Title of Article: Effect of New Zealand Blackcurrant on Blood Pressure, Cognitive Function and Functional Performance in Older Adults.

Authors: Matthew David Cook, Amber Kaur Sandu, Jennifer Patricia Joyce.

Affiliation: University of Worcester School of Sport & Exercise Science Henwick Grove Worcester, WR2 6AJ United Kingdom

Corresponding author: Dr Matthew Cook University of Worcester School of Sport & Exercise Science Henwick Grove Worcester, WR2 6AJ United Kingdom

Phone: +44 (0)1905 52 2698 Email: matthew.cook@worc.ac.uk
ABSTRACT

New Zealand blackcurrant (NZBC) can increase exercise performance in young adults, potentially by anthocyanin-induced cardiovascular function alterations and increased blood flow, however effects upon blood pressure, functional exercise performance and cognitive function in older adults is unknown. In a randomised, double-blind, placebo-controlled, cross-over design, 14 older adults (age: 69±4 years, height: 172±9 cm, body mass: 85±12) ingested NZBC extract (600 mg·day⁻¹ CurraNZ™) or placebo (PL, 600 mg microcrystalline cellulose) for 7-days (7-day washout between conditions). On day-7, 2-hours following consumption of the capsules, resting blood pressure, cognitive function (Cambridge neuropsychological test automated battery) and 6-minute walk test performance and were measured. Intake of NZBC caused a decrease (P<0.05) in systolic (PL: 136±14; NZBC: 130±12 mmHg) and diastolic (PL: 84±11; NZBC 78±6 mmHg) blood pressure. There was no effect on 6-minute walk performance or cognitive function variables. Future research should address optimisation of intake and examine cardiovascular responses during exercise.

Keywords: New Zealand blackcurrant; anthocyanins; cognitive function; functional performance; older adults.
INTRODUCTION

Ageing is a universal process that is associated with a deleterious decline in physical and cognitive function.1 Cognitive function decrements include processing speed, working memory capacity and inhibitory processes, however implicit memory and knowledge storage are less effected.2 Physical impairments in older adults are partly resultant of sarcopenia and reduced cardiovascular capacity and these have implications for functional performance in activities of daily living.3 As a result, interventions that can promote cognitive function and functional performance are of interest.

Anthocyanins act as natural pigments within fruits and vegetables, and observational studies have identified causal links between their intake and disease risk such as cardiovascular disease and type-2-diabetes.4,5 Mechanisms for these observations are likely multifactorial, including anti-oxidative and anti-inflammatory effects, and their ability to alter signalling pathways.6 There have been observations of anthocyanins having positive effects upon age-associated cognitive decline in adults over 65 years old.7 Mechanisms for effects upon cognitive function by anthocyanins are unclear, however may result from effects upon an increase in blood flow to the brain. For example, Bowtell et al8 observed 12 weeks of blueberry concentrate supplementation providing 387 mg·day⁻¹ increased brain activity within Brodmann areas 4/6/10/44/45, precuneus, anterior cingulate and insula/thalamus in older adults. In addition, Bowtell et al8 also observed increased perfusion of the parietal and occipital lobes with blueberry supplementation.

What is more, observations have shown anthocyanins and their metabolites to have an inhibitory effect upon monoamine oxidase (MAO).9 These enzymes metabolise monoamines and as a result produce hydrogen peroxide. Inhibition may therefore reduce oxidative stress and in turn lead to an increase in monoamines which are needed
More recently, Watson et al\textsuperscript{10} observed an almost complete inhibition of MAO-B activity (96%), a reduction in plasma normeadrenaline concentration (60%) and an increase in dihydroxyphenylglycol (\sim35.5\%) 2.5 hours following blackcurrant juice treatment in healthy young (18-35 years) adults. This was also coupled with an attenuation of an increase in the cognitive function variable, digit vigilance reaction times with blackcurrant supplementation and trends in Bond-Lader alertness ratings and mental fatigue. Therefore, these effects may extend to older adults and have similar positive effects upon cognitive function.

In healthy young adults (i.e. <45 years), blackcurrant anthocyanins have been shown to increase peripheral blood flow and reduce muscle fatigue during typing activity and increase femoral artery diameter during isometric exercise.\textsuperscript{11,12} Therefore, if anthocyanins can increase blood flow in older adults, improvements in functional tasks that require provision of energy from aerobic pathways may be observed. For older adults this is possible as blood flow is reduced to muscle in comparison to young adults and aerobic capacity is decreased.\textsuperscript{13,14} What is more, in younger adults New Zealand blackcurrant extract has shown positive benefits to exercise performance in both cycling and running.\textsuperscript{15–19} Therefore, the primary aim of the present study was to examine the effect of New Zealand blackcurrant upon functional performance in an aerobic task, while the secondary aims were to examine effects on cognitive function and resting blood pressure in older adults following a 7-day intake.

**METHODS**

**Participants**

Fourteen participants (12 male, age: 69\pm4 years, height: 172\pm9 cm, body mass: 85\pm12 kg, BMI: 28.5\pm2.9) volunteered to participate in the study. Following explanation of the experimental protocol and procedures, potential risks and benefits, participants
completed a health history questionnaire and provided written informed consent. The participants were community dwelling, physically active independent older adults, free from any injuries and not taking any prescription medication that controlled blood pressure, heart or neurological conditions. Participants were excluded from the study if they were current smokers or habitually using antioxidant supplements (including vitamin C and E and high anthocyanin products). All participants were also screened for dementia with the Mini-Cog© (3-item recall and clock drawing) and any participants failing the test were not allowed to participate. The study was approved by the University of Worcester Health & Sciences Research Ethics Committee (SH17180001) with protocols and procedures performed in accordance with the ethical principles outlined by the Declaration of Helsinki (World Medical Association, 2013).

**Experimental Design**

Participants visited the laboratory four times at the same time of day (9:00 or 11:00 am) for each visit. Before arrival, participants were instructed to not consume alcohol the day before and caffeine the day of each visit to the laboratory. Analysis of food diaries indicated 100% adherence to these restrictions. During the first visit participants height (Seca 213, Seca, Birmingham, UK) and body mass (Seca 887, Seca, Birmingham, UK) were measured. Blood pressure was then measured (Omron M5-I, Omron Healthcare Ltd, Milton Keynes, UK) in accordance with methods from the British Hypertension Society. Briefly, participants rested while seated in a chair for 5-minutes before the cuff was placed around the upper arm, with the artery indicator aligned 2cm above the brachial artery. The arm was then rested on a pillow at the level of the heart, with three measures taken and averaged. Subsequently participants completed the cognitive function assessment and 6-minute walk test.
The first and second visit allowed familiarisation of the protocols and procedures and were a maximum of 7-days apart (Figure 1 for the timeline of experimental visits). For 6-days prior to visits three and four, participants consumed two 300 mg capsules per day of placebo (microcrystalline cellulose M102) or concentrated NZBC extract (300 mg containing 105 mg of anthocyanins, i.e. 35–50% delphinidin-3-rutinoside, 5–20% delphinidin-3-glucoside, 30–45% cyanidin-3-rutinoside, 3–10% cyanidin-3-glucoside) (CurraNZ™, Health Currency Ltd., Surrey, UK). In the first six-days participants were instructed to separate the capsule consumption by an 8-hour interval, while on the morning of the seventh day of intake, participants consumed both capsules 2-hours prior to arriving at the laboratory. The NZBC capsules were independently analysed for ingredients and confirmed the anthocyanin profile. Between visits two and three, there was a 7-day washout, followed by another 7-day intake of the cross over condition capsules. This dosing period has been used previously in studies examining the effects of New Zealand blackcurrant extract on exercise performance and cardiovascular responses.\textsuperscript{16,19} Dose response work has also identified 600 mg·day\textsuperscript{-1} (dosed at 300 mg twice daily for 6-days and 600 mg 2-hours before measurement) to alter cardiovascular function with a higher dose having no additional effect.\textsuperscript{20}

**Cognitive Function**

Participants completed the Cambridge neuropsychological test automated battery (CANTAB, Cambridge Cognition, Cambridge, UK) to assess cognitive function whilst sat at a desk. The testing battery assessed reaction time, paired associates learning, spatial working memory and rapid visual information processing, and took ~35 minutes to administer on a handheld computer tablet (Gigabyte, Slate S10, Windows 10). Participants were allowed to wear vison correcting eye glasses or contact lenses during
the cognitive function assessment. The assessment system has previously been shown to be sensitive to a nutritional intervention of polyphenol supplementation. The battery of cognitive tasks is described in more detail below.

**Reaction time**

The reaction time task assessed motor and mental response speeds. The participants held a button at the bottom of the screen and circles were presented above. For the simple reaction mode, a single yellow circle was presented, while in the five choice there were five circles presented with one containing a yellow dot. The participant must release the button at the bottom of the screen and select the circle containing the yellow dot. The test took 3-minutes to administer. The outcome measures included reaction time and movement time for the single and five-choice tests.

**Paired Associates Learning**

The PAL test assesses visual memory and new learning taking 8-minutes to administer. Boxes were presented on the screen and some of the boxes randomly revealed a pattern behind them. The patterns were then presented in the order they were revealed, and the participant then had to select the box in which the pattern was originally located. The outcome measures included errors made, the number of trails required to locate the patterns correctly, memory scores and stages completed.

**Spatial Working Memory**

The SWM test assessed retention and manipulation of visuospatial information and took 4-minutes to administer. Boxes were displayed on the screen and in a process of elimination participants had to find a yellow token in a number of boxes to fill up an empty column. The test increased in difficulty until 12 boxes were displayed for the participants, and for each trial the colour and position of the boxes changed. Outcome measures included errors of selecting boxes that have already been selected and shown
to be empty (working memory) and strategy (indexed strategy of executive function from the number of different boxes participants complete a new search for the token with the same problem).

Rapid Visual Information Processing

The RVIP test measured sustained attention and took 7-minutes to administer. At the centre of the screen a white box was displayed, wherein numbers from 2-9 appeared in a pseudo-random order at the rate of 100 digits per minutes. Participants were instructed to detect when a target sequence of digits was displayed (i.e. 2-4-6). The outcome measures included were response latency (speed of response), probability of false alarms and sensitivity.

Functional Aerobic Performance

Functional aerobic performance of participants was determined from performance in the 6-minute walk test. Briefly, participants were instructed to walk around a 45.7-metre course (50 yards) as far as they could within 6-minutes. The course was set up indoors on a level non-slip floor with cones marking the walking area. During the 6-minutes, participants were instructed to give their best effort and were given standardised encouragement during the walk. After 6-minutes, total distance covered in metres was recorded.

Physical Activity and Dietary Standardisation

Participants completed a 48-hour food diary before the first and second experimental condition visit (i.e. visit 3 and visit 4). Participant’s nutritional intake was not controlled by the study, however at visit three, participants food diary was photocopied to guide them in replicating their intake for the final experimental visits (i.e. visit 4). Participants then recorded their intake for the 48-hours prior to the fourth visit on a new diary. Food diaries were analysed using Nutritics (Nutritics LTD, Dublin, Ireland) for absolute and
relative to body mass carbohydrate, fat and protein intake and total energy intake (kJ). The total anthocyanin consumption in the 48-hours before each experimental visits was estimated from the anthocyanin content of food multiplied by the portion size reported.

Statistical Analysis

All data was analysed in SPSS 25.0 (SPSS, Chicago, IL, USA). Data normality assumptions were assessed using Kolmogorov-Smirnov test. Differences between placebo and NZBC conditions were analysed with a paired samples t-tests to compare dietary intake, blood pressure and each parameter of cognitive function and a Wilcoxon Signed Rank test for 6-minute walk performance due to normality violations. Significance was set at alpha level of $P \leq 0.05$. Where differences were present, Cohen’s $d$ effect sizes were calculated, with an effect size interpreted <0.2 as trivial, 0.2-0.39 as small, 0.4-0.69 as moderate and >0.7 as large. A prior power analysis showed a sample size of 14 would allow detection of a 2-3% difference in exercise performance with an 80% power ($1-\beta=0.80; 0.05=\alpha$ level).

RESULTS

Food Diary Analysis

There were no differences ($P>0.05$) in absolute or relative per kilogram of body mass values for carbohydrate, fat, protein, or total energy for 48 hours prior to each experimental visit (Table 1). The estimated intake of anthocyanins for the 48-hours before the experimental visits was not different (placebo: 84±51; NZBC: 82±52 mg·day$^{-1}$, $t=0.839, P=0.416$).

[Insert table 1 here]

Blood Pressure
Intake of NZBC reduced systolic blood pressure (placebo: 136±14; NZBC: 130±12 mmHg, t=2.334, P=0.036, d=0.46), with a group mean reduction of 5±8 mmHg (range: 2 – 22 mmHg) and 10 participants showing a decrease (Figure 2). This was coupled with NZBC also reducing diastolic blood pressure (placebo: 84±11; NZBC 78±6 mmHg, t=2.329, P=0.036, d=0.68), with a group mean reduction of 12±8 mmHg (range: 2 – 23 mmHg) and 8 participants lower (Figure 3).

**Cognitive Function**

There were no differences in cognitive function variables reaction time, paired associates learning, spatial working memory and rapid visual processing (Table 2) between placebo and NZBC.

**6-minute walk test performance**

Due to balance concerns, one participant did not complete the 6-minute walk test, therefore 13 participants completed and were analysed. There was no difference in total walking distance between the conditions (placebo: 704±72; NZBC: 718±115 metres, Z=−0.39, P=0.969).

**DISCUSSION**

The principle finding from this study was that New Zealand blackcurrant extract had a moderate effect on resting systolic and diastolic blood pressure in older adults. Systolic blood pressure was 5±8 mmHg lower and diastolic was 12±8 lower due to the intake of New Zealand blackcurrant extract, with 10 and 8 participants showing a change respectively. However, the study did not confirm our hypothesis of improved functional performance in an aerobic task or cognitive functions by New Zealand blackcurrant extract.
To the author’s knowledge, this is the first study to demonstrate effects on blood pressure from the intake of New Zealand blackcurrant. Previous studies examining effects of NZBC extract upon cardiovascular responses at rest have shown no effect upon blood pressure in trained cyclists and triathletes.\textsuperscript{20,24} Therefore, the results shown in this study may reflect the different participant characteristics between the studies. For example, based upon the resting blood pressure of the placebo condition, 11 of the participants would be classified as having; pre-hypertension with systolic pressure of 120-139 mmHg and diastolic pressure of 80-89 mmHg, or hypertension such that systolic was $\geq$140 mmHg or diastolic pressure $\geq$90 mmHg.\textsuperscript{25}

Recent studies have shown cherry juice to decrease resting systolic and diastolic blood pressure in young and old adults, old adults with mild-to-moderate dementia, middle-aged adults and young men with pre-hypertension.\textsuperscript{26–29} Interestingly, the results from these studies both match the methodology within this study such that measurement of blood pressure was taken 2-hours following intake. What is more, it potentially indicates that changes in blood pressure from anthocyanin intake is not specific to cherry but extend to blackcurrant for older adults. Berry specific effects are possible due to the unique anthocyanin profiles within fruits. For example, cherry is high in the anthocyanin cyanidin-3-glucosylrutinoside while blackcurrant is highest in delphinidin-3-rutinoside, which will then have an impact upon the metabolites produced.\textsuperscript{22,30} The specific metabolites produced are then determinate of the physiological responses; with Keane et al\textsuperscript{31} observing that migration of human vascular smooth muscle cells \textit{in vitro} was dependent upon the presence of both protocatechuic acid and vanillic acid, rather than in isolation.

On the whole, the findings in this study may have implications for the management of blood pressure in older adults. For example, blood pressure is a modifiable risk factor
for cardiovascular disease, of which, diet is a contributing factor.\textsuperscript{32,33} The observed mean decrease in systolic blood pressure of 5 mmHg is meaningful as Collins et al\textsuperscript{34} have shown that reductions of 2-5 mmHg can contribute to reductions in cardiovascular mortality. The magnitude of changes in blood pressure in this study are also similar to those of Kent et al.\textsuperscript{26} who observed a 5.5 mmHg decrease in both systolic and diastolic blood pressure following cherry juice, and Keane et al\textsuperscript{29} who observed a 7±3 mmHg decrease in systolic blood pressure following cherry juice.

This study showed no change in cognitive function in older adults following a 7-day intake of anthocyanins from NZBC. These findings reflect those of Keane et al\textsuperscript{28} and Bowtell et al\textsuperscript{8} who similarly showed no change in cognitive function following cherry juice (measured acutely) and blueberry juice (12-week intake), respectively. However, it contrasts the findings of Watson et al\textsuperscript{10} who demonstrated that following supplementation with a single intake of blackcurrant in young adults, digit vigilance was higher, and rapid visual information processing and mental fatigue were lower, with a Bon-Lader visual analogue mood scale also indicating higher alertness in comparison to placebo. These differences may result from methods used to examine cognitive function. Within the current study, cognitive function assessment took ~35 minutes to administer and participants completed each test during the battery once. Whereas, the procedure used by Watson et al\textsuperscript{10} took 70-minutes and participants completed seven repetitions of the cognitive function tests and in turn, were designed to induce mental fatigue. Furthermore, differences may also occur from duration of intake. For example, Miller et al\textsuperscript{35} and Whyte et al\textsuperscript{36} both observed positive effects of blueberry anthocyanins on aspects of executive function with a 3 and 6-month intake, respectively. Therefore, the interaction of anthocyanins on cognitive function with and
without mental fatigue, and different dosing durations in older adult is potentially an area for future research.

This study also observed no change in exercise performance from NZBC in older adults. These findings contrast those of Cook et al\textsuperscript{15}, Murphy et al\textsuperscript{16}, Perkins et al\textsuperscript{17} and Godwin et al\textsuperscript{18} with differences likely due to the ages and training status of the participants and demands of the exercise tests. What is more, the 6-minute walk test used in this study is valid ($r=0.78$) and reliable ($R=0.94$ [95% CI 0.90-0.96]) for identifying functional performance limitation in older adults.\textsuperscript{37} However, the intensity of the exercise experienced by the participants in this study would likely be low to moderate and the scores of the participants in comparison to normative data are ‘excellent’ as they are within the 90\textsuperscript{th} percentile.\textsuperscript{38} As a result, more research is needed to identify if exercise performance is effected in older adults and studies should also examine if functional performance is effected in those with health conditions.

As the metabolites produced from different anthocyanin parent bodies are different, future studies with NZBC should examine the time-course changes of NZBC metabolites within plasma and then these can be compared against blood pressure to identify if changes coincide with the peaking of certain metabolites. Furthermore, this is the first study to show changes in resting blood pressure and this occurred in older adults, future investigations should therefore examine cardiovascular function responses during exercise in older adults. The effects of dose and duration of intake on cognitive function should also be addressed, as the findings of this within the literature are unclear. Future studies should also identify if responses to anthocyanin intakes are dependent upon habitual anthocyanin intake. For example, those with a low baseline status of vitamin C and glutathione improved their VO$_{2\text{max}}$ following supplementation with vitamin C and N-acetylcysteine, respectively, however the participants with higher
baseline levels did not respond. Therefore, similar responses may occur in those who have a low anthocyanin intake. \(^{39,40}\)

**Limitations**

The results of the present study should not be viewed without recognition for some of the limitations in the study design. Firstly, due the large availability of polyphenols within the diet, there was no dietary restrictions placed upon participants. Polyphenol metabolites can act synergistically, therefore a low polyphenol wash-out diet would confirm the observations were resultant from the NZBC intake. However, this would come with a decrease in ecological validity as any changes are only of interest to practitioners if they can be seen in addition to the normal diet. Secondly, as the testing occurred 2-hours following the last intake of the NZBC extract capsules it is possible that the effects observed on blood pressure are a result of the last intake, rather than the accumulative 7-days intake. As a result of this change in dosing pattern (i.e. 600 mg in one dose on day 7, versus days 1-6 where 300 mg was taken twice) it currently limits interpretation and generalization of the findings. Therefore, future studies should consider this and investigate time-course responses of NZBC intake with a consistent dosing strategy used.

**Conclusions**

In conclusion, a 7-day intake of New Zealand blackcurrant extract can decrease resting systolic and diastolic blood pressure in older adults. There are no effects of 7-days intake of New Zealand blackcurrant upon distance covered during a 6-minute walk test or the cognitive function variables reaction time, paired associates learning, spatial working memory and rapid visual processing in older adults. The implications of these findings are that New Zealand blackcurrant extract could be considered a nutritional
strategy to manage resting systolic and diastolic blood pressure in physically active older adults.

Acknowledgement

Supply of supplement (CurraNZ™) for this study was donated from Health Currancy Ltd (United Kingdom).

Conflict of interest

The authors declare no conflict of interest.

References


6. Qin B, Anderson RA. An extract of chokeberry attenuates weight gain and


Flavonoid intake and cognitive decline over a 10-year period. *Am J Epidemiol.*


doi:10.1093/gerona/gly166

doi:10.1093/database/bat070


doi:10.1016/j.maturitas.2014.10.001


FIGURE TITLES

Figure 1 – Experimental design and time line of the four laboratory visits.

Figure 2 – Systolic blood pressure following 7-days intake of New Zealand blackcurrant extract capsules in older adults. Data are mean±SD, * difference between placebo and NZBC extract (P<0.05).

Figure 3 – Diastolic blood pressure following 7-days intake of New Zealand blackcurrant extract capsules in older adults. Data are mean±SD, * difference between placebo and NZBC extract (P<0.05).
For Peer Review Only

### Order of condition assigned in a randomised, cross-over design
(600 mg·day⁻¹ NZBC or placebo)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
<th>Visit 3</th>
<th>Visit 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 7-days</td>
<td>7-days supplementation with last 2-days food-diary</td>
<td>7 washout and 7 supplementation with last 2-days food-diary</td>
<td></td>
</tr>
</tbody>
</table>

- **Visit 1**
  - Pre-screening and informed consent, discussion about study protocol
  - Anthropometry (height, body mass, BMI)
  - Familiarisation

- **Visit 2**
  - Capsules consumed 2-hours prior to visit
  - Arrival (0 minutes)
  - Resting blood pressure (5-10 minutes)
  - Familiarisation

- **Visit 3**
  - Cognitive function testing battery (10-45 minutes)
  - 6-minute walk (50-56 minutes)
  - Arrival (0 minutes)
  - Resting blood pressure (5-10 minutes)

- **Visit 4**
  - Cognitive function testing battery (10-45 minutes)
  - 6-minute walk (50-56 minutes)
Table 1 - Absolute and relative to body mass dietary intake 48 hours before each visit for the experimental conditions.

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>NZBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate (g)</td>
<td>404±116</td>
<td>398±106</td>
</tr>
<tr>
<td>(g·kg body mass⁻¹)</td>
<td>4.8±1.2</td>
<td>4.7±1.2</td>
</tr>
<tr>
<td>Fats (g)</td>
<td>143±37</td>
<td>151±48</td>
</tr>
<tr>
<td>(g·kg body mass⁻¹)</td>
<td>1.7±0.6</td>
<td>1.8±0.7</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>186±13</td>
<td>181±14</td>
</tr>
<tr>
<td>(g·kg body mass⁻¹)</td>
<td>2.3±0.5</td>
<td>2.2±0.4</td>
</tr>
<tr>
<td>Total Energy Intake (kJ)</td>
<td>15,234±1743</td>
<td>15,380±2188</td>
</tr>
<tr>
<td>(kJ·body mass⁻¹)</td>
<td>184±34</td>
<td>185±35</td>
</tr>
</tbody>
</table>

Values are means±SD, n = 12.
Table 2 – Scores for placebo and NZBC on the variables measured for reaction time, paired associated learning, spatial working memory and rapid visual information processing by the Cambridge neuropsychological test automated battery.

<table>
<thead>
<tr>
<th></th>
<th>NZBC</th>
<th>Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reaction Time Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple accuracy score (number of correct responses)</td>
<td>29±2</td>
<td>29±1</td>
</tr>
<tr>
<td>Simple reaction time (ms)</td>
<td>298±44</td>
<td>301±46</td>
</tr>
<tr>
<td>Simple movement time (ms)</td>
<td>192±56</td>
<td>214±76</td>
</tr>
<tr>
<td>Five choice reaction time (ms)</td>
<td>327±61</td>
<td>338±58</td>
</tr>
<tr>
<td>Five-choice movement time</td>
<td>222±56</td>
<td>250±70</td>
</tr>
<tr>
<td><strong>Paired Associated Learning Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total errors</td>
<td>34±19</td>
<td>24±14</td>
</tr>
<tr>
<td>Total errors adjusted (6 shapes adjusted)</td>
<td>11±6</td>
<td>8±5</td>
</tr>
<tr>
<td><strong>Spatial Working Memory Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between errors</td>
<td>15±10</td>
<td>14±8</td>
</tr>
<tr>
<td>Strategy</td>
<td>15±8</td>
<td>14±8</td>
</tr>
<tr>
<td><strong>Rapid Visual Information Processing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RVP A</td>
<td>0.93±0.05</td>
<td>0.92±0.07</td>
</tr>
<tr>
<td>Probability of hit</td>
<td>0.74±0.16</td>
<td>0.70±0.23</td>
</tr>
<tr>
<td>Total false alarms</td>
<td>3.85±5.42</td>
<td>3.67±4.89</td>
</tr>
<tr>
<td>Latency (ms)</td>
<td>461±100</td>
<td>482±106</td>
</tr>
</tbody>
</table>