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BRIEF REPORT

Attentional Bias to Betel Quid Cues: An Eye Tracking Study

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The World Health Organization regards betel quid as a human carcinogen, and *DSM–IV* and *ICD-10* dependence symptoms may develop with heavy use. This study, conducted in central Taiwan, investigated whether betel quid chewers can exhibit overt orienting to selectively respond to the betel quid cues. Twenty-four male chewers' and 23 male nonchewers' eye movements to betel-quid-related pictures and matched pictures were assessed during a visual probe task. The eye movement index showed that betel quid chewers were more likely to initially direct their gaze to the betel quid cues, t(23) = 3.70, p < .01, d = .75, and spent more time, F(1, 23) = 4.58, p < .05, $\eta_p^2 = .17$, and were more fixated, F(1, 23) = 5.18, p < .05, $\eta_p^2 = .18$, on them. The visual probe index (response time) failed to detect the chewers' attentional bias. The current study provided the first eye movement evidence of betel quid chewers' attentional bias. The results demonstrated that the betel quid chewers (but not the nonchewers) were more likely to initially direct their gaze to the betel quid chewers (but not the nonchewers) were more likely to initially direct their gaze to the betel quid cues, and spent more time and were more fixated on them. These findings suggested that when attention is directly measured through the eye tracking technique, this methodology may be more sensitive to detecting attentional biases in betel quid chewers.

Keywords: betel quid, attentional bias, dependence, eye tracking

The World Health Organization regards betel quid (BQ; "bin lang" in Taiwanese Mandarin) as a human carcinogen (IARC, 2004), and *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition (*DSM–IV*; American Psychiatric Association, 1994) and International Classification of Diseases, 10th revision dependence symptoms may develop with heavy use (Benegal, Rajkumar, & Muralidharan, 2008; Lee et al., 2014). Arecoline, the primary alkaloid in BQ, acts as an agonist primarily toward muscarinic and nicotinic acetylcholine receptors (Chu, 2002). People have long chewed BQ as a stimulant because of its physiological effects (e.g., increased stamina and a general feeling of well-being; Chu, 2002). The Ministry of Health and Welfare reported some 15.8% male chewers and 1.0% female chewers among the population of Tai-wan (MHW, 2008).

In the current study, we asked whether BQ chewers exhibit overt orienting to selectively respond to the BQ cues. Attentional bias (AB) toward substance cues has been reported to be related to subjective craving (Field, Marhe, & Franken, 2014) and impulsivity (Coskunpinar & Cyders, 2013). The likelihood of consuming the substance may therefore rise (Schoenmakers et al., 2010), increasing the risk of substance-related disease (e.g., oral submucous fibrosis).

The visual probe task is commonly adopted to measure AB (Field & Cox, 2008). Ho, Chang, Li, and Tang (2013) adopted the visual probe task and manipulated the presentation duration of the BQ cues to investigate the different phases of attentional processing. They reported that heavy chewers exhibited supraliminal AB to BQ cues in initial orienting and kept their attention focused. Although the 200-ms presentation can involve initial overt orienting (Field, Mogg, Zetteler, & Bradley, 2004), the 2000-ms presentation can involve multiple shifts in the cues (Franken, 2003). The reaction time (RT)-based visual probe task usually makes an indirect inference on the attentional processing. However, this task is unable to delineate the eye

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movement (EM) patterns. The eye tracking technique provides various indexes, offering important insight into overt AB. The eye tracking technique enables us to obtain a higher ecological validity and internal reliability than with the visual probe task alone (Castellanos et al., 2009; Miller & Fillmore, 2011).

The eye tracking technique employed in the visual probe task has been used in studies of substance use, such as nicotine (Bradley, Garner, Hudson, & Mogg, 2007; Field, Mogg, & Bradley, 2004b, 2005; Mogg, Bradley, Field, & De Houwer, 2003; Mogg, Field, & Bradley, 2005), cannabis (Field, Eastwood, Bradley, & Mogg, 2006), alcohol (Schoenmakers, Wiers, & Field, 2008), and food (Castellanos et al., 2009). AB, as reflected by the direction of the initial fixation and dwelling time, is commonly reported. For example, Mogg et al. (2003) found that smokers (but not nonsmokers) had a higher proportion of initial EM directed toward smoking-related pictures, and the duration of their initial fixation on these pictures was longer. Field et al. (2006) reported that regular cannabis users, rather than nonusers, spent longer fixated on cannabis-related pictures. Schoenmakers et al. (2008) reported that heavy drinkers had a longer fixation time on alcohol-related pictures and were more likely to initially direct their gaze to these pictures.

We hypothesized that in comparison with the nonchewers, the BQ chewers' initial fixations would probably fall on the BQ cues. The chewers would have shorter latency to first move their gaze to the BQ cues and spend more time on these cues. The chewers would have more total fixation counts and a longer dwelling time on the BQ cues.

Method

Participants

There were two groups of male participants: BQ chewers (N =24) and nonchewers (N = 23). Because there are far more male chewers than female chewers, we recruited only males. To maximize the between-groups difference in AB, we recruited heavy chewers and nonchewers. The participants were recruited using three methods: human resources or employment agencies, recruitment advertisements, and introduction of BQ chewers by former participants. BQ chewers were included if they were (a) current BQ chewers, (b) at least 20 years of age, (c) free from current major medical or vision problems that could interfere with the experiment protocol, and (d) had dependence scores higher than the cut-off point of 24 on the Betel Nut Dependency Scale (BNDS) (Li, Ho, Tang, & Chang, 2012). The BNDS consists of three factors: craving and desire, withdrawal response, and tasting habits (e.g., I care about types, textures, and the feeling that comes from chewing BQ). Higher scores indicated a higher level of dependence. The nonchewers had never chewed BQs and were not asked to complete the BNDS. The nonchewers were eligible if they fit the abovementioned criteria (b) and (c). The process of recruiting participants followed the regulations set up by the Research Ethics Committee Central Regional Research Ethics Center, Taichung, Taiwan. Informed consent was obtained before the experiment.

Apparatus

The visual probe task was programmed with E-prime software (Schneider, Eschman, & Zuccolotto, 2002) and presented on a 17-in. CRT desktop monitor (refresh rate 85 Hz). The EMs were

recorded using the Eyelink 1000 desktop mount system (SR Research, Hamilton, Ontario, Canada) at a 1000 Hz sampling rate.

Materials

The stimuli in the visual probe task were identical to those in Ho et al. (2013). A set of 20 BQ-related color photographs (7.6° in length and 5.4° in width, unit in visual angle) was paired with matched photographs without BQ content (e.g., a man pinching a BQ toward his mouth vs. pinching a piece of chewing gum). An additional 20 pairs of non-BQ photographs were used as stimuli for filler trials, and their RT was excluded from the analysis. The matched pictures were 3.0° apart (edge to edge) when they were simultaneously presented on the monitor. In each trial, the probe consisted of an arrow randomly pointing either upward or downward. This arrow appeared on one of each pair of pictures, 5° apart from the central fixation point.

Design

In the visual probe task, there were 16 practice trials, followed by two buffer trials. There were 120 formal trials, consisting of 80 critical test trials and 40 filler trials. Each of the 20 experimental picture pairs was repeated four times, with a BQ-related picture equally and randomly on the left or right of the center. Each of the 20 filler pairs was repeated twice, with each picture appearing equally on the left or right of the center. The arrow appeared randomly on the BQ-related and matched neutral pictures for an equal number of times. The arrow pointed upward or downward equally and randomly.

Procedure

Participants were required to complete a questionnaire about their demographic background, major medical history, BQ histories, urge to chew at this moment, and BNDS (Li et al., 2012). After completing the questionnaire, they began the visual probe task. To rate their urge to chew, we asked participants to assess "how strong your urge to chew is right now" on an anchored rating scale, which ranged from 0 (not at all) to 10 (extremely). The urge rating and visual probe task were administered in a dimly lit room, where the participant leaned his or her chin on a chinrest with a viewing distance of 86 cm from the monitor.

After the practice trials in the visual probe task, the calibration of the eye tracker began. The eye tracker was calibrated by displaying one dot at a time randomly distributed in a 3 by 3 array. There were 9 dots in total. Participants looked at each dot while their eye gaze direction was recorded. Upon the completion of calibration, the buffer trials and formal trials began. In each trial, participants were asked to look at the central cross and press the space bar to begin the trial. The eye tracker started tracking from the onset of the central cross to the disappearance of the picture pairs. The trial would not begin if participants pressed the space bar without looking at the fixation point. After they pressed the space bar, the central cross disappeared and a pair of pictures was presented for 2000 ms. Immediately after the pictures disappeared, an arrow appeared. Participants were asked to press the corresponding directional arrow keys as accurately and quickly as possible. The arrow stayed on the screen until a response had been recorded or the trial timed out after 2000 ms. A warning tone signaled an erroneous response.

Preparation of EM Data

An Eyelink DataViewer (SR Research, Hamilton, Ontario, Canada) was used to analyze EM data. The only data analyzed were from the critical trials where the BQ-related picture and matched neutral picture were presented. Fixation on a position was identified if EMs stayed within 1° of the visual angle for more than 100 ms, and the duration of this fixation was recorded (Mogg et al., 2003). Fixations were classified as being directed at the left or right pictures if they were at least 1.5° wide at the central position on the horizontal plane (this visual angle corresponds to the distance between the fixation cross position and the inner edge of each picture; Field, Mogg, et al., 2004b). Initial fixation latency was computed as the interval between picture onset and the onset of the first fixation (Mogg et al., 2003).

We followed the criteria below to include the appropriate EM data (Castellanos et al., 2009; Mogg et al., 2003). Participants were fixated in the central region before picture onset. EMs occurred at least 100 ms after picture onset and before picture disappearance. Gaze fixations that were on either picture were included. To avoid the floor effect due to too much missing data, all participants had a missing data rate of lower than 15%.

Results

Participants

There were no significant age, t(45) = .12, p = .56, d = .04(Chewers: 34.5 years, SD = 7.6 years; Nonchewers: 34.2 years, SD = 8.2 years), or monthly income¹, t(45) = .32, p = .76, d = .30 (Chewers: 3.3, SD = 1.4; Nonchewers: 2.9, SD = 1.4) differences between the chewers and the nonchewers (see Table 1).

Direction of Initial Fixation

A direction bias probability was computed for each participant as follows: [the number of trials when the EM was directed initially toward the BQ cue] divided by [the total number of trials in which an EM was made to either the BQ cue or the matched cue]. BQ chewers were more likely than the nonchewers to direct their gaze first to the BQ cues, F(1, 45) = 15.69, p < .0001, $\eta_p^2 =$.258 (see Figure 1). We compared the direction bias probability with 50% (no bias). The chewers' direction bias probability was significantly over 50%, t(23) = 3.70, p < .01, d = .75, but the nonchewers' bias probability was not significant, t(22) = -1.60, p = .12, d = -.33.

Table 1Characteristics of Chewers

BNDS	Months	Days per month	Number per day	Urge to chew		
31.5 (5.49)	159 (108.5)	24.6 (10.8)	28.1 (27.3)	5.9 (2.6)		

Note. Standard deviations are in parentheses. BNDS = Betel Nut Dependency Scale; Months = number of months chewing BQ; Days per month = average number of days chewing BQ in the recent month; Number per day = number of BQ per day in the recent month.



Figure 1. Direction bias probability for the chewers and nonchewers. Error bars indicate the standard error of means. * p < .05. ** p < .01.

Latency of Initial Fixation

To reduce the influence of outliers, for each group, we excluded the trials over three standard deviations from the mean latencies (Mogg et al., 2003). This resulted in 2.69% and 2.73% removal rates in the chewers and the nonchewers, respectively. We conducted a 2 (group: chewers or nonchewers) × 2 (cue type: BQ or matched) mixed analysis of variance (ANOVA) on latencies of initial fixation, with the first as a between-groups factor and the other as a within-group factor. There were neither significant main nor interaction effects (all ps > .45, $\eta_p^2 < .01$). Mean latencies of initial fixations on BQ cues and matched cues were 424 ms and 423 ms, respectively, for chewers and 437 ms and 442 ms, respectively, for nonchewers.

Duration of Initial Fixation

The same exclusion procedure was applied, resulting in 1.66% and 1.31% removal rates in the chewers and the nonchewers, respectively. We conducted a 2 (group) × 2 (cue type) mixed ANOVA on durations (see Figure 2). The interaction effect was significant, F(1, 45) = 4.61, p < .05, $\eta_p^2 = .09$, but the main effects were not (all ps > .18, $\eta_p^2 < .04$ (see Figure 2). Further analysis of the interaction revealed that the chewers did not have significant initial fixation duration differences on the BQ cues and the matched cues, F(1, 23) = .68, p = .42, $\eta_p^2 = .03$. Alternatively, the nonchewers had lger fixation durations (M = 448 ms, SD = 104ms) on the matched cues than on the BQ cues (M = 408 ms, SD =106 ms) F(1, 22) = 8.66, p < .01, $\eta_p^2 = .28$.

Dwell Time

The same exclusion procedure was applied, resulting in .11% and .11% removal rates in the chewers and the nonchewers,

¹ For monthly income, participants selected from the following options (unit is thousands of NT dollars): (1) lower than 10, (2) 10–20, (3) 20–30, (4) 30–50, (5) over 50.



Figure 2. Duration of initial fixation for the chewers and nonchewers. Error bars indicate the standard error of means.^{*} p < .05.

respectively. A 2 (group) × 2 (cue type) mixed ANOVA on dwell times (see Figure 3) showed that the interaction effect was significant, F(1, 45) = 7.54, p < .01, $\eta_p^2 = .14$, but the main effects were not (all ps > .30, $\eta_p^2 < .02$). Further analysis showed that the chewers had longer dwell times on the BQ-related pictures (M = 577 ms, SD = 173 ms) than on the matched pictures (M = 490 ms, SD = 117 ms) F(1, 23) = 4.58, p < .05, $\eta_p^2 = .17$. The nonchewers did not show significant dwell time differences on either set of pictures, F(1, 22) = 3.83, p = .06, $\eta_p^2 = .15$.

Total Fixation Counts

The same exclusion was applied resulting in .51% and .09% removal rates in the chewers and the nonchewers, respectively. We conducted a 2 (group) \times 2 (cue type) mixed ANOVA on total



The practice, buffer, filler, and erroneous trials were excluded from further analysis. All participants had an error rate of less than 10%. The error rate for the chewers was .52% and 1.14% for the nonchewers. For each group, correct RTs faster than 200 ms and over three standard deviations from the mean RT were removed. This resulted in 1.6% and 1.4% removal rates in the chewers and the nonchewers, respectively. We conducted a 2 (group) \times 2 (probe location: BQ or matched) mixed ANOVA on correct RTs. There were neither significant main (group: F[1, 45] = 3.69, p =.06, $\eta_p^2 = .08$; probe location: $F[1, 45] = .66, p = .42, \eta_p^2 = .01$) nor interaction effects, $F(1, 45) = .01, p = .91, \eta_p^2 = .00$. Mean correct RTs of BQ cues and matched cues were 606 ms (SD = 86ms) and 604 ms (SD = 84 ms), respectively, for chewers; 561 ms (SD = 83 ms) and 558 ms (SD = 75 ms), respectively, for nonchewers.

fixation counts (see Figure 4). The interaction effect was signifi-

cant, F(1, 45) = 4.61, p < .05, $\eta_p^2 = .093$, but the main effects

were not (all ps > .24, $\eta_p^2 < .03$). Further analysis showed that the

Internal Reliability

We computed Cronbach's alpha for the direction of initial fixation, dwell time, total fixation counts, and manual RTs for the chewers (Table 2). For the direction of initial fixation, we calculated the probability to initially direct EMs to the BQ cue for each of the 20 experimental picture pairs. AB scores for dwell time, total fixation counts, and manual RTs were calculated for each picture pair by computing the mean differences of these measures on the matched cues and BQ cues (for EM indices: measures on BQ cues minus matched cues; for manual RTs: measures on





Figure 3. Dwell times for the chewers and nonchewers. Error bars indicate the standard error of means. * p < .05.



Figure 4. Fixation counts for the chewers and nonchewers. Error bars indicate the standard error of means. * p < .05.

Table 2 Internal Reliability of Attentional Bias Indices for the Chewers (Values are Cronbach's Alpha)

Direction of initial fixation	Dwell time	Total fixation counts	RT-based bias	
.34	.93	.89	.39	

matched cues minus BQ cues). Thus, for each participant, each index had 20 bias scores. We did not include latency and duration of initial fixation. Initial EM was directed either to the BQ cue or matched cue, making it impossible to calculate the mean differences between these cues. Estimates for internal reliability ranged from .34 to .93, with the dwell time and total fixation count measures of AB in excess of the .7 cut-off for acceptable internal reliability (Kline, 1999).

Correlations Between AB and Addiction Indices

Many EM indices correlated positively with many indices of addiction (Table 3). Particularly, the direction of initial fixation, dwell time, and total fixation counts correlated at least three indices of addiction (r = .29 to .54), showing good construct validity.

General Discussion

We reported that BQ chewers (but not nonchewers) exhibited biases to BQ cues primarily in the three EM indexes: direction of initial fixation, dwell time, and total fixation counts. The chewers tended to direct their gaze initially to the BQ cues, consistent with studies using various substance cues (Castellanos et al., 2009; Mogg et al., 2003). Repeated use of addictive substances renders the brain hypersensitive to the substance and substance-related cues (Robinson & Berridge, 1993, 2003, 2008). Consequently, such cues become highly attractive and can capture substance users' attention (Castellanos et al., 2009; Field, Mogg, et al., 2004b; Giel et al., 2011; Mogg et al., 2003).

The chewers had a longer dwell time on the BQ cues than on the matched cues. AB in maintained attention may be a general phe-

nomenon for substance users across various substances (Field et al., 2006; Field, Mogg, et al., 2004b) because substance users are usually motivated to consume addictive substances, and such bias is influenced by states of motivational need (LaBerge, 1995). The chewers had more total fixation counts on the BQ cues than the matched cues. No studies used this index in the visual probe task. The chewers and the nonchewers had comparable latencies and durations to first move their gaze to the BQ cues and matched cues. Only one study (Mogg et al., 2003) reports latency of initial fixation in the visual probe task, and our result was in line with theirs. Mogg, Bradley, Field, and De Houwer (2003) reported that the smokers had similar latencies to first move their gaze to the smoking cues and nonsmoking cues. On the other hand, our result for the duration of initial fixation was inconsistent with previous studies (Bradley et al., 2007; Mogg et al., 2003). One possibility for this is the capability of the user to disengage from the substance. For example, smokers may have difficulty disengaging from the smoking cues once they initially respond to these cues (Mogg et al., 2003), but BQ chewers may have less difficulty disengaging from the cues. The nonchewers showed longer durations of initial fixation on the matched cues than on the BQ cues. BQ in Taiwan is usually associated with a lower educational level, a lower socioeconomic status, and the elderly (Lin, Chu, Wu, & Shen, 2004; Wu et al., 1999). With such stereotypes or even stigmatizations relating to BQ, the nonchewers may divert their attention away from the BQ cues. We did not find RT-based AB (Field, Mogg, & Bradley, 2004a; Hogarth, Mogg, Bradley, Duka, & Dickinson, 2003; Robbins & Ehrman, 2004). The manual response provides only a snapshot assessment of AB at the time of the picture disappearance (Mogg et al., 2000); however, the EM data provides more dynamic and continuous information about attentional orienting (Mogg et al., 2003).

Direction of initial fixation, dwell time, and total fixation counts had good construct validity, each of which correlated with at least three addiction indices. Also, dwell time (Christiansen, Mansfield, Duckworth, Field, & Jones, 2015; Marks, Pike, Stoops, & Rush, 2014; Marks, Roberts et al., 2014) and total fixation counts had good internal reliability. RT-based AB had low construct validity and internal reliability, consistent with recent findings (Ataya et al., 2012; Christiansen et al., 2015; Marks, Pike, et al., 2014;

Table 3

Pearson Correlations Between Attentional Bias and Addiction Indices for the Combined Chewers and Nonchewers

Variables123456789100. Direction of initial fixation.11.39**.53**.55**.07.54**.27.44**.30*.41. Latency of initial fixation20.27.24.09.06.07.19.14.002. Duration of initial fixation96**.93**.46**.21.29*.23.05.113. Dwell time96**.93**.51**.29*.29*.32*.16.24. Total fixation counts54**.32*.32*.33*.19.25. RT-based bias0405.000116. BNDS70**.86**.64**.8											
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Variables	1	2	3	4	5	6	7	8	9	10
7. Months - .76** .71** .7 8. Days per month - .69** .8 9. Number per day - .7 10. Urge to chew - .7	 0. Direction of initial fixation 1. Latency of initial fixation 2. Duration of initial fixation 3. Dwell time 4. Total fixation counts 5. RT-based bias 6. BNDS 7. Months 8. Days per month 9. Number per day 10. Urge to chew 	.11	.39** .20 	.53** .27 .96** 	.55*** .24 .93** .98**	.07 .09 .46** .51** .54**	.54** .06 .21 .29* .32* 04	.27 .07 .29* .32* 05 .70**	.44** .19 .23 .32* .33* .00 .86** .76**	.30* .14 .05 .16 .19 01 .64** .71** .69**	.48*** .06 .17 .27 .28 16 .88** .71** .86** .71**

Note. BNDS = Betel Nut Dependency Scale; Months = number of months chewing BQ; Days per month = average number of days chewing BQ in the recent month; Number per day = Number of BQ per day in the recent month. * p < .05. ** p < .01. Marks, Roberts, et al., 2014). The construct validity was computed for the combined chewers and nonchewers, but the internal reliability was computed for the chewers. For correlational analysis, the high homogeneity of chewers (dependence scores higher than the cut-off point) and small sample size can incorrectly diminish possible correlations between AB and addiction indices, thereby causing incorrect inference of low construct validity. In the future, a larger sample of chewers with a larger variance of addiction degree can be collected for computing construct validity. To conclude, we have provided the first EM evidence of AB for BQ chewers. Because we adopted only males and used small sample sizes, this study might be limited in the generalizability of results. A longitudinal design is encouraged to investigate to what extent AB can predict future BQ use.

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