TOPICS IN EXERCISE SCIENCE AND KINESIOLOGY

Effects of Caffeinated and Non-Caffeinated Gum on Premotor, Motor, and Overall Reaction Time

Process of Science

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Abstract

- Chewing gum and caffeine when used independently and concurrently increase neural activity ultimately improving reaction time but less is known about how caffeinated gum influences distinct phases of the reaction time response.
- Physically active college females (n=14) completed a 60-second reaction time test on a visuomotor board under the following counterbalanced conditions: 1) Baseline, 2) Non-caffeinated gum, 3) Caffeinated gum (300 mg caffeine).
- **Point of application #1:** Chewing gum improved premotor reaction time compared to baseline, but caffeine did not provide additional benefit.
- **Point of application #2:** Neither non-caffeinated nor caffeinated gum improved motor reaction times from baseline.
- **Point of application #3:** Chewing gum improved overall reaction time compared to baseline, but caffeine did not provide additional benefit.
- **Keywords:** Chewing, Visuomotor, Visual processing

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Introduction

Caffeine is one of the most widely use psychoactive substances due to its ability to antagonize adenosine receptors and increase central nervous system (CNS) activity (1). Previous studies have shown increased alertness, muscle recruitment, neural firing rate, and velocity of movement with caffeine ingestion (2,3). The act of chewing, gum specifically, has been shown to increase neural activity in portions of the brain responsible for motor control (4). Furthermore, gum chewing has been shown to increase cerebral blood flow which may aid in cognitive decision making (5). Independently, both caffeine and gum chewing have been reported to induce ergogenic effects in aerobic exercise, resistance training, and in sport performance (6,3,7). When combined into caffeinated gum, ergogenic effects have been well documented in various sport-specific skills, athletic performance, and reaction time (8,9,10). However, reaction time and responding to stimuli has multiple components (11). The premotor component denotes the time it takes to visualize and process the stimuli while the motor component is the time it takes from the initiation of the response to physically react fully to the stimuli. When summed, overall reaction time is calculated denoting the entire process of reacting from the presence of the stimuli to reacting physically. Each of these may be affected differently by caffeinated and non-caffeinated gum but no investigations to date have examined this. Thus, the purpose of this study to investigate the effects of chewing caffeinated and non-caffeinated gum on premotor, motor, and overall reaction time.

Methods and Results

This study utilized a double-blinded crossover design. Physically active females (18-24 yrs; n=14) who reported ingesting <300 mg · day $^{-1}$ were recruited as described by Degrange et al. (3). Females were studied in particular due to gaps in knowledge related to responses to caffeinated gum in female populations. Prior to each visit, individuals were asked to refrain from caffeine, nicotine, and alcohol 24 hours prior. Informed consent was obtained from each participant and all experimental procedures were approved by the Samford University IRB. This work was carried out fully in accordance to the ethical standards outlined in the International Journal of Exercise Science (12). Participants completed 3 trials in a counterbalanced manner: 1) Baseline (no gum), 2) Non-caffeinated gum (Wrigley Company, USA), 3) Caffeinated gum (300 mg of caffeine; MEG, USA). In the gum conditions, participants chewed the gum for 20 minutes prior and during testing, as described by (13,), while participants sat quietly for 20 minutes and chewed no gum for the baseline condition. Following the 20-minute period, participants completed a 60 s reaction time (RT) test on a Dynavision D2 Visuomotor Board (see below; Dynavision Global Holdings LLC, USA). The Dynavision is an interactive 64 button light board and participants were instructed to hit each illuminated light as quickly as possible with their dominant hand. On the first visit, participants were instructed to stand from a distance where they could comfortably touch the top light and that distance was used for all tests for that individual. The following parameters were used: RT mode D, tachistoscope off, 60 s long. These measures were analyzed using a repeated measures ANOVA at $p \leq 0.05$ a priori with Tukey post hoc analysis: 1) Fastest reaction time - the single fastest time over the 60 s test, 2) Slowest reaction time- the single slowest time over the 60 s test, 3) Average reaction time- the average of all response times during the 60 s test. Results indicate that chewing gum, regardless of if it contains caffeine, results in faster premotor and overall reaction time but does not influence motor reaction time. Addition of caffeine to gum did not provide further benefit.

1. Chewing gum improved premotor reaction time compared to baseline, but caffeine did not provide additional benefit.

Analysis of premotor reaction times are shown in [Table 1]. Fastest reaction time (RT), or the single fastest response during the test, was significantly faster in both the non-caffeinated ($p=0.011$) and caffeinated ($p=0.009$) trials. Slowest RT, or the single slowest response during the test, was also significantly faster in both non-caffeinated ($p=0.012$) and caffeinated ($p=0.011$) conditions. Finally, average RT, or the mean response time over the test, was also significantly faster in both non-caffeinated ($p<0.001$) and caffeinated ($p=0.014$) conditions. No differences were observed between caffeinated and non-caffeinated gum conditions ($p>0.05$). We interpret these findings to suggest that the act of chewing itself is likely improving underlying RT improvements and caffeine does not impart additive benefit. This is supported by previous literature showing that chewing gum improved processing speed of visual stimuli (13).

Premotor

	Baseline	NON-CAFF	CAFF
Fastest RT (s)	0.38 ± 0.05	0.33 ± 0.05 *	0.34 ± 0.06 *
Slowest RT (s)	1.47 ± 0.80	0.76 ± 0.25 *	0.70 ± 0.34 *
Average RT (s)	0.63 ± 0.15	0.47 ± 0.12 *	0.44 ± 0.08 *

Table 1. Fastest, slowest, and average premotor reaction times (RT) during the 60 s RT test for baseline (no gum), non-caffeinated gum (NON-CAFF), and caffeinated gum (CAFF). Data are presented at mean ± SD. * indicates significantly different from baseline ($p<0.05$).

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2. Neither non-caffeinated nor caffeinated gum improved motor reaction times from baseline.

Analysis of motor reaction times are shown in [Table 2]. No significant differences existed for fastest, slowest, or average motor reaction times between any of the conditions ($p>0.05$). We interpret these results to indicate that chewing gum with or without caffeine does not enhance reactive motor ability. Previous reports investigating coffee consumption have reported that caffeine may only improve efficiency of motor reaction to stimuli if individuals are in a fatigued state (15). Fatigue state of participants in the current investigation was not directly measured and future investigations should attempt to identify if fatigue state influences caffeinated gum chewing efficacy.

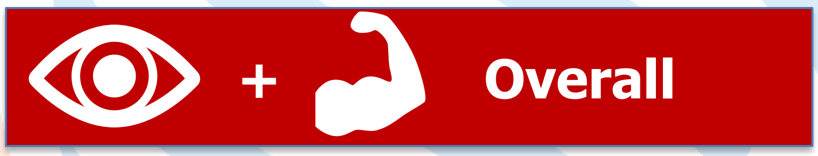
Motor

	Baseline	NON-CAFF	CAFF
Fastest RT (s)	0.25 ± 0.06	0.26 ± 0.06	0.24 ± 0.06
Slowest RT (s)	0.63 ± 0.19	0.85 ± 0.55	0.72 ± 0.18
Average RT (s)	0.42 ± 0.10	0.43 ± 0.11	0.42 ± 0.07

Table 2. Fastest, slowest, and average motor reaction times (RT) during the 60 s RT test for baseline (no gum), non-caffeinated gum (NON-CAFF), and caffeinated gum (CAFF). Data are presented at mean ± SD.

3. Chewing gum improved overall reaction time compared to baseline, but caffeine did not provide additional benefit.

Analysis of overall reaction times, or the sum of premotor and motor times, are shown in [Table 3]. Fastest reaction time (RT) was significantly faster in both the non-caffeinated (p=0.035) and caffeinated (p<0.001) trials. Slowest RT was significantly faster in both non-caffeinated (p=0.012) and caffeinated (p=0.012) conditions. Lastly, average RT was significantly faster in both non-caffeinated (p<0.001) and caffeinated (p=0.010) conditions. No differences were observed between caffeinated and non-caffeinated gum conditions (p>0.05). Given the data on premotor and motor times, we interpret these findings to suggest that gum chewing improves overall reaction time, but through enhancement of visual processing and premotor reaction time rather than improvements in motor performance. Thus, chewing caffeinated or non-caffeinated gum may be particularly useful to increase performance in populations highly reliant on rapid visual processing including soldiers, pilots, drivers, etc.



	Baseline	NON-CAFF	CAFF
Fastest RT (s)	0.69 ± 0.09	0.62 ± 0.09 *	0.64 ± 0.09 *
Slowest RT (s)	1.99 ± 0.76	1.34 ± 0.21 *	1.47 ± 0.72 *
Average RT (s)	1.05 ± 0.18	0.89 ± 0.17 *	0.87 ± 0.16 *

Table 3. Fastest, slowest, and average overall reaction times (RT) during the 60 s RT test for baseline (no gum), non-caffeinated gum (NON-CAFF), and caffeinated gum (CAFF). Data are presented at mean ± SD. * indicates significantly different from baseline (p<0.05).

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Equipment Utilized

Dynavision D2 Visuomotor Board
(Dynavision Global Holdings LLC, USA)

Military Energy Gum (MEG) Spearmint
(MEG, USA)

Eclipse gum- Spearmint
(Wrigley Company, USA)

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