would it sound like the target word?” (“yes” verdict = correct response; “no” verdict = incorrect). The judges disagreed on 44 T1 responses (0.83% of the 5280 trials) and 50 T2 responses (0.95% of trials); the discordant trials were rated by a third judge, who made the final decision. The primary analyses used repeated measures ANOVA to examine the effects of State (abstinent vs. non-abstinent), T2 Word Type (smoking vs. neutral) and T1-T2 Lag on 1) recall of T2 (for correct T1), and 2) recall of T1. We coded T1-T2 Lag as an 8-level variable (1-8), and as a 2-level variable (early vs. late, described in 2.3). Participants with missing data for T1 recall on any cell were procedurally excluded from the analyses of T2 recall (2, 18 participants in the 2-, 8-level analyses respectively). To examine the association between blink survival (described in 3.3) and the smoking Stroop effect, we used Generalized Estimating Equations (GEE; Zeger, Liang, & Albert, 1988) to model the effects of Session (first vs. second), State (abstinent vs. non-abstinent) and the smoking Stroop effect on blink survival (using all 109 scores; due to missing data, 1 participant had no blink survival score at one state). We used a compound symmetry structure, and empirically-based robust estimates of standard errors and z-scores.

3. Results

3.1 Recall of T2 (Table 1, right side)

A State $\times$ T2 Word Type $\times$ Lag (1-8) ANOVA yielded a significant T2 Word Type by Lag interaction ($F(7, 252) = 2.23, p < .05$) (Figure 1). Similar results were obtained (i.e., a significant T2 Word Type by Lag interaction) when Lag was coded as a 2-level variable (early vs. late). There were no effects involving State ($ps > .1$). Follow-up comparisons revealed that recall of neutral T2s on lags 1, 2, 3 and 4 was worse than recall on lag-8 (all $ps < .05$). Recall of smoking T2s on lags 1, 2, and 3 was worse than recall on lag-8 (all $ps < .01$). The effect of T2 Word Type was only significant at lag-2 ($F(1, 51) = 7.07, p = .01$) and lag-3 ($F(1, 49) = 8.01, p < .01$).

3.2 Recall of T1 (Table 1, left side)

A repeated measures ANOVA revealed no significant effects (all $ps > .1$).

3.3 Associations with Attentional Bias

We computed a “blink survival” score for each participant at each state by taking a difference score between mean recall of T2 smoking and neutral words at the two lags for which there were robust effects of T2 Word Type (i.e., lag-2, lag-3) (Figure 1). Larger (more positive) blink survival scores indicate greater survival (vs. neutral words). Using GEE analyses, there was no significant effect of Session (Parameter Estimate = 2.40, SE = 4.42, $p > .5$) or State (Parameter Estimate = -2.96, SE = 4.29, $p > .4$) on blink survival. However, Stroop scores were significantly associated with blink survival (Parameter Estimate = 0.068, SE = 0.032, $p < .$

001); a 100ms increase in the smoking Stroop effect resulted in an increase of blink survival of 6.8%. If the blink survival scores were computed using data from lags 1-4 (rather than just lags 2-3), the results were: Parameter Estimate = 0.039, SE = 0.018, $p < .05$.

4. Discussion

The main finding was that the AB was attenuated for smoking words, compared to neutral words. These data suggest that, under conditions of limited attentional resources, smoking words are more likely to be consciously identified than neutral words. To the best of our knowledge, this is the first study to report that drug-related stimuli can survive the AB to some extent in drug users, and add to the literature indicating that the AB is attenuated for motivationally-salient items (Anderson & Phelps, 2001; Keil & Ihssen, 2004; Shapiro et al., 1997). Clinically, this suggests that drug users may readily become conscious of drug-related cues, and this enhanced awareness may promote drug use and undermine cessation attempts.

Blink survival was associated with attentional bias assessed with the smoking Stroop task. The smoking Stroop task is thought to assess automatic attention capture by the smoking words. The AB task is thought to assess the degree to which an unstable non-conscious representation can be converted to a consciously identifiable representation under conditions of limited attention (Shapiro et al., 1997). The two tasks, using different outcome measures (recall vs. reaction times), may tap overlapping automatic processing of drug-related cues. The association between the two effects is noteworthy, given that different measures of attentional bias have not typically been reported to be strongly inter-correlated (Waters & Leventhal, 2006).

The attenuation of the AB was not moderated by abstinence state, and abstinence did not exert any significant influence on the AB data (no main effects or interactions involving State). This is consistent with the results of Heinz et al. (2007), who reported no effect of 12-hr abstinence on recall of neutral T1s or T2s. (The study reported by Heinz et al. only included neutral targets; there were no smoking targets). It is possible that the effects of abstinence might become apparent with a stronger manipulation (e.g., 24-hr). In addition, in the current study the AB task was administered at the end of the session, and the participants would have been abstinent for over an hour by the time of test at the non-abstinence session. This may have weakened the abstinence manipulation. Further work is required to examine the effects of abstinence on the AB. It was also unclear why the AB was not attenuated at lag-1 (Figure 1); processing of lag-1 items involves distinct processes (Shapiro et al., 1997), and this will also be the focus of future research.

Acknowledgements

This research was supported by a Transdisciplinary Tobacco Use Research Center Grant from the National Cancer Institute and National Institute on Drug Abuse P5084718 (C.L.).

References

- Anderson AK, Phelps EA. Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature* 2001;411:305–309. [PubMed: 11357132]
- Heinz A, Waters AJ, Taylor RC, Myers CS, Moolchan ET, Heishman SJ. Effect of tobacco deprivation on the attentional blink in a rapid serial visual presentation task. *Human Psychopharmacology: Clinical and Experimental*. 2007in press
- Keil A, Ihssen N. Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion* 2004;4:23–35. [PubMed: 15053724]
- Kucera, H.; Francis, WN. Computational analysis of present day American English. Providence, RI: Brown University Press; 1967.

- Leventhal AM, Waters AJ, Boyd S, Moolchan ET, Lerman C, Pickworth W. Gender differences in acute tobacco withdrawal: Effects on subjective, cognitive, and physiological measures. *Experimental and Clinical Psychopharmacology* 2007;15:21–36. [PubMed: 17295582]
- Munafo MR, Johnstone EC, Mackintosh B. Association of serotonin transporter genotype with selective processing of smoking-related stimuli in current smokers and ex-smokers. *Nicotine & Tobacco Research* 2005;7:773–778. [PubMed: 16191748]
- Shapiro KL, Arnell KM, Raymond JE. The attentional blink. *Trends in Cognitive Sciences* 1997;1:291–296.
- Waters, AJ.; Leventhal, AM. Clinical Relevance of Implicit Cognition in Addiction. Munafo, M.; Albery, I., editors. *Cognition and Addiction*, Oxford, England: Oxford University Press; 2006. p. 249-278.
- Zeger SL, Liang KY, Albert PS. Models for longitudinal data: a generalized estimating equation approach. *Biometrics* 1988;44:1049–1060. [PubMed: 3233245]

Figure 1. Recall of T2 by Word-Type (N = 55)
Mean recall of Smoking and Neutral T2s (1 SE), averaged over abstinence states

Table 1

Recall of T1 and T2

State	T2-Type	T1								T2							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
AB	Smoking	78.2	78.2	77.0	83.0	75.8	78.8	77.6	76.4	48.4	72.5	72.3	81.1	87.2	82.1	84.3	85.3
	Neutral	77.0	81.8	77.6	78.8	77.6	77.6	83.6	80.6	59.3	62.8	64.2	73.5	84.9	73.1	79.9	85.2
NONAB	Smoking	78.8	84.8	80.6	83.6	80.6	81.2	83.0	81.8	57.2	69.7	77.0	79.8	73.5	83.0	80.9	80.9
	Neutral	76.4	78.2	83.6	81.2	75.2	81.2	81.8	83.0	46.9	59.4	63.2	80.5	78.0	85.5	83.3	86.1

Note. % Recall of T1 (left side of table, ns = 55), and T2, for correct T1 (right side of table), as a function of State (abstinent vs. non-abstinent), T2 Word Type (smoking vs. neutral), and T1-T2 Lag (1-8). Due to missing data, ns for T2 range from 48-55. Key: AB = abstinent; NONAB = non-abstinent.