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Effect of Standing Estrus Prior to an Injection of GnRH on Steriodogenic Enzyme Expression in Luteal Tissue

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ABSTRACT

Cows detected in estrus around the time of fixed-time AI had increased pregnancy success and progesterone concentrations. Additionally, GnRH following onset of estrus influenced LH pulse frequency and CL formation/function. Therefore our objective was to determine steriodogenic enzyme expression within luteal tissue of cows that were or were not detected in standing estrus prior to an injection of GnRH. Cows were synchronized with the CO-Synch protocol (day -9 100 mg GnRH; day -2 25 mg PGF2α; day 0 100 mg GnRH). Estrus was detected with the HeatWatch system. Location and size of the ovulatory follicle was determined on day 0 at time of GnRH by transrectal ultrasonography; blood samples were collected on day 3,4,5,7, and 9; and luteal tissue was collected on d 10 (n = 3 estrus and n = 8 no estrus) from CL originating from similar sized follicles (13.5 to 16 mm). Total cellular RNA was extracted and relative mRNA levels were determined by real-time RT-PCR and corrected for GAPDH. There was no effect of estrus on CL weight (P = 0.83). There was no effect of estrus by time (P = 0.17) or estrus (P = 0.97) on progesterone concentrations, but there was an effect of time (P < 0.01). In addition, there was no effect of estrus, follicle size, or CL weight on LH receptor expression (P = 0.97, 0.94, and 0.85), StAR expression (P = 0.87, 0.92, and 0.86), CYP11A1 expression (P = 0.49, 0.27, and 0.99), or 3HSD expression (P = 0.49, 0.61, and 0.91). However, there was a correlation between follicle size and CL weight (P = 0.01; R^2 = 0.51); for every increase of 1 mm in follicle size, CL weight increased by 1.1 g. In addition, there was an effect of CL weight by time (P = 0.01) on progesterone concentrations and an effect of time (P < 0.01) with a tendency for an effect of CL weight (P = 0.06). In summary, estrus did not influence CL weight, progesterone concentrations, or expression of steriodogenic enzymes. However, as follicle size increased, CL weight increased, and CL weight influenced progesterone concentrations.

INTRODUCTION

Progesterone is essential for the establishment and maintenance of pregnancy (McDonald et al., 1952). Therefore, several studies have investigated techniques to increase fertility by increasing corpus luteum (CL) function. One proposed method is to give an injection of GnRH at time of insemination. Kaim et al. (2003) reported that an injection of

GnRH given within 3 hours of the onset of standing estrus increased the ovulatory LH surge, and LH is involved in CL development and function (Peters et al., 1994; Quintal-Franco et al., 1999; Kaim et al., 2003). Approximately 80% of progesterone secreted by corpora lutea is believed to be secreted by large luteal cells (Niswender et al., 1985), and Farin et al. (1988) reported when ewes were treated with LH or hCG on day 5 through 10 of the estrous cycle, more large luteal cells and fewer small luteal cells were present in the corpus luteum compared to untreated controls. However, when LH was blocked around the time of ovulation, animals had decreased subsequent concentrations of progesterone compared to controls (Peters et al., 1994; Quintal-Franco et al., 1999). Furthermore, when GnRH was administered to cows that did and did not exhibit standing estrus; cows that initiated standing estrus had greater subsequent concentrations of progesterone compared to cows that did not initiate estrus (Fields 2008).

Moreover, research has reported cows detected in standing estrus around the time of the GnRH injection during a fixed-time artificial insemination (FTAI) protocol had increased pregnancy rates compared to cows not detected in estrus (Perry et al., 2005; 2007). However, there was no difference in the rate of increase in progesterone between animals that initiated standing estrus and those that did not initiate standing estrus, and no effect of standing estrus on area under the LH curve, average concentrations of LH, or LH pulse frequency (Fields et al., 2008).

Therefore, the objective of this experiment was to determine steriodogenic enzyme expression within luteal tissue of cows that were or were not detected in standing estrus prior to an injection of GnRH.

MATERIALS & METHODS

Experimental Design

Thirty-three Angus-cross non-pregnant, non-lactating, cycling mature beef cows were synchronized with the CO-Synch protocol. Cows were injected with GnRH (100 g as 2 mL of Cystorelin i.m.; Merial, Diluth, Ga) on day -9. An injection of prostaglandin F2α (PGF2α 25 mg as 5 mL of Lutalyse i.m.,Pfizer Animal Health, New York, NY) was given on day -2. Forty-eight hours after the PGF2α injection cows were given an injection of GnRH (100 g as 2 mL of Cystorelin i.m.). The HeatWatch electronic estrous detection system was used to determine initiation of standing estrus. Onset of estrus was determined as the first of 3 mounts within a 4-hour period of time lasting 2 seconds or longer in duration. Transrectal ultrasonography was performed using an Aloka 500V ultrasound with a 7.5 MHz transrectal linear probe (Aloka, Wallingford, CT). Both ovaries of each cow were examined at time of the second GnRH injection. All follicles > 8 mm in diameter were recorded.

Blood samples were collected by venipuncture of the Jugular Vein into 10 mL Vacutainer tubes (Fisher Scientific, Pittsburgh, PA) on day 3, 4, 5, 7, and 9 after GnRH treatment. All blood was allowed to coagulate at room temperature then stored at 4° C for 24 h. Samples were centrifuged at 1,200 x g for 30 min, and the serum was harvested and frozen at -20° C until analyzed by radioimmunoassay (RIA). On day 10 after the second GnRH injection cows were transported to a local abattoir. Only animals (n = 11) that had a similar

dominant follicle size (14.8 ± 0.39 and 15.0 ± 0.24 mm for estrus and no estrus, respectively) were analyzed in the study.

Radioimmunoassay

Blood samples were analyzed for serum concentrations of progesterone by RIA using methodology described by Engel et al. (2008). All samples were analyzed in a single assay and intra-assay coefficients of variation was 5.39%. Assay sensitivity was 0.4 ng/mL.

Blood and Tissue Collection

Ovaries were collected within 30 minutes of slaughter and immediately placed on ice. Location of CL were confirmed with location of dominant follicle prior to GnRH. Corpra lutea were dissected from the ovary and divided into equal part. Each section of the CL was placed in RNase free tubes (USA Scientific) and snap frozen in liquid nitrogen. Samples were stored at $-80°$ C until total RNA was extracted.

RNA isolation

A SV Total RNA Isolation System (Promega Corporation) was used to extract RNA from the corpra lutea samples. An empty 1.5 ml eppendorf tube (USA Scientific) was weighed and ¼ of the corpus luteum was inserted into the tube and measured again to find the weight of the sample. The sample was then placed in a tube with lysis buffer and homogenized. After homogenization, lysis buffer was added to sample in order to bring the concentration to the recommended 171 mg/ml, and 175 µl of sample was then transferred to a new 1.5 ml eppendorf tube. The remaining sample was inserted into a 2.0 ml eppendorf tube and frozen at $-80°$ C. To the sample, 350 µl of RNA dilution buffer was added and mixed. Samples were then incubated in a $70°$ C heating block for 3 min and then centrifuged at 13,000 x g for 1 minute at room temperature. The supernatant was then transferred to a new 1.5 ml eppendorf tube and 200 µl of 95% ethanol was added and mixed. The mixture was transferred to a Spin Column and centrifuged at 13,000 x g for 1 minute at room temperature. The liquid was removed from the collection tube and collected as waste. To the spin column, 600 µl of RNA wash solution was added and centrifuged at 13,000 x g for 1 minute at room temperature. After removing the liquid from the collection tube, 50 µl of DNase incubation mix was added to the membrane of the spin basket and incubated at room temperature for 15 minutes, then 200 µl of DNase stop solution was added. The spin basket was centrifuged for 1 minute at 13,000 x g at room temperature. The spin column assembly was washed twice with RNA wash solution centrifuged for 1 minute at 13,000 x g at room temperature. The RNA was eluted off the spin basket membrane by adding 100 µl of nuclease-free water and centrifuged at 13,000 x g for 1 minute at room temperature. After purification RNA concentrations were measured at 260nm and 280nm by spectrophotometry.

Quantitative Real-Time PCR

Prior to quantitative real-time RT-PCR, all RNA samples were diluted to 30ng/µl with RNase/DNase free water (MP Biomedicals), and concentration was determined by spectrophotometry. A single-step SYBR Green reaction was performed using the iScript One-step RT-PCR Kit with SYBR Green (Bio-Rad Laboratories, Inc) and a Stratagene MX

3000P QPCR System. The SYBR Green reaction was performed for genes with the reverse transcription at 42°C for 30 minutes and 95°C for 10 minutes to inactivate reverse transcription. For all of the genes of interest, transcription was followed by 40 cycles of: 30 seconds at 95°C for melting; 1 minute at the annealing temperatures (61°C for StAR, CYP11A1, 3HSD, LH receptor, and GAPDH); and 30 seconds at 72°C for extension.

Statistics

Influence of expression of standing estrus on CL weight was analyzed by the GLM procedure of SAS. Plasma concentrations of progesterone were analyzed by repeated measures using the Mixed procedures of SAS as described by Littell et al., (1998). All covariance structures were modeled in the initial analysis. The indicated best fit covariance structure, Ante-dependence, was used for the final analysis. The model included the independent variables of treatment (estrus or no estrus; and CL weight), day, and treatment by day. Relative expression of StAR, CYP11A1, 3HSD, and LH receptor were analyzed using the GLM procedure of SAS with expression of GAP-DH as a covariate. The correlation between dominant follicle size and CL weight was analyzed by the PROC CORR procedure of SAS.

RESULTS

There was no effect of standing estrus prior to an injection of GnRH on day 10 CL weight ($P = 0.83$; Figure 1). In addition there was no effect of estrus by time ($P = 0.17$) or estrus ($P = 0.97$) on progesterone concentrations on days 3, 4, 5, 7, and 9 after the GnRH injection. However, there was an effect of time ($P < 0.01$, Figure 2), with circulating concentrations of progesterone increasing from day 3 through day 9.
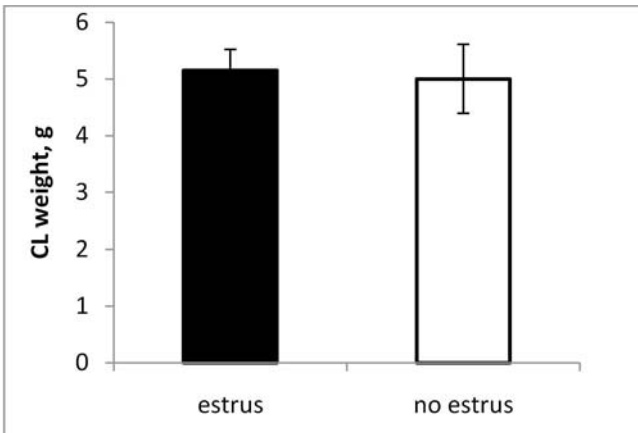
Figure 1. Influence of detection in standing estrus prior to an injection of GnRH on day 10 luteal weight ($P = 0.83$).
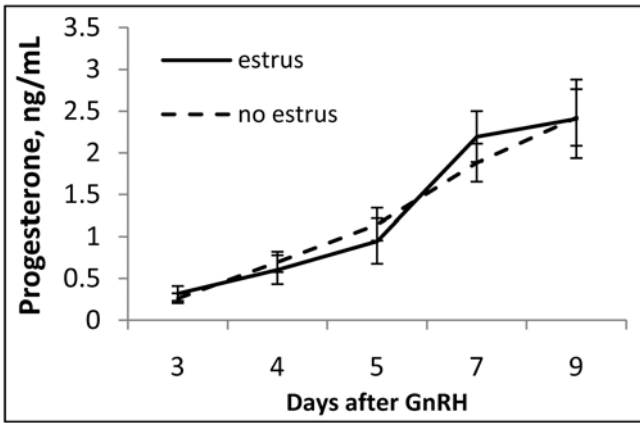
Figure 2. Influence of detection in standing estrus prior to an injection of GnRH on circulating concentrations of progesterone. Estrus by time ($P = 0.17$), estrus ($P = 0.97$), time ($P < 0.01$).

There was no effect of estrus, follicle size, or day 10 CL weight on LH receptor expression ($P = 0.97$, 0.94, and 0.85, Figure 3). There was no effect of estrus, follicle size, or day 10 CL weight on expression of StAR ($P = 0.87$, 0.92, and 0.86, Figure 4), CYP11A1 ($P = 0.49$, 0.27, and 0.99, Figure 5), or 3HSD ($P = 0.49$, 0.61, and 0.91, Figure 6).
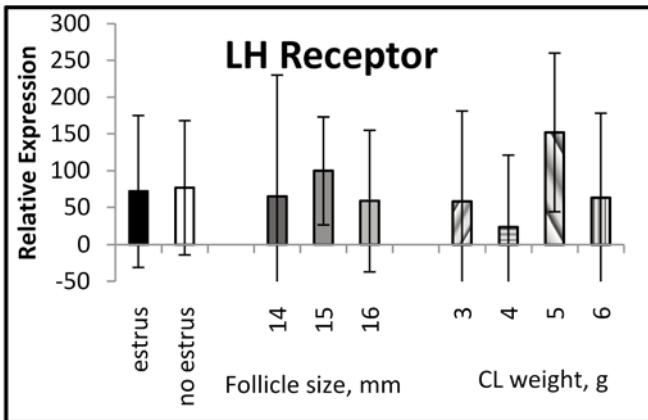
Figure 3. Influence of standing estrus prior to an injection of GnRH, ovulatory follicle size at time of GnRH injection, and luteal weight on day 10 on expression of LH receptor ($P > 0.85$).
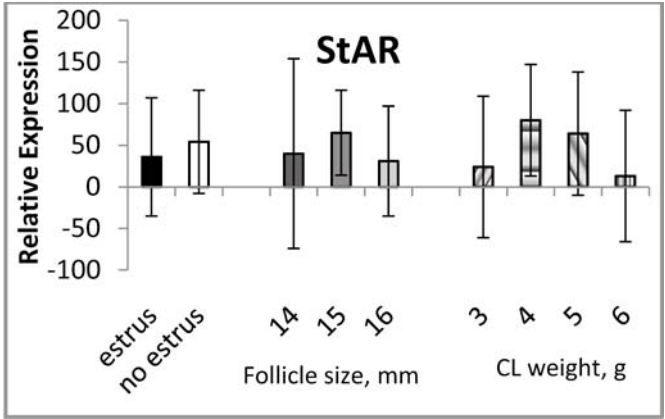
Figure 4. Influence of standing estrus prior to an injection of GnRH, ovulatory follicle size at time of GnRH injection, and luteal weight on day 10 on expression of StAR (P > 0.86).
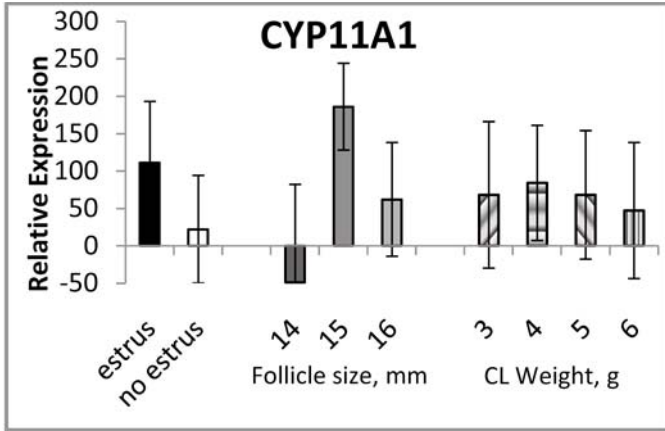
Figure 5. Influence of standing estrus prior to an injection of GnRH, ovulatory follicle size at time of GnRH injection, and luteal weight on day 10 on expression of CYP11A1 (P > 0.27).
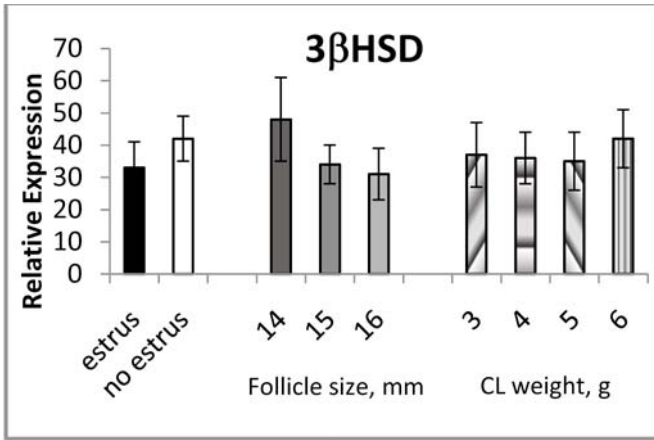
Figure 6. Influence of standing estrus prior to an injection of GnRH, ovulatory follicle size at time of GnRH injection, and luteal weight on day 10 on expression of 3HSD (P > 0.85).

A correlation was found between follicle size and CL weight (P = 0.01; R^2= 0.51, Figure 7), for every increase of 1 mm in follicle size, CL weight increased by 1.1 g. In addition, there was an effect of CL weight by time (P = 0.01) on concentrations of progesterone and an effect of time (P < 0.01) with a tendency for an effect of CL weight (P = 0.06, Figure 8). As CL weight increased circulating concentrations of progesterone tended to increase.
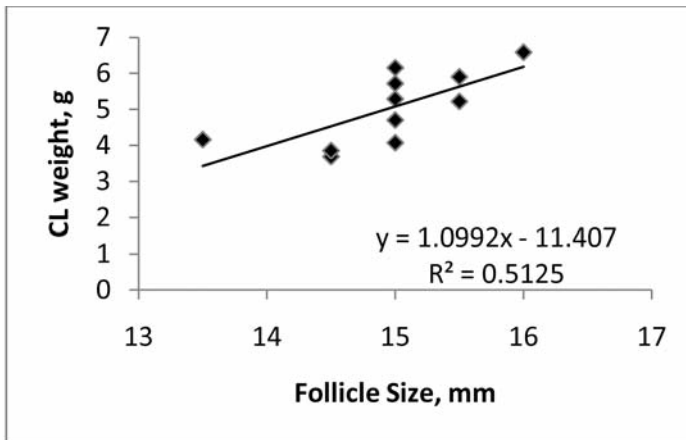
Figure 7. Correlation between ovulatory follicle size at time of GnRH injection and luteal weight on day 10 (P = 0.01).
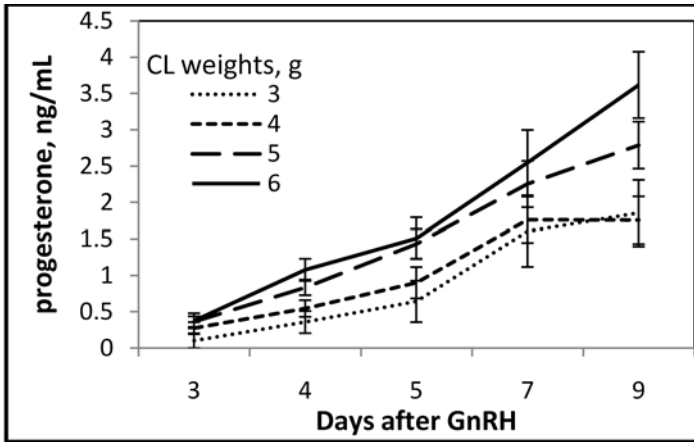
Figure 8. Influence of day 10 luteal weight on changes in circulating concentrations progesterone following induced ovulation. Luteal weight by time (P = 0.01), time (P < 0.01), luteal weight (P = 0.06).

DISCUSSION

Luteinizing hormone (LH) plays a vital role in the development and function of the corpus luteum. Previous work has reported that increasing the ovulatory LH surge increased CL function (Kaim et al., 2003). Furthermore, when GnRH was administered to cows that did and did not exhibit standing estrus; cows that initiated standing estrus had greater subsequent concentrations of progesterone compared to cows that did not initiate estrus (Fields 2008). However in the present study, detection of standing estrus prior to an injection of GnRH had no effect on CL weight, progesterone concentrations, or expression of steroidogenic enzymes. In the present study cows that did and did not exhibit standing estrus were selected to have similar sized ovulatory follicles. Among dairy cows, induced ovulation of small follicles (11.54 ± 0.22 mm) resulted in smaller CL that secreted less progesterone compared to cows induced to ovulate larger follicles (14.47 ± 0.39 mm, Vasconcelos et al., 2001), and ovine follicles induced to ovulate 12 hours after luteal regression had fewer granulosa cells and formed smaller CL that secreted less progesterone than follicles induced to ovulate 36 hours after luteal regression (Murdoch and Van Kirk, 1998). This is important since granulosa cells are generally believed to differentiate into large luteal cells (Smith et al., 1994) and approximately 80% of progesterone secreted by the corpora lutea is believed to be secreted by large luteal cells (Niswender et al., 1985). In the present study, there was a correlation between follicle size and CL weight; as follicle size increased, CL weight increased, and CL weight influenced progesterone concentrations. However, there was no difference in steriodogenic enzyme expression. Therefore, larger follicles had more cells and resulted in a heavier CL, and a larger CL was capable of producing more progesterone. This

is important because greater production of progesterone by the CL could lead to higher conception rates, and an increase in pregnancy success.

ACKNOWLEDGEMENTS

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Affect Comprehension in Children With Autism Spectrum Disorder: A Visual Field Isolation Intervention

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ABSTRACT

Children diagnosed with Autism Spectrum Disorders (ASD) tend to show under-activation of the right fusiform face area of the ventral temporal cortex when viewing emotional faces, which may explain their affect comprehension deficits. This left hemisphere dominance, indicative of a piecemeal processing strategy, has been shown a less effective method of understanding true emotion. The present study aimed to condition the left-visual-field-to right-FFA pathway by allowing children with ASD to work through an emotion-matching computer program. One group completed the experiment with both eyes uncovered, while the other worked with only their left visual field open. Though no significant differences between improvement in accuracy, reaction time, and physiological response were found between the groups, almost all participants showed some improvement, and future investigations with larger sample sizes would be useful in puzzling out the benefit of visual field isolation in emotion comprehension interventions in children with ASD.

Keywords: autism, visual field isolation, emotional comprehension, intervention.

AFFECT COMPREHENSION IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A VISUAL FIELD ISOLATION INTERVENTION

Often taken for granted, the ability to decode human facial expressions is not universal. Though two-month-old infants are able to recognize and reciprocate facial expressions, people with Autism Spectrum Disorders (ASD) show affect comprehension deficits (Grelotti, Gauthier, & Schultz, 2002; Silver & Oakes, 2001). And though individuals with autism have demonstrated the capacity to generate descriptive qualifiers, like gender, from photographs, they seem unable to extract emotional information (Clark, Winkielman, & McIntosh, 2008). Obviously such a deficit can make day-to-day social interactions intellectually taxing and can impede the formation of meaningful relationships.

Some mental health professionals postulate that the root of the social impairment is a lack of eye contact shown by individuals with ASD (Pierce, Müller, Ambrose, Allen, & Courchesne, 2001). Perhaps their lack of interest in faces and concomitant lack of experience with faces hinders emotional understanding. Others have suggested that a maladaptive

emotional encoding system is at fault. In normal individuals, the fusiform face area (FFA), a region of the ventral temporal cortex, is dominantly activated when viewing facial expressions (Cox, Meyers, & Sinha, 2004; Kanwisher, Stanley, & Harris, 1999). In tests of affect recognition with autistic participants, on the other hand, FFA activity is markedly decreased in comparative responsiveness (Deeley et al., 2007; Grelotti et al., 2005; Pierce et al., 2001; Piggot et al., 2004).

Additionally, an imaging study conducted by Minnebusch (2009) revealed that the left FFA in normal participants was never activated in the absence of right hemisphere FFA activation. The right hemisphere FFA may act as a gateway into activation of other emotional processing regions and seems to be the center of emotional processing. Numerous other studies have confirmed this right hemisphere bias, a bias proven stable even across time and individuals. Yovel, Tambini, and Brandman (2008) reported that 16 out of 17 normal subjects in their study showed larger FFA activation in the right hemisphere, as compared to the left. Bourne (2008) similarly found that normal subjects asked to identify emotional expressions were fastest and most accurate when stimuli were presented in the left visual field; this corresponds to the right hemisphere FFA because of visual information crossover at the optic chiasm. Interestingly, numerous studies have revealed reduced right hemisphere FFA activation in individuals with ASD (Pierce et al., 2001; Schultz et al., 2003), and overtly slower and more error-filled responses on affect comprehension tasks (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Celani, Battacchi, & Arcidiacono, 1999; Nijokiktjen et al., 2001; Piggot et al., 2004).

Autistic individuals do not show the severe recognition deficits of prospagnosiacs (Hadjikhani, et al., 2004). That is, they can recognize faces but are just not adept at reading the expressed emotion. A priori, an underdeveloped left-visual-field-to-right-hemisphere FFA pathway (rather than a lesion of the right FFA) may be to blame for emotional recognition deficits in ASD. In fact, Celani et al. (1999) and van Kooten et al. (2008) offer that autistic individuals may instead rely on a left hemisphere FFA pathway, characteristic of a more analytic processing approach. They maintain that holistic processing is a more preferred mode of decoding emotion, because it allows for a direct knowledge of another's emotion. The right hemisphere dominance shown in normal individuals corresponds to a more holistic processing strategy, but in autistic individuals, emotion is not as automatically inferred because the face is perceived as a mere collection of individual features (Gauthier & Tarr, 2002).

In support of a piecemeal processing theory in individuals with ASD, the present researcher's recent study demonstrated that children with autism spectrum disorders show a left hemisphere advantage (Brindley & Schmidt, 2009). When their right visual field was isolated, the autistic participants showed a slight increase in accuracy, significantly faster responses, and increased heart rate. Typically developing participants confirmed previous findings of left visual field bias in normal individuals.

Given all of the above, perhaps a method involving visual field isolation would be helpful in remediation of the emotional comprehension deficits faced by children with ASD. Studies of social and emotional skills interventions with autistic children are few, but those available have shown computer interventions to be most effective (Bö lte, Feineis-Matthews, & Poustka, 2008; Lopata, Thomeer, Volker, Nida, & Lee, 2008; Silver & Oakes, 2001). Computer programs work with the natural predispositions of autistic children, who tend to

like structured and predictable environments. Silver and Oakes (2001) found that the traditional student-teacher format of social skills training can be problematic, as it intrinsically requires social interaction. Autistic children have shown increased motivation, attention, and enthusiasm with computer intervention programs; they have also reported satisfaction with programs that are predictable, allow them to make choices, and provide immediate feedback—especially auditory feedback (Lopata et al., 2008). Of course, the obvious caveat with a computer-facilitated face intervention is whether any progress will transfer reliably into real-life human face comprehension.

Expounding on the findings of typically developing individuals' left visual field/right hemisphere bias and superior emotional processing abilities, the present study aimed to implement a left visual field isolation intervention for children with ASD. It was hypothesized that autistic children, allowed to practice matching emotions with only their left eye, would show more improvement in affect comprehension –operationally defined as greater accuracy, faster reaction times, and higher BPM heart rate—than children with ASD who practiced matching emotions to their labels with both eyes uncovered. If the right hemisphere FFA pathway can be conditioned, the children in the experimental group should demonstrate more improvement.

METHOD

Participants

Participants were recruited from Hillcrest and Medary Elementary schools (grades K-3) and Camelot Intermediate School (grades 4-5). Permission to recruit from these schools was granted by the Brookings School District, and parent permission forms were returned by each student. Participants included a total of six boys between the ages of 5 and 11 years, who were randomly assigned to the experimental or control group. The experimental group participants were of the same mean age (M = 7.67 years, SD = 3.06) as the control group (M = 7.67 years, SD = 2.89). All participants had an Individual Education Plan based on the diagnosis of Autism Spectrum Disorder and had normal or corrected-to-normal vision.

Materials

The present experiment utilized SuperLab 4.0 software (Cedrus Corporation, 2008) installed on a MacG4, OS10.4 laptop computer. The software was programmed to randomly present affective pictures and then to prompt participants to choose the corresponding emoticon. SuperLab automatically recorded the accuracy of answers, as determined by placement of a left mouse click. Reaction time was also recorded as the latency between response screen appearance and a left mouse click on any trial.

Affective stimulus pictures were drawn from the experimenter's personal photographs and the public domain picture site Dreamstime Free Images (2009). Pictures were also drawn from an educational photo bank comprised of pictures of college-age students showing a variety of emotions. Students depicted in these pictures gave consent for the use of their images in the project. All photographs were subsequently categorized by affective label— happy, sad, or angry—by a panel of six undergraduate, non-psychology-major judges (4

women, 2 men). Judges were also given a "not sure" option in efforts to exclude any pictures which they judged as unrepresentative of any of the prescribed categories. Pictures were selected for inclusion in the study only if there was at least .80 inter-rater reliability for a certain emotion. Pictures were edited in Photoshop 4.0 (Adobe Systems, Inc., 2005) so that they included only head and shoulders against a white background (See Figure 1).

Biopac MP35 (Biopac Systems, Inc., 2007) was used to collect physiological data. A photoplethysmograph finger wrap, sensitive to changes in blood flow, was plugged into the acquisition unit via Channel 2. Pulse rate information was recorded from the non-dominant index finger and was converted into visual form on a Toshiba Intel Centrino laptop computer connected by USB to the Biopac acquisition unit. Pulse rate data was automatically saved and was then converted into beats per minute units.

To achieve visual field isolation, a pair of children's sunglasses was modified. Original lenses were taken out; the right eye was occluded using black construction paper to cover the entire lens, which was then reinserted. The lateral portion of the left eye of the glasses was covered with black construction paper, as well. Only the medial portion of the left eye was open for sight, achieving right hemisphere visual pathway isolation. A pair of identical children's sunglasses was modified for control group participants by removal of both lenses. No further adjustments were made to these glasses.

DESIGN AND PROCEDURE

The present study was a simple, between-group experiment. Experimental and control groups were equivalent, each including three elementary-school-aged boys diagnosed with Autism Spectrum Disorder. Participants who had returned parental permission forms were individually taken to a quiet area of their normal special education classroom. Teachers were present in the room during the course of the experiment, so as to make participants as comfortable as possible. The participants sat directly in front of the computer monitor and were greeted by a recorded message explaining the procedure. After they assented, participants were fitted with either the experimental or control glasses and the photoplethysmograph on their self-reported non-dominant index finger.

Day 1

Participants were led through practice block of the SuperLab program. They were asked to match a happy, sad, and angry photograph with their respective emoticons. For each of the three practice trials a stimulus picture appeared on screen for 2.5 seconds, followed automatically by a response choice screen. The left third of the screen featured a "happy" emoticon, the middle third a "sad" emoticon, and the right third a "mad" labeled emoticon. A left mouse click in any of these three areas would elicit auditory feedback (prerecorded message). If the participant made a successful match, he would hear "Correct." If the participant answered incorrectly, he would hear "Oops. That's incorrect. Pick a different answer," and then see the stimulus presented again before being allowed to correct the answer. SuperLab would not progress to the next trial until the participant selected the correct answer.

Next, participants completed the baseline block, consisting of 45 matching trials comparable to the ones they had done for practice. Fifteen pictures from each emotional category (happy, sad, or mad) were presented in random order. SuperLab recorded accuracy and reaction times of these baseline responses, while heart rate was recorded by Biopac.

Subsequently, participants completed the feedback block. This was the teaching portion of the intervention, where participants completed the same matching task with 30 new photographs. For each answer, participants heard "Correct" if they completed the trial correctly or "Incorrect. Pick a different answer" if they made an incorrect match. The computer program would show the trial stimulus again and progress to the next trial only after the correct answer had been selected.

Finally, participants completed the no feedback block. This teaching portion utilized the same 30 pictures used during the feedback block, except this time, participants were not told after each trial whether their match was correct. The purpose of withholding feedback here was to discourage the participants from becoming reliant on the feedback once they were asked to complete the final block at the conclusion of three days of the teaching intervention.

Day 2

Participants completed the feedback block in the same manner as Day 1. The no feedback block was also presented in the same manner as day one. Accuracy, reaction time, and pulse rate measurements were recorded but not saved.

Day 3

Day 3 also began with the teaching feedback and no feedback blocks. Then, participants were asked to again complete the 45 trials of the final block which was equivalent to the baseline block. In this way, changes in accuracy, reaction time, and physiological reactions from the start to conclusion of the intervention could be measured. A recorded debriefing message explained the purpose of the experiment, prompted participants to ask the experimenter questions if they had any, and thanked them for their participation. All participants received a small prize upon completion of each of the three sessions, including their choice of stickers, pencils, and pencil grippers. See Figure 2 for a complete diagram of each day's procedures.

RESULTS

Analysis of baseline block measures confirms that there were no significant pre-existing differences between groups in percent accuracy, $t(4) = -.47$, $p = 0.66$ (two-way).

Pre-intervention percent accuracy averaged across both experimental and control groups, was 70%. There were negligible differences between the groups' baseline reaction times, $t(4) = .60$, $p = .58$ (two-way), and baseline heart rates, $t(4) = 1.36$, $p = .25$ (two-way). An alpha level of .05 was designated for this experiment.

Table 1 shows the baseline and final percent accuracy scores, as well as total changes in percent accuracy for each participant. Participants in the experimental group showed an average decrease in percent accuracy ($M = -2.00\%$, $SD = 21.68\%$), while participants in the

control group showed an average increase in percent accuracy (M = 7.41%, SD = 10%). The change in accuracy shown by the experimental group did not differ significant from that shown by the control group, $t(4)$ = -.68, p = .53 (two-tailed). Notably, when the outlier (participant three of the experimental group) was excluded from analysis, the experimental group actually showed an average increase in percent accuracy (M = 10.33%, SD = 5.19%), slightly greater that of the control group, though still not significant.

There were no significant differences between groups on average change in reaction time, $t(4)$ = -.33, p = .76 (two-tailed). The average improvement (decrease) in reaction time (M = 54.82 ms, SD = 3209.86) for members of the experimental group over the course of the intervention was less than average improvement shown by members of the control group (M = 670.73 ms, SD = 503.39). Again, if outlying data from participant three of the experimental group is excluded from analysis, the experimental group showed an average improvement in reaction time (M = 1680.39 ms, SD = 2179.82) greater than that of the control group, though not significantly so, $t(3)$ = .835, p = .465, (two-tailed).

Figure 3 shows that the heart rates of members of the experimental group declined across trials (M = -3.67 BPM, SD = 15.05), whereas heart rates for the control group increased from baseline to final measurement (M = 47.06, SD = 45.64). There was no significant difference between the groups at the .05 level, $t(4)$ = -1.83, p = .14 (two-tailed). If outlying data is excluded from examination (participants 3 and 4), there is, in fact, a significant difference between the mean change in heart rate shown by experimental participants (M = -11.70, SD = 8.16 and mean change in heart rate shown by control participants (M = 47.06, SD = 45.64), $t(2)$ = -10.73, p = .009, (two-tailed). That is, the average heart rate of experimental participants dropped, while the average heart rate of control participants sped up.

DISCUSSION

In contrast to the hypothesis that the group with visual isolation would show significant improvement above that of the control group, no differences were found. In line with similar studies of facial affect recognition in autistic populations (Silver & Oakes, 2001), in the current study, the groups had a combined average of 70% accuracy at the beginning of the first day of intervention. However, contrary to the hypothesis that the visual field isolation group would demonstrate improvement in accuracy beyond the control group, the group's average accuracy actually decreased. A likely explanation for the decrease in average percent accuracy is the outlying data of one participant in the experimental group. This participant was particularly vulnerable to frustration and on the day of final measurements, became visibly irritated. When this data was excluded, the experimental group showed an improvement in accuracy greater than that of the control group. Previous studies of similar intervention programs have garnered mixed results. Lopata and colleagues (2008) also found no significant change in accuracy on children's' ability to identify emotion, whereas Silver and Oakes (2001) found modest improvements.

There are a few ways in which the present method could be improved to clarify changes in accuracy: In the present study, one participant in the control group achieved near-perfect accuracy on baseline and final measures, indicating a possible ceiling effect. Although some

research has indicated children with ASD have the most trouble with emotions of negative valence such as anger and sadness included in the present study (Ashwin et al., 2006), others have found that the most trouble comes with more complex emotions like embarrassment, pride, and jealousy (Golan, Baron-Cohen, & Golan, 2008). Perhaps replacement of current stimulus pictures with those of more complex emotions would assist in discrimination of percent accuracy differences between groups. Additionally, although inter-rater reliability was .80 for all pictures, some pictures were consistently mislabeled by most participants. The mislabeled pictures were judged to be sad, but most children matched them to the mad emoticon. These pictures should be discarded and replaced in future studies.

Both experimental and control groups showed improvement in processing speed by decreasing their reaction times from baseline to final evaluation, though there were not significant differences present. Again, the emotional lability and inattention of participant 3 in the experimental group may misrepresent actual trends in reaction time. If this outlying data is excluded, the experimental group achieved demonstrably faster reaction times than the control group. While faster processing does not necessarily equate with better accuracy in processing emotional stimuli, it does indicate a greater level of stimulus salience, which is an improvement for children with autism, who tend to ignore faces (Krysko & Rutherford, 2009).

The findings of heart rate change in the present study are puzzling. Physiological measures are thought to be a particularly valid measure of arousal because they theoretically should not be affected by the communication impairments present in ASD and have been shown to change relatively quickly with changes in affective state (Liu, Conn, Sarkar, & Stone, 2008). According to Liu and colleagues, two minutes is the minimum amount of time needed to confidently identify these changes; participants in the current study worked on the baseline block and equivalent final block for more than two minutes. Therefore, physiological changes induced by the emotion-laden photographs should have been detected in the current study's participants.

Average heart rates, as measured by Biopac in the current experiment ($M = 128.75$ BPM, $SD = 27.73$) were very high— higher than the 70-80 BPM expected in typically developing individuals (Liu et al., 2008). Possible explanations for this discrepancy include evidence that autistic children have naturally-higher pulse rates than typically developing children (James & Barry, 1980). All of the participants in the present study demonstrated some anxious, repetitive hand activity while recording took place, which likely artificially inflated their heart rates. As this anxious activity took place on both the baseline block of trials and the final block of trials, its effects on the —change in heart rate data of each participant are negligible.

According to the results of the present researcher's past study, ASD individuals showed significantly increased heart rate when viewing stimuli with their right visual field/left hemisphere (Brindley & Schmidt, 2009). If in the present study, left visual field isolation could condition the right hemisphere pathway, the experimental participants would have shown the most increase in arousal to stimuli after practice. The contrary was actually true. When outliers (Participants 3 and 4) were removed from their respective groups, the control group showed a significantly greater increase in heart rate than the experimental group. It is unclear why the control group improved more than the experimental group. Possibly, the experimental group stopped paying attention to the stimuli when they were not allowed to

use their left hemisphere piecemeal strategy. This would fit well with hypothesis that autistic individuals do not pay attention to faces, because they just do not understand them.

Clearly, there were a number of limitations in the present study. Five of the six participants completed all three days of training, but due to illness, one of the children was able to complete only two of the days. Participants generally accepted the photoplethysmograph and glasses without irritation, although at times, participants would fidget with the glasses and move their fingers. Another possible source of error is that some children had to be periodically redirected back to the activity after they would get distracted or start to talk to the examiner.

Though significant differences between groups were not found, each student showed some level of improvement in accuracy and reaction time. It is important to interpret the present findings in light of the fact that the sample size of each group was very small. Additionally, there were severe time restrictions which allowed for only three days of the teaching intervention. Most interventions have occurred over the course of months, not days (Bryson, Rogers, & Fombonne, 2003; Lacava, Golan, Baron-Cohen, & Smith Myles, 2007; Lopata et al., 2008; Silver & Oakes, 2001). Future research should greatly expand the sample size. More time to teach would also allow for the most accurate understanding of visual field isolation and its potential utility in teaching emotional affect comprehension to children with ASD.

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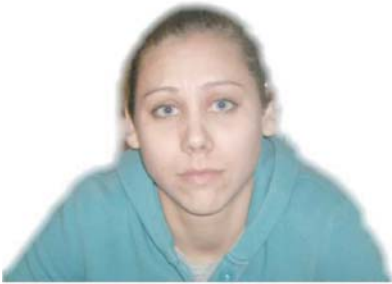
Table 1:

Percent Accuracy by Participants Across Three Days of Affect-Learning Activity

Group	Participant	Baseline	Final	Percent Accuracy
Experimental	1	0.67	0.80	0.14
	2	0.62	0.69	0.07
	3	0.71	0.44	-0.27
Control	4	0.93	0.91	-0.02
	5	0.47	0.64	0.18
	6	0.80	0.87	0.07

Pictures Depicting Happy Affect

Pictures Depicting Sad Affect

Pictures Depicting Angry Affect

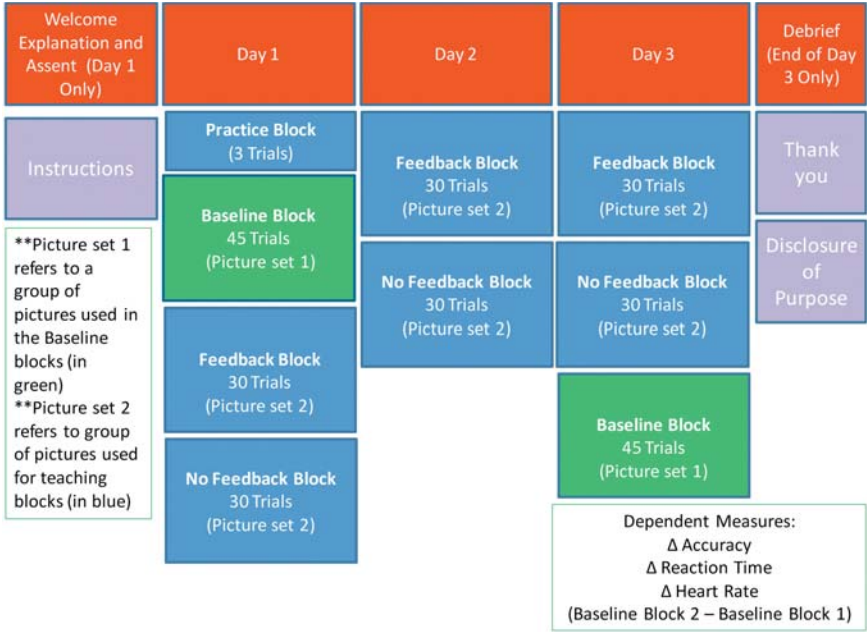**Figure 1.** Examples of facial affect stimuli used in the intervention.

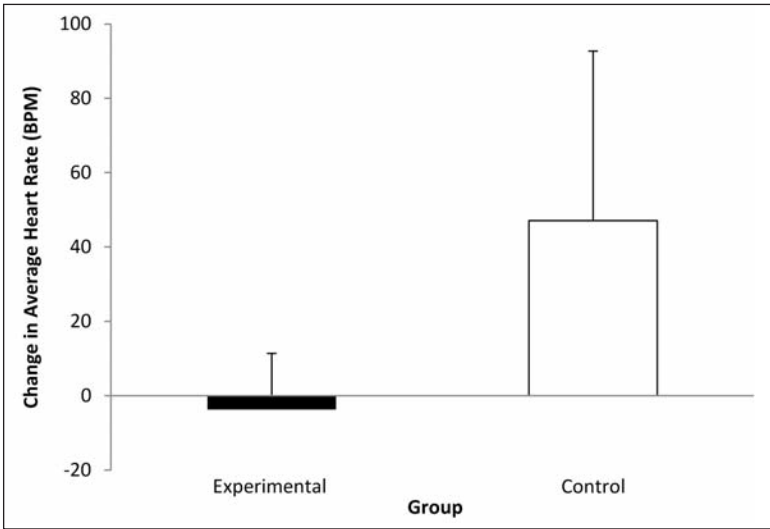**Figure 2.** Three-day intervention design and measurements.

Figure 3. Mean (*SD*) change in heart rate (BPM) for the experimental group (*n* =3), and control group (*n* = 3) across three days of practice on a matching task of facial affective stimuli.

Parental Influence on the Financial Literacy of Their School-Aged Children: An Exploratory Study

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ABSTRACT

The purpose of this research is to assess the parental perception about their financial habits and their children's. This research was conducted through interviews, which were administered through email, on the phone, or in person, in October 2009.

Financial literacy, promoting proper knowledge and habits, is very important in sustaining a healthy economy and in achieving a good personal financial situation. Danes (1994) points out that parents play an essential role in transferring knowledge of the realistic and sensitive aspects of money. Mandell (2009) states that the use or misuse of financial knowledge can affect an entire national economy. Clearly, more financial education is necessary for young adults to better the economy. The family is the source for most of a child's financial knowledge. However, parents seem to pass only their own feelings about money on to their children. If more parents could factually educate their children about finance, children may be less likely to develop poor habits. If enough young adults entered the adult world with sound financial literacy, it could have a macroeconomic effect.

INTRODUCTION

Today's level of personal financial literacy in young adults has declined. More than ever, people now live so far outside of their means that they cannot efficiently manage their debts. The occurrence of bankruptcy has skyrocketed in the last twenty years. People so often purchase items on credit; perhaps they have forgotten the value of their money. Poor choices stem from a lack of knowledge, and finances are no exception. Since 1997, the Jump$tart Coalition for Personal Financial Literacy has studied the financial literacy of high school students. Mandell (2009) reported that the 2008 results of these surveys fell to the lowest ever. The average survey score of 2008 was 48.3%; and 57.3% in 1997-98. Researchers hoped that the initial failing grade in 1997-98 would rise over time, but the opposite took place. Mandell (2009) deduced that an overwhelming 75% of young adults do not have the knowledge to perform well financially. "Financial literacy clearly has ongoing macroeconomic ramifications," (Mandell, 2009, p. 6).

Some researchers focused a large portion of their study of this topic on college-aged students. Thus, few studies show the financial aptitude of younger children. More research on the young children and the early source of poor financial habits would prove beneficial.

College students surveyed in past research thought back to their family and home life and accounted for their financial education from their parents. However, this remains anecdotal and unquantifiable information. More concrete results would stem from studying young children and their parents to form a more valid and reliable description of reasons why some families do not adequately teach their children about finance.

Beverly & Burkhalter (2005) found that research establishes that young people's knowledge of finance is lacking and many do not use optimal financial skills. This statement generalizes current research on this topic. Nevertheless, it seems that researchers have not thoroughly written on this topic as there are only a limited number of articles available. Considering the research found, the common conclusion is that children and young adults desperately need more financial education so they can make more informed decisions as adults.

Researchers have conducted studies on the parental role of a child's financial education. The trend in research demonstrates that a child's most significant source of financial knowledge comes from their family. Danes (1994) points out that parents play an essential role in transferring knowledge of the realistic and sensitive aspects of money. The family, then, must realize this and act accordingly. Clarke, Heaton, Israelsen, & Eggett (2005) argued that a very small amount of research exists pertaining to the passing of information from parent to child about adult roles and responsibilities, particularly about finances. After reviewing past research, it is evident that more research is necessary to see how parents effectively communicate financial messages to their children.

Adolescents in particular experience difficulty in receiving proper financial guidance. Many parents do not feel that they can influence their teenage child's spending habits due to peer influence. Furthermore, many teenagers have a high spending rate when using cash, checks, or credit cards. Pinto, Parente, & Mansfield (2005) established that the age at which young adults receive credit cards is dropping. As children have access to more money and credit at a younger age, the need to ensure a quality financial education increases. Clarke, et al. (2005) found that if teens have not received proper financial education from their parents, they are likely to have unrealistic income aspirations and unwise financial habits.

Families provide the most deep-seated education. Clarke, et al. (2005) found that the poor financial habits of parents commonly present themselves in their children's lives. Children watch and model their parental figures. From birth until they leave home, children look to their parents for guidance and knowledge of the world. Clarke, et al. (2005) explained that parents have a duty to educate and guide their children into taking on mature responsibilities and tasks. They play the role of primary educator in a child's life. Parents themselves may not feel comfortable with their own financial situation so they do not want to talk about it with their children. Edwards, Allen, & Hayhoe's (2005) research found that young adults are more reserved about discussing their personal finances with parents who (a) have a fixation with money, (b) associate money with authority, and (c) make unwise budgetary and savings decisions. Parents must establish good lines of communication with their children about several aspects of the adult world, especially finance.

Young people must learn about financial responsibility before they develop lasting poor habits. Bowen & Jones (2006) emphasize that young adults who lack education in matters of personal finance will eventually have the control of our nation's financial culture. The general economy may improve by simply helping children learn about money at an early

age. Clarke, et al. (2005) suggests that young adults feel more equipped to handle financial responsibilities if they acquired a good education on the subject at home. This shows that the best education starts at home. As research has indicated, families should place high priority on teaching children about finances and the associated future adult responsibilities.

Schools also play a part in a child's financial education, though a less significant part than parents. Pinto, Parente, & Mansfield (2005) have observed that after a child starts kindergarten, most of that child's time will be spent within the school. The school system provides an effective way to reach children and teach them about personal finance. Unfortunately, many states do not require that schools incorporate finance into their curriculum. Green (2009) clarifies that in the last five years, seventeen states have made personal finance mandatory in their educational programs. She adds that only in Missouri, Tennessee, and Utah, students have to take a course specifically covering personal finance. Two websites in particular have begun trying to promote financial education in schools: Jump$tart Coalition (http://www.jumpstart.org) and National Endowment for Financial Education's High School Financial Planning Program (http://hsfpp.nefe.org). These sites provide free and low cost educational tools for all ages to learn about personal finance. Though some schools across the country have begun incorporating financial education, it still does not have the impact that parents do. Furthermore, according to Mandell (2009), students who take a financial class in high school receive similar scores on the Jump$tart Coalition survey as students who do not. This proves that the financial courses in schools may not actually have a substantial effect.

Among all ages, harmful financial practices are on the rise in America. Edmiston (2006) identified that five times more people are filing for bankruptcy than in 1980. Likewise, comparing the FDIC Press Release (2010) and Reinsdorf's (2007) statistics, it is evident that personal savings rates are currently more than six percent lower than in the early 1980s. As stated by Mandell (2009), three quarters of America's young adults do not have an adequate amount of financial knowledge. His data exemplifies that financial illiteracy leads to more individuals making poor decisions in their money management. Mandell (2009) has also stated that the use or misuse of financial knowledge can affect an entire national economy.

The rate that individuals save their money lacks promise. In a February 2007 report by the Bureau of Economic Analysis, Reinsdorf (2007) shows the highest rate of personal savings occurred in the mid-1940s at over 25% of income. This report also shows that in 2005 and 2006 the savings rate dropped to a negative number. Fortunately the savings rate has risen, but only to a meager 4.6% in 2009, as a February 2010 press release by the Federal Deposit Insurance Corporation confirms. Personal savings rates are so low that it seems as if people do not have necessary concern for their future. Clearly, an underlying cause of all these problems is a lack of financial literacy. More financial education is necessary for young adults to better the economy.

Financial literacy, promoting proper knowledge and habits, remains important in sustaining a healthy economy and in achieving a good personal financial situation. When young people learn about finance, they will take those skills and habits with them into their adult years. As children best learn about adult responsibilities from their parents and home-life while growing up, it is important to study the transfer of financial knowledge from parent to child. This research assesses the parental perception not only about their financial habits but also their children's.

METHODS

The research for this paper was conducted using interview questionnaires given to parents through phone, e-mail, and in-person (see Appendix A). Six of the ten interviewees were from Gregory County, SD; and the other four were from Brookings, SD. E-mails were sent to the parents of 5th graders in Gregory County; and one phone interview was given to a parent there. Three parents in Brookings were interviewed by e-mail and one in person. These interviews were all conducted between October 12th and 14th, 2009.

Basic demographic questions asked were: age, income, number and age of children, and marital status. A scale was given so the participants could choose their bracket for age and income. Marital status was selected between single and married. The children's information was simply filled in by the participant.

The core questions in the interview were left open-ended to permit various responses. Creswell (2003) explains that the open-ended data leads to a qualitative analysis of the results. Creswell (2003) also describes qualitative research as open to explanation–implying that the interviewer provides their own understanding of the responses. The first questions asked about the participant's ease and frequency in addressing their children about financial matters; and then asked for elaboration. Next, these questions addressed the participant's own financial beliefs compared with that of their children. The last question asked about what could potentially benefit their children's financial futures.

RESULTS

The compiled demographics appear in Table 1. Seven participants are married and three are single. Seven are aged in their thirties, and three are in their forties. The average household income of participants is between $40,000 and $49,000. Three participants reported a household income of $0-$19,000 and five reported the highest income of $60,000+. The median age of the participants' children is eleven years, ranging from two to nineteen. The median number of children in the participants' families is three, ranging from two to six.

Table 1: Participants characteristics

	number of children	marital status	age	children's age	household income ($)
Participant 1:	3	single	30-39	10,13,16	0-19000
Participant 2:	6	married	40-49	8,8,10,11,15,17	60000+
Participant 3:	2	married	30-39	6, 7	60000+
Participant 4:	4	single	30-39	12,13,16,19	0-19000
Participant 5:	3	married	40-49	10,13,16	60000+
Participant 6:	4	married	30-39	2,8,10,12	60000+
Participant 7:	2	married	30-39	7, 17	30-39000
Participant 8:	4	married	40-49	2,15,18,19	60000+
Participant 9:	3	married	30-39	5,9,11	40-49000
Participant 10:	4	single	30-39	9,10,12	0-19000

The responses to the core questions were compared to each other and some prominent findings were discovered. Corresponding figures appear in Appendix B.

All four of the single participants only talk to their children about finances 'Sometimes', as well as one married participant. The remaining six married participants talk with their children 'Often' or 'Very Often' about finances (see Appendix B, Figure B1).

Seven of the participants feel comfortable talking about finance with their children. They all explain that they do so to build their children's knowledge of finance so they can apply it properly when they are older. Three participants are not at all or only somewhat comfortable talking to their children about finance. They each had different reasons: the parents themselves feel negative about their financial situation, the children do not understand finance, or the parent does not want to stress their children with financial matters (see Appendix B, Figure B2).

When asked how they could increase the amount of time they talk to their children about finances, the participants responded in a few different ways. Three participants said they would simply need to find time to address this matter. Four responded they are unsure. The other three participants responded as follows: do nothing, engage the children as appropriate by age and situation, and make them work more for their money (see Appendix B, Figure B3).

Six of the participants felt that saving money was very important. However, only three felt that their children held the same value (see Appendix B, Figure B4). Only two participants felt very confident in their own financial decisions; four were not very confident and four were somewhat confident. Likewise, only two felt very confident in their children's financial decisions; three were not very confident and five were somewhat confident (see Appendix B, Figure B5).

The last question, addressing what participants think will best benefit their child's financial future, produced a variety of responses. Some participants responded with more than one option of ways to help their children's financial future. Of the ten participants, five responded with just one idea, four responded with two ideas, and one responded with three ideas; creating a total of 16 total responses. The most frequent answer that appeared in eight participant responses was parental influence, or education from home. The other two answers received four responses each: financial education in a school classroom setting, and learning from real world experiences (see Appendix B, Figure B6).

CONCLUSIONS

This research was conducted to learn about personal financial literacy passing from parent to child. It was to show frequency, effectiveness, and a correlation, if any, to lifestyle and personal beliefs. The research shows, on a small scale, what may commonly occur among America's population.

The supporting idea of this research is that a parent's personal feelings about finance determine how they pass financial information to their child. The participants who felt comfortable talking with their children about financial matters do so because they want their children to have strong knowledge of personal finance to help with a better future. The participants who do not feel comfortable talking with their children about financial matters

either do not understand it themselves, think their children will not understand it, or they do not want their children to stress about it. Two of the three participants who do not feel comfortable talking with their children about financial matters also responded that they are not very confident in their own financial decisions and do not regard saving money as important. The third is only fairly confident in personal financial decisions and is not likely to save money. These results reveal parents who are passing their own feelings about money on to their children.

Other research has also come to this conclusion. Pinto, Parente, and Mansfield (2005, p. 360), presented findings by Cohen & Xiao (1992) and Hira (1997): "financial attitudes and spending behavior … are thought to be transmitted by parents and other influential individuals." Furthermore, Clarke, et al. (2005) explained that the poor financial habits of parents commonly present themselves in their children's lives.

Parental guidance in financial matters is of primary importance. Children learn the most from home. Also, as the results show, parents themselves realize their importance in their children's education. Eight of the ten participants interviewed responded that more interaction from them would help most with their children's financial education and future. Knowing this, there should be more emphasis on parents to help their children understand personal finance.

The connection between lifestyle and financial capability of parents and children is evident in the research. All of the three single participants, who are also the only three in the lowest household income bracket, are the least likely to have financial confidence in themselves and their children. Also, these three participants and their children are the least likely to understand the importance of saving their money. Single working parents do not always have much quality time to spend with their children. This lack of time with their children implies reason for the lack of financial education at home. On the contrary, the four married participants in the highest reported income bracket are the most likely to have financial confidence in themselves and their children. These participants and their children are also the most likely to understand the importance of saving their money and actually practice it. The same conclusion arises in Mandell's (2009) results: students with parents who earn a higher income are likely to score higher on the Jump$tart Coalition survey.

Another observation from the research shows that parents hold different views of when the right time is to teach their children about finance. Some participants only talked about financial matters to their children of upper-teenage years. Half of all the participants made age based comments in some of their responses. They talk with the older children about finance but not the younger. They do not think it is necessary to teach their children about finance until a later age. On the contrary, one participant in particular has children ages six and seven who are already learning about spending and saving and price comparison. The perception of a child's preparedness to learn about finance definitely varies from household to household. If more parents started educating their children earlier about finance, the children may be less likely to develop the poor habits in their early years.

The family is the source of a majority of a child's financial knowledge. This is reflected in other research studies as well as in these results. Pinto, Parente, & Mansfield (2005) offer one reference to this: Children in America feel that most of their financial knowledge came from their parents. Although most of the participants admit that they should be the ones

teaching their children about financial matters, many of them still don't have an active involvement with their children on the issue. There must be a way to awaken the parents that are least likely to have financial confidence and financial knowledge; and to help them learn and teach their children. Modern theorists and cultural philosophers agree that parents have a duty to educate and guide their children into taking on mature responsibilities and tasks, as Clarke, et al. (2005) found.

LIMITATIONS

The small number of people interviewed is a limitation. A more thorough collection of data could have been found if more people were interviewed. Also, if more were interviewed from other parts of the state or regions of the country it would give a more broad perspective. A sampling bias is evident as some of the parents who received the interview e-mail might have not responded. Parents who themselves are not comfortable with personal finance may not have responded to the e-mail survey. This limitation is characterized by the unlikelihood of people to freely give information that they are not comfortable with. Also, some families may simply be more private about their financial information.

ACKNOWLEDGEMENTS

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APPENDIX A - INTERVIEW QUESTIONS

1) How many children do you have? _____
2) Are you a single parent or are you married? *Single; Married*
3) What is your age? *18-29; 30-39; 40-49; 50-59; 60+*
4) What are the ages of your children? _____
5) What is your household income? *$0-$19,000; $20,000-$29,000; $30,000-$39,000; $40,000-$49,000; $50,000-$59,000; $60,000+*
6) Do you feel comfortable talking with your children about financial matters?
   a) Why?
   b) Does your spouse?
7) How frequently do you and/or your spouse talk to your children about money?
   Very Often (2+ times/week); Often (once/week); Sometimes (1-2 times/month); Rarely (1-3 times/year); Never
   a) Do you think this is enough?
   b) What can you do to increase the number of times you talk to your children about money?
8) How important is saving money to you and/or your spouse?
9) How well do your children understand the importance of saving money?
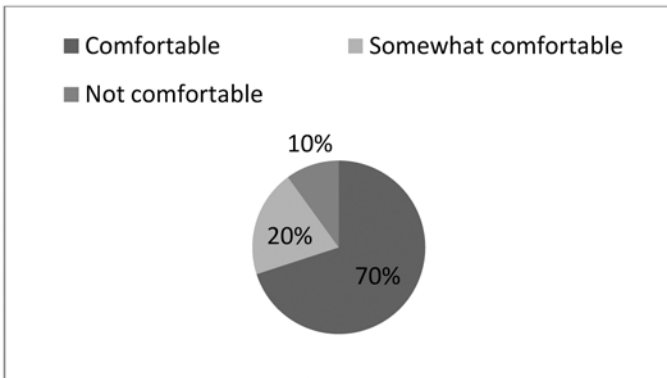10) How confident are you in your own financial decisions?

11) How confident are you in your children's financial decisions?
12) What do you feel would help your children most with financial education and their financial future?
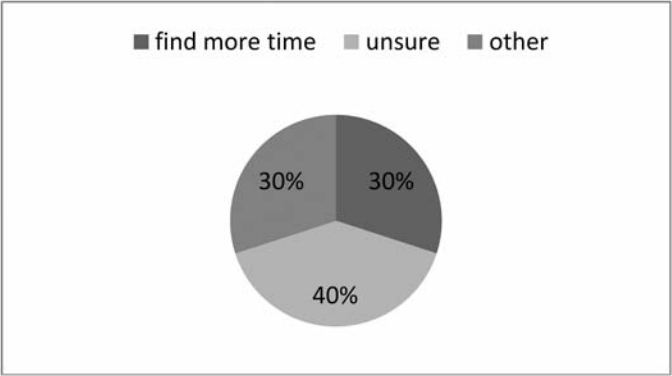
APPENDIX B – FIGURES

Figure B1: How frequently do you and/or your spouse talk to your children about money?
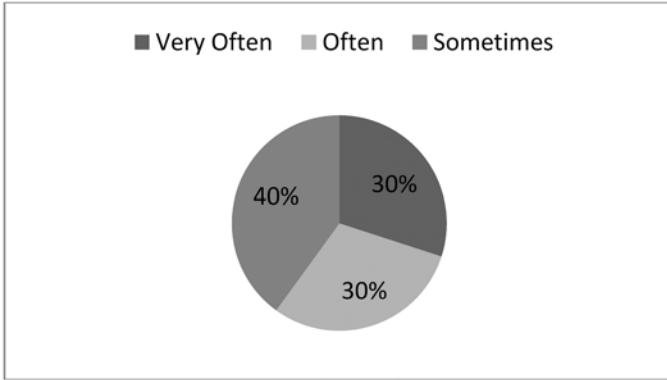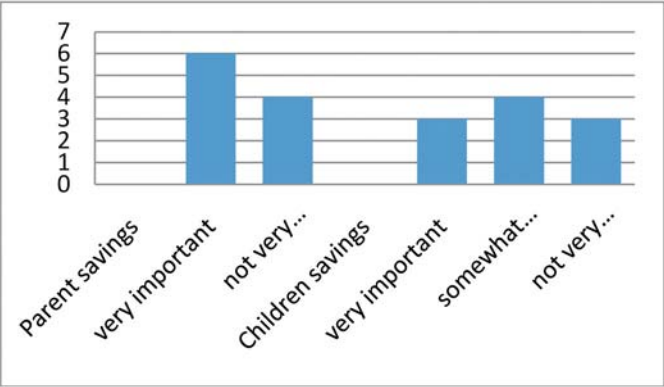

Figure B2: Do you feel comfortable talking with your children about financial matters?
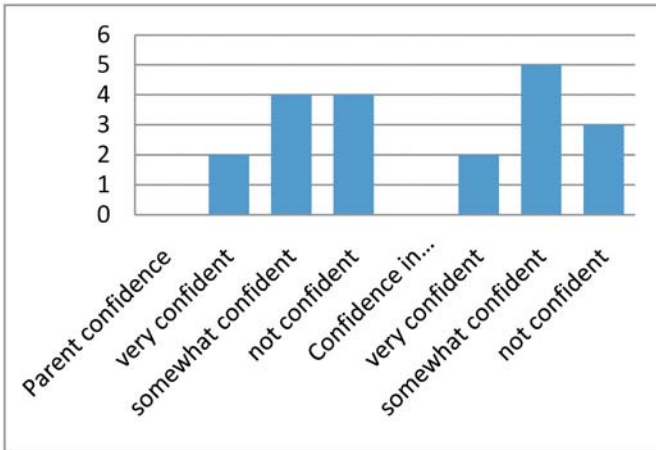
**Figure B3:** What can you do to increase the number of times that you talk with your children about money?

Figure B4: How important is saving money to you and/or your spouse? How well do your children understand the importance of saving money?

Figure B5: How confident are you in your own financial decisions? How confident are you in your children's financial decisions?

Figure B6: What do you feel would help your children most with financial education and their financial future?
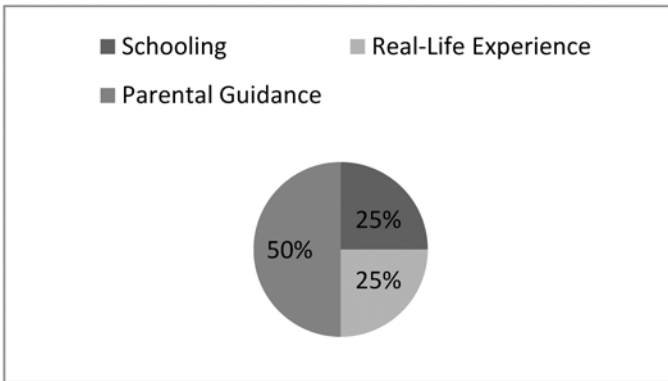
Formula SAE Impact Attenuator Testing

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ABSTRACT

The purpose of this paper is to validate the impact attenuator designed by SDSU Formula SAE team according to 2010 Formula SAE rules. The impact attenuator is made of Plascore PCGA-XR1-5.2-1/4-P-3003 aluminum honeycomb that is pre-crushed to 245 psi. The test was dynamically performed using a 661 lb mass dropped 8.3 ft onto the material sample at 23 ft/sec, and data was measured with an Olympus i-SPEED 3 high speed camera. The impact attenuator must have an average deceleration equal to or less than 20 G's and a peak deceleration equal to or less than 40 G's. Two specimens were tested. The physical dimensions of the first specimen are 10 inches long by 8 inches wide by 5 inches tall. Data of the first sample showed a peak deceleration of 46.88 G's and an average deceleration of 17.86 G's. The velocity at impact was above 24ft/sec. The second specimen is 10 inches long by 10 inches wide by 4 inches tall. The second sample had a peak deceleration of 36.2 G's and an average deceleration of 14 G's. The velocity at impact was slightly above 23ft/sec. The first sample was unacceptable and the second specimen was acceptable under the guidelines set forth by Formula SAE Rule B.3.21.1.

INTRODUCTION

Formula SAE is a student design competition organized by the Society of Automotive Engineers. In the mid 1970s, several universities began hosting local student design competitions with off-road vehicles called SAE Mini Bajas. At one of the competitions, Fred Stratton, from the Briggs & Stratton Corporation (B&S), was a design judge. After judging the competition, there was a strong connection with SAE and B&S. A few years after the Mini Baja gained popularity, members developed the idea of a road race instead of off-road and so the SAE Mini Indy was born in 1978.

The experiments performed in this paper will focus on the impact attenuator required by the 2010 Formula SAE Rules. To understand the type and design of the vehicle in question, South Dakota State University's 2009 Formula SAE Car is presented in Figure 1. The impact attenuator is located under the front of the nosecone.

Figure 1: SDSU 2009 Formula Car.

An Impact Attenuator, which is also known as a crash cushion or crash attenuator, is a device that is used to reduce the damage done to structures, vehicles, and motorists resulting from a motor vehicle collision. Attenuators are designed to absorb the vehicle's kinetic energy in the form of an even deformation. If the deformation is uneven, then the motorist might suffer injury by experiencing spikes in G's.

Impact attenuators are very common in the automotive industry and can be largely depending on the application. FSAE rule B.3.21.1 is the testing guideline for this experiment and states; "the team must submit test data to show that their Impact Attenuator, when mounted on the front of a vehicle with a total mass of 300 kg (661 lbs) and run into a solid, non-yielding impact barrier with a velocity of impact of 7.0 m/sec (23.0 ft/sec), would give an average deceleration of the vehicle not to exceed 20 g's with a peak deceleration less or equal to 40 g's"[1]. The rules are very open to what type of experiment the teams perform to test the attenuator. Dropping a weight from a calculated height is an easy and effective way to test an attenuator. A clear explanation of the test method and supporting calculations must justify that the attenuator will meet the design requirements. It is suggested that a full-scale sample attenuator is used, as there are many factors in the scaling process.

The purpose for collecting and analyzing data for different impact attenuator materials is to find a proper material that meets the rules and application requirements. The dynamic testing was completed by dropping an object of known mass from a known height onto the full-scale impact attenuator while measuring the deformation of the specimen. Once data was collected, the calculations were performed to check if the materials meet rule requirements.

METHODS

To determine how high to drop the mass that would allow it to attain the proper velocity at impact, principle of conservation of energy was used. Using the potential and kinetic energy equation, the energy conservation is presented in equation (1).

$$\tfrac{1}{2}mv_0^2 + mgh_0 = \tfrac{1}{2}mv_f^2 + mgh_f \tag{1}$$

Where,   m = mass

v_o = initial velocity

g = gravity
h_o = initial height
V_f = final velocity
h_f = final height

Defining the final position, when the mass impacts the attenuator, the right hand side of the equation can be reduced by stating the final height is equal to zero. The left hand side of the equation is reduced by recognizing that the mass has an initial velocity of zero. The mass in the equation is the same for each term so it is divided at both sides of equation (1). Then equation (1) is reduced to the equation presented in equation (2). Solving Equation 2 for initial height gives equation (3).

$$gh_0 = \tfrac{1}{2}v_f^2 \tag{2}$$
$$h_0 = \tfrac{1}{2g}\, v_f^2 \tag{3}$$

In order to find the deceleration of the mass, data was taken from an Olympus i-SPEED 3 high speed camera. The camera was set to capture pictures at a rate of 7500 frames per second. A checkered pattern placed on the barrel provided the data analyzer with a known pixel per inch to calculate the speed of the barrel before and during impact. The video collected by the camera was analyzed frame by frame. Knowing the frames per second and the distance that the barrel fell per frame of video gives the velocity of the barrel, which is the change in distance per time. Deceleration is the change in velocity per time, so using the data calculated from the camera the deceleration of the barrel was found over the crushing of the impact attenuator.

To test the impact attenuator for the 2009-2010 South Dakota State University formula car, the team designed the model presented in Figure 2. The structure is modeled to have at least 8.2 feet between the bottom of the falling mass and the top of the impact attenuator so that the mass will attain the proper velocity at impact. The mass is a 30 gallon barrel filled full with concrete. I-bolts were inserted in the sides of the barrel to use for lifting if necessary.

A half inch aluminum plate was placed on the frozen ground as a platform. Testing was performed in the middle of winter when the temperature outside was well below freezing to minimize the energy absorbed by the ground. The structure design is modeled around the overhead hoist available for use at South Dakota State University. The impacting mass is attached to the overhead hoist with a rope. The rope is cut to release the mass from the overhead hoist allowing the mass to fall on the impact attenuator.
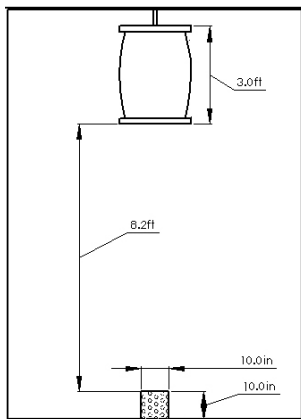
The overhead hoist and all components of the testing procedure are presented in Figure 3. The aluminum plate was centered under the impacting mass using a plumb bob. The barrel was fitted with a checkered pattern so the high speed camera would have sufficient points for data recovery. The high speed camera was placed approximately 10 feet from the impact attenuator. When the mass was released the camera operator pressed a button to capture the process.

Figure 2: Model of Testing Method.

Figure 3: Overhead Hoist and Testing Components.

After capturing the process with the camera, the data was analyzed using i-SPEED Control Pro Software. A screen shot of the software during analysis of the testing is presented in Figure 4. The data collected was calculated into the velocity of the barrel before impact and the deceleration of the barrel after impact.
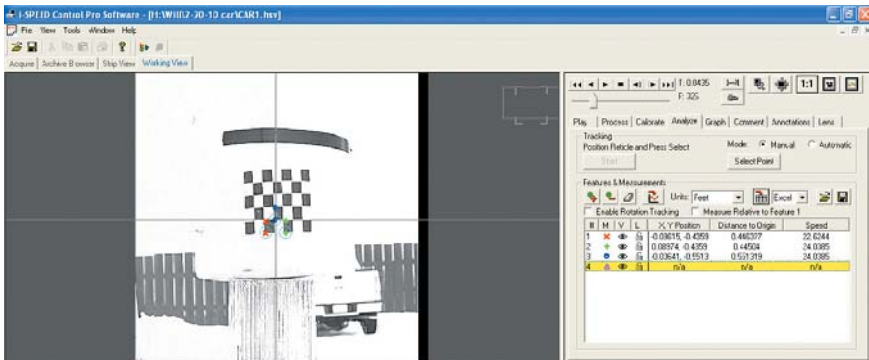

Figure 2: Velocity Before Impact.

RESULTS

The experimental results of the impact attenuators were calculated via the high speed camera. Velocity, deceleration, and G-force were then calculated from the results of the high speed camera. Each of the values was placed into figures to show the relation to time. The values of sample 1 from the high speed camera are listed in Table 1.

Table 1: Sample 1 High Speed Camera Results.

Frame#	Time(s)	Track Point 1				Track Point 2			
		x	y	distance	speed	x	y	distance (in)	Speed (in/s)
230	0.046	0	0	0	0	18.768	14.275	23.580	-1.000
240	0.048	0	0	0	0	18.768	14.783	23.891	253.623
250	0.05	0	0	0	0	18.768	15.362	24.254	289.855
260	0.052	0	0	0	0	18.768	15.870	24.578	253.623
270	0.054	0	0	0	0	18.768	16.449	24.956	289.855
280	0.056	0	0	0	0	18.768	16.957	25.294	253.623
290	0.058	0	0	0	0	18.768	17.536	25.686	289.855
300	0.06	0	0	0	0	18.768	18.0430	26.035	253.623
310	0.062	0	0	0	0	18.768	18.478	26.338	217.391
320	0.064	0	0	0	0	18.768	18.913	26.645	217.391
330	0.066	0	0	0	0	18.768	19.348	26.955	217.391
340	0.068	0	0	0	0	18.768	19.710	27.216	181.159
350	0.07	0	0	0	0	18.768	20.072	27.480	181.159
360	0.072	0	0	0	0	18.768	20.362	27.692	144.928
370	0.074	0	0	0	0	18.768	20.652	27.906	144.928
380	0.076	0	0	0	0	18.768	20.942	28.121	144.928
390	0.078	0	0	0	0	18.768	21.159	28.284	108.696
400	0.08	0	0	0	0	18.768	21.377	28.447	108.696
410	0.082	0	0	0	0	18.768	21.522	28.556	72.464
420	0.084	0	0	0	0	18.768	21.667	28.665	72.464
430	0.086	0	0	0	0	18.768	21.739	28.720	36.232
440	0.088	0	0	0	0	18.768	21.812	28.775	36.232
450	0.09	0	0	0	0	18.768	21.884	28.830	36.232
460	0.092	0	0	0	0	18.768	21.957	28.885	36.232
470	0.094	0	0	0	0	18.768	21.957	28.885	0.000
480	0.096	0	0	0	0	18.768	21.957	28.885	0.000
490	0.098	0	0	0	0	18.768	21.957	28.885	0.000
500	0.1	0	0	0	0	18.768	21.957	28.885	0.000
510	0.102	0	0	0	0	18.768	21.884	28.830	36.232
520	0.104	0	0	0	0	18.768	21.884	28.830	0.000

The calculated result for velocity of sample 1 does not match the experimental velocity results. The calculated velocity is 23 ft/sec while the video shows 24.1546 ft/sec. Figure 5

shows the experimental velocity. The velocity is initially 24.1546 ft/sec and steps down per unit time. The time it takes to reach zero velocity is .042 seconds.

Figure 5: Sample 1 Experimental Velocity.
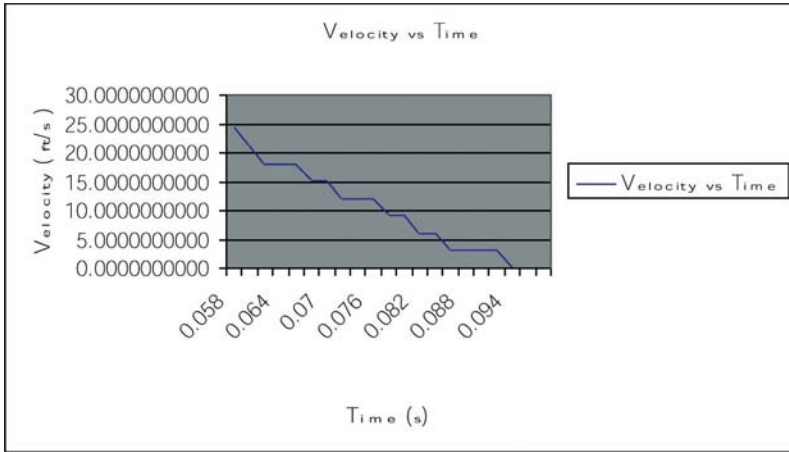
The deceleration of the mass in theory will have an initial spike on impact and a smoothed curve after impact. The deceleration being directly related to velocity and time can be found for each time interval.

The average deceleration is found to be 575.4128 ft/s^2. The deceleration versus time graph is shown in Figure 6.
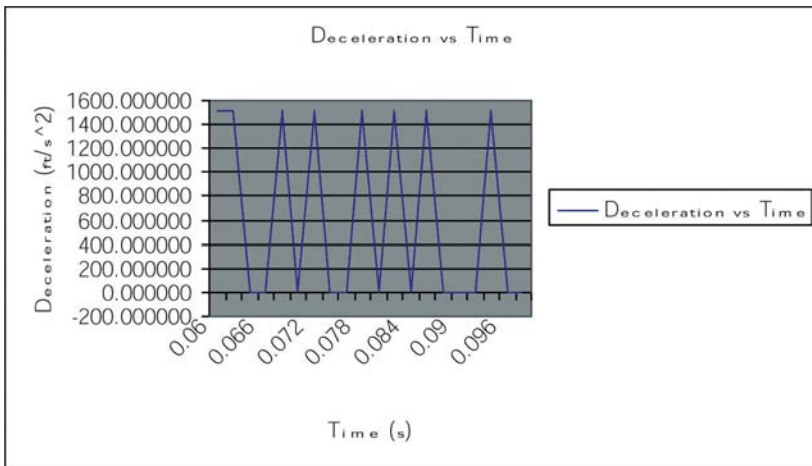

Figure 6: Sample 1 Experimental Deceleration.

The G-force is calculated using the deceleration value divided by the gravitational constant. The FSAE rules limit the average G-force to 20 G's. The calculated average G-force for specimen 1 is 17.8616 G's and the max G- force is 46.88 G's. The graph of the G-force will be similar to the deceleration graph. Figure 7 shows the G-force versus time graph.
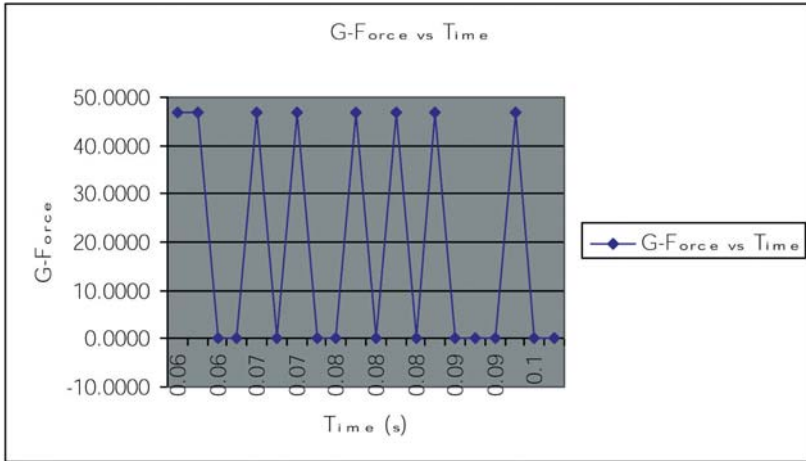
Figure 7: Sample 1 Experimental G-force.

Corrected values for both the deceleration and G-force are shown in graphs below. This is done to smooth the graph of each; it omits the values at which the deceleration and G-force values are at or near zero. These graphs are shown in Figure 8 and 9.
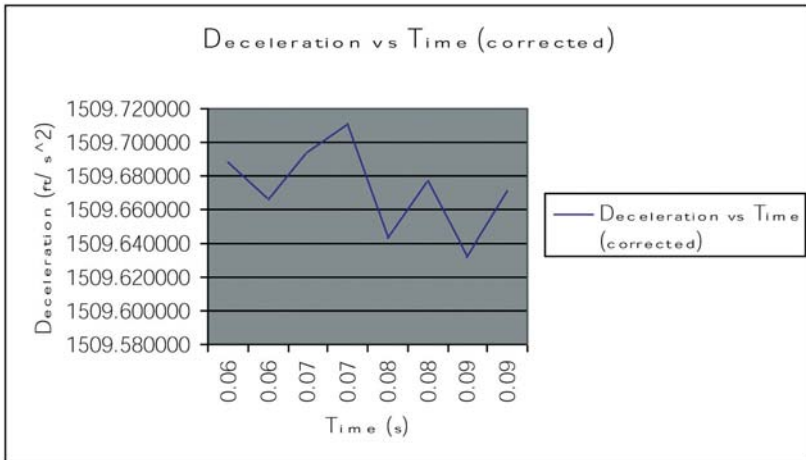
Figure 8: Sample 1 Experimentally Corrected Deceleration.
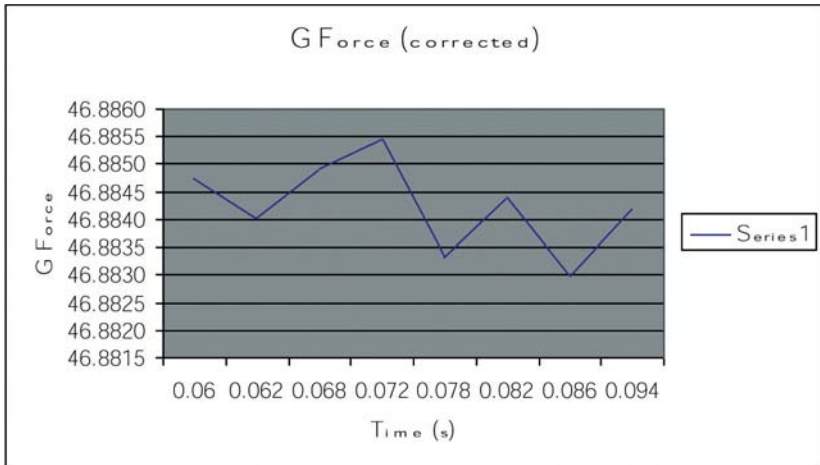
Figure 9: Sample 1 Experimentally Corrected G-Force.

The 2nd specimen used as an impact attenuator is shown before and after testing in Figure 10 shows the second specimin used as an impact attenuator before and after testing.

Figure 10: Sample 2 Impact Attenuator Before and After Testing.

Using the data from the high speed camera, the velocity before impact was found to be 24.04 ft/sec and is shown in Table 2.

Table 2: Sample 2 Velocity before Impact.

Frame #	Time (s)	Track Point 2		Distance (ft)	Velocity (ft/s)	Track Point 3		Distance (ft)	Velocity (ft/s)
		x	y			x	y		
292	0.039	0.090	-0.545	0.552	-	-0.006	-0.660	0.660	-
326	0.043	0.090	-0.436	0.445	24.038	-0.006	-0.551	0.551	24.038

The camera cannot read the initial speed until it tracks the distance between two data points. This is why the velocity cannot be displayed for the initial frame.

After the velocity was proven to be above the required 23 ft/sec before impact, data was compiled for the full impact and is shown in Table 3.

Table 3: Sample 2 Deceleration of Barrel during Impact.

Frame #	Time (s)	x	y	Distance (ft)	Velocity (ft/s)	t	V (ft/s)	Acceleration (ft/s2)	g
292	0.039	-0.096	-0.53	0.552	-	-	-	-	-
326	0.043	-0.096	-0.436	0.445	24.038	0.00453	-	-	-
360	0.048	-0.096	-0.327	0.341	22.436	0.00453	-1.60	-353.5	-11.0
377	0.050	-0.096	-0.282	0.298	19.796	0.00227	-2.64	-1164.5	-36.2
399	0.053	-0.096	-0.224	0.244	19.668	0.00293	-0.13	-43.8	-1.4
420	0.056	-0.096	-0.173	0.198	18.315	0.00280	-1.35	-483.1	-15.0
440	0.059	-0.096	-0.128	0.160	16.827	0.00267	-1.49	-558.0	-17.3
462	0.062	-0.096	-0.077	0.123	17.483	0.00293	0.66	223.5	6.9
492	0.066	-0.096	-0.026	0.100	12.821	0.00400	-4.66	-1165.5	-36.2
519	0.069	-0.096	0.019	0.098	12.464	0.00360	-0.36	-98.9	-3.1
549	0.073	-0.096	0.058	0.112	9.615	0.00400	-2.85	-712.3	-22.1
584	0.078	-0.096	0.096	0.136	8.242	0.00467	-1.37	-294.3	-9.1
624	0.083	-0.096	0.128	0.160	6.010	0.00533	-2.23	-418.5	-13.0
670	0.089	-0.096	0.147	0.176	3.135	0.00613	-2.87	-468.6	-14.6
720	0.096	-0.096	0.154	0.181	0.962	0.00667	-2.17	-326.1	-10.1
								Average	-14.0

It is shown that the peak deceleration was 36.2 G's and the average deceleration was 14 G's which is in compliance with 2010 Formula SAE rule B3.21.1.

DISCUSSION

The results of the impact attenuator have to meet specific requirements of the FSAE rulebook. The rulebook states the maximum deceleration of a certain mass must not exceed

40 G's and maintain an average G-force of 20 G's. The result from the first sample showed a max G-force of 46.88 G's and an average of 17.86 G's. The peak deceleration needs to be equal to or less than 40 G's so the first attenuator did not pass the test.

The second specimen was tested with better methods and corrected camera settings. The second attenuator performed within the rules and guidelines. The peak deceleration of the second sample was 36.2 G's and the average deceleration was 14 G's which is in compliance with 2010 Formula SAE rule B3.21.1.

LIMITATIONS

For the first test specimen the conflict in our data came from several sources. The camera recorded images with a certain pixels per inch and during analysis of the video points were selected from frame to frame. The pixilated image differed from frame to frame and made it difficult to choose points consistently during analysis which lead to the jumps in velocity in the data. The deceleration and G-force is directly related to the velocity. Any erroneous data could lead to invalid results of the calculated G-force. The experimental velocity is also higher than the FSAE specification velocity. This also led to a higher maximum G-force calculation. Another problematic area is the mass did not hit the honeycomb exactly perpendicular.

The deceleration and G-force graphs have a corrected graph in order to smooth the points in the graph. This is done to show an accurate measure of the peak deceleration and G-force data points. The points omitted are the points at which the deceleration and G-forces were zero.

ACKNOWLEDGEMENTS

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[1] 2010 Formula SAE® Rules, http://students.sae.org/competitions/formulaseries/rules/2010fsaerules.pdf

APPENDIX

PLASCORE®

PCGA-XR1 3003
Aluminum Honeycomb

Description:

PCGA-XR1 3003 commercial grade aluminum honeycomb is a lightweight core material offering excellent strength and corrosion resistance for industrial applications at low cost. PCGA-XR1 3003 honeycomb is made from 3003 aluminum alloy foil.

Applications:

PCGA-XR1 3003 honeycomb uses include air/light directionalization, energy absorption, tooling, ceiling and floor panels, counter tops and other applications for which elevated physical and mechanical properties are not required.

Features:

- Use temperatures up to 350°F
- High thermal conductivity
- Flame resistant
- Excellent moisture and corrosion resistance
- Fungi resistant
- Low weight / High strength

Availability:

PCGA-XR1 3003 honeycomb is available in four forms: unexpanded blocks, unexpanded slices, untrimmed expanded sheets and cut to size expanded sheets. It is also available with or without cell perforations to facilitate cell venting for certain applications.

Cell Sizes:	1/4" - 1.0"
Densities:	1.4 pcf - 5.2 pcf
Sheet "Ribbon" (L):	48" typical
Sheet "Transverse" (W):	96" typical

Tolerances:		
	Length:	+ 6", - 0"
	Width:	+ 6", - 0"
	Thickness:	± .008" (under 4" thick)
	Density:	± 15%
	Cell Size:	± 15%

NOTE: Special dimensions, sizes, tolerances, CNC machining and die cut to size can be provided upon request.

Plascore, Inc. employs a quality management system in the manufacture of honeycomb core and composite panels that is ISO 9001:2000 certified.

PCGA-XR1 3003 commercial grade aluminum honeycomb is specified as follows:

Material - Density - Cell Size - Perforated - Alloy

Designates aluminum commercial grade

The nominal density in pounds per cubic foot

Cell size in inches

Example: **PCGA** - **XR1** - **1.8** - **3/4** - **P** - **3003**

Designates XR1 corrosion coating

Indicates cell walls are perforated

Designates the alloy of the foil
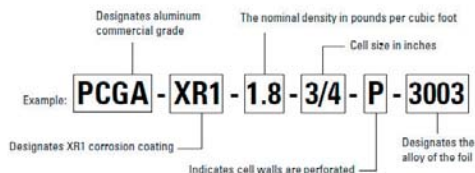
PCGA-XR1 3003 Mechanical Properties

PLASCORE® Honeycomb Designation			Bare Compressive		Plate Shear			
					STRENGTH PSI		MODULUS KSI	
CORE TYPE	CELL SIZE	DENSITY	STRENGTH PSI	MODULUS KSI	"L"	"W"	"L"	"W"
PCGA-XR1	1/4	5.2	620	148	345	215	63	31
PCGA-XR1	3/8	3.6	325	92	210	130	40	20
PCGA-XR1	1/2	2.5	165	40	130	70	25	15
PCGA-XR1	3/4	1.8	110	24	95	55	16	8
PCGA-XR1	1.0	1.4	75	16	55	40	14	7

Tested at 0.625" per MIL-STD-401 at room temperature.
Note: Lighter foil gage versions available upon request: 1/4 - 3.4, 3/8 - 2.3, 1/2 - 1.8, 3/4 - 1.2, 1.0 - 1.0

Serial and Concurrent Presentations of Stimuli and Their Effects on Items Recalled

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ABSTRACT

The present study examined differences in accuracy of responses to serial and concurrent stimuli in an immediate free recall task for individuals from chemistry and psychology courses. Average accuracy of responses for presentation order, stimulus type, and gender differences were measured. The procedure used Superlab 4.0 and consisted of one practice trial followed by eight recorded trials of serial and concurrent word lists. Counterbalancing was used to try to control learning of one order of presentation over the opposite order. Serial word lists consisted of ten words presented two seconds apart and one at a time. Concurrent lists consisted of ten words presented simultaneously for twenty seconds. No significant main effects of presentation order, stimulus type, or gender were found when calculating a mixed ANOVA. No gender differences in accuracy between the two types of stimuli were expected. There were also no significant effects of the interactions for these variables. However, a medium effect was found for the interaction of presentation order and stimulus type. Increasing the population may lead to a significant effect of the presentation order by stimulus type interaction.

Immediate free recall (IFR) is a common method used to try to determine individual differences in the number of stimuli (usually words) that can be stored in working (short-term) memory (Bhatarah, Ward, Smith & Hayes, 2009; Huang, Tomasini & Nikl, 1977; Seiler & Engelkamp, 2003; Ward & Maylor, 2005). Most often, a recall task involves participants presented with a given number of words in a serial presentation. Presentation of this format is a specific word, followed every one or two seconds by each consecutive word, until the list is complete (Bhatarah et al, 2009; Matlin, 1976). Stimuli presentation is either oral or visual depending on the procedure (Baumeister & Luszcz, 1976; Ozubko & Joordens, 2007). IFR is employed promptly following the final stimulus. According to Laming (2009), the recall task regularly occurs for one minute; and at this time, individuals write down or verbally list as many items as they can remember (Russo & Grammatopoulou, 2003; Smith, Jones & Broadbent, 1981). This provides the measurement of recall as number of items remembered, or accuracy of recall.

According to current theory, working memory consists of a system that briefly stores and processes information from the environment, from long-term memory, as well as maintaining and altering stimuli that are still currently in the system itself (Gazzaniga, Ivry & Mangun, 2009). The phonological loop is one aspect of the working memory system and its main function is the encoding and rehearsal of stimuli such as words. Verbal stimuli, rehearsed or processed by the phonological loop, may stay in the working memory system,

or may be processed and stored in long-term memory. IFR procedures record the number of words processed and subvocally rehearsed in the phonological loop (Campoy, 2008). The words at the beginning of the list tend to be encoded in long-term memory and the most recent words in the list are thought to be present in the short-term store, or working memory.

Accuracy of recall, the number of items correctly recalled, using serial presentation of stimuli, spans most of the literature over the past forty years (Campoy, 2008; Haist, Shimamura & Squire, 1992; Joseph, McKay & Joseph, 1982; Matlin, 1976). Students make up the participants in many of the studies by performing serial presentation recall tasks (Bhatarah et al, 2009; Seiler & Engelkamp, 2003; Ward & Tan, 2004). Serial presentation of IFR is used to test accuracy of individuals' working memory; concurrent presentation, in a similar manner, is useful for the same reason.

Very few recall tests include concurrent presentation of stimuli (Harness, Jacot, Scherf, White & Warnick, 2008; Sneed, Brunts, Mueller, 1977). This method presents all the stimulus words simultaneously to the participants. Once the stimulus exposure period ends, individuals perform the recall task as they would in serial presentation formats. Concurrent presentation recall procedures have been used to compare recall accuracy of schizophrenic populations versus healthy subjects (Brebion, David, Bressan & Pilowsky, 2006). It was found that healthy subjects did have increased accuracy in the free recall task. Concurrent lists, presenting all the words at the same time, may lead to many words being processed into the long-term store, or may allow more words to remain in short-term memory.

Some studies suggest that concurrent presentation is believed to lead to diminished accuracy of items recalled in comparison to serial presentation. (Hoppe, Stojanovic, Karg Foundation Young Researchers Group 2008/09, & Elger, 2009). Sneed, Brunts, and Mueller (1977) found that concurrent lists of more than two words decreased performance in free recall. Theoretically, this is due to less ability to process single words in a concurrent list because the individual will instead process that list as a „chunk,' in which case the entirety of the list can be one single stimulus, as well as a few words, or even just one word. Other research has shown that the availability of more words can also lead to increased recall stemming from the ability to make more chunks from a larger set of words, leading to recalling more words in the list (Chen & Cowan, 2005; Miller, 1956). It is also possible that one chunk can even cue the participant for the next chunk in a list, further increasing the likelihood of recalling more words (2005).

The present study aims to determine if format of presentation alters the number of items remembered for each individual. If there is a difference between the accuracy of responses to each presentation, this may lead to increased understanding of the working memory model. If concurrent presentation of stimuli leads to an increased number of accurate responses, it is possible that the list presenting all the stimuli simultaneously allows individuals to process more words and move them into long-term memory. Participants will recall eight lists of words in concurrent presentation and eight lists in serial presentation. Counterbalancing of each presentation type, by switching around the order of presentation, should help counteract learning of one presentation over the other, if accuracy of recalled items increases temporally. This study does not employ the use of distractors between serial presentation stimuli. This allows for performance of chunking in both presentations. Participants can also covertly rehearse words from the lists. Covert rehearsal is the process of practicing the words without orally reciting them. Chunking and covert rehearsal are two of the main strategies used to

remember words in a recall task (Eagle, 1967). Accuracy will be determined by the number of items recalled that are perfect matches.

Differences in accuracy of items recalled for concurrent compared to serial presentation of stimuli for individuals is the focus of this paper. The effects of stimulus type are expected to alter accuracy. However, it is not clear whether concurrent or serial presentation will lead to increased accuracy. Order of presentation will also be reported. It is expected that as individuals proceed through the serial and concurrent presentation tasks, some learning will occur and items remembered will increase over time for both stimuli presentations for all individuals. As mentioned earlier, counterbalancing will control for learning of the presentation types in a specific order. As a quasi-experimental variable, gender differences in accuracy of items recalled shall be examined. There is expected to be no difference between the accuracy scores of men and women.

METHOD

Participants

Forty-eight undergraduate students at South Dakota State University participated in the free recall task. Psychology majors (2 males, 13 females), Chemistry majors (16 males, 15 females) and other majors (2 males, 0 females) made up the sample. Individuals in some courses were offered extra credit for their participation in the study. Those students in classes where extra credit was offered for participation who did not want to be a part of the study were given alternate opportunities for extra credit by their professors. Recruitment of students took place in psychology, sociology, and chemistry classes. Students taking part in the study also had their name entered into a drawing for a fifty-dollar gift certificate to the SDSU Bookstore. The Institutional Review Board approved the procedure and participants gave implied consent prior to performing the task. Data from students with any of the following criteria was not used: diagnosis of psychiatric or behavioral disorders, those currently under the influence of alcohol, any other illegal substances, anti-anxiety, anti-depressant, anti-histamine, or cold medication, history of epilepsy or seizures, students taking medication for Attention Deficit Disorder, and any student under the age of eighteen. The basis for data use was voluntary consent of each participant.

Materials

This immediate free recall task implemented the use of the English Lexicon Project (ELP) Database for word selection (Balota et al, 2007). Using the database allowed for controlling the word length for each item in the word lists, as well as the frequency of use, in the English language. Words for all the lists were four or five letters long. Hyperspace Analogue to Language (HAL) frequency norms were used to set the parameters of word frequency. The list of words was narrowed down from the 3815 most frequently used four and five letter words to a list of 180 that were randomly selected to 18 trial lists via Microsoft Excel.

Superlab 4.0 (Cedrus Corporation, 2009), a computer program, was used to conduct the recall task on a color-monitor computer. Performance of the recall task occurred in sets of one practice trial followed by eight recorded trials for concurrent stimuli or serial stimuli.

Whichever stimuli were presented for the first nine trials was then followed by a practice trial and eight recorded trials of the other stimulus type. On the computer, serial presentation occurred with a list of words one after the other. The single word appeared in the center of the screen for two seconds and was immediately on the screen as the trial began. The second word in the list, and all proceeding words, replaced the one before it after the two-second time limit. There was no interval between words. At the end of the list of ten words, the screen read "Begin Recall Now" and "Press 1 to End Recall."

For concurrent presentation, the list of ten words appeared on the screen simultaneously. In order to try to reduce chunking as much as possible, the words were presented on separate lines and spread across the page. One word appeared on the first line, and the second word was on the next line but across the page, with at least 14 spaces between them. This process was used for each word, spanning the entire screen. As with the serial presentation, the concurrent presentation appeared for two seconds per word, or for 20 seconds concurrently. After the 20 seconds, the "Begin Recall Now" screen appeared.

Participants used paper and a pencil to write down their responses for each recall task. The paper was cut in half and each half-sheet of paper was stapled together into a packet consisting of 16 half-sheets, eight each for the concurrent and serial lists. A demographic survey at the end of the task obtained age, gender, and class standing for each participant. Recorded answers were also printed using pencil and paper. The experimenters collected data after the procedure period ended.

Procedure

The recall task was conducted in a computer lab, on multiple days, with each session supervised by one experimenter. Participants followed along as the experimenter read the consent form. The final statement from the consent form stated that moving on with the study would imply consent. Prior to the participants' arrival, the computers were set up and ready to run the recall task. Each stimulus presentation consisted of a practice trial and eight trials of recorded recall. The experimenter read the directions for each task prior to running through the practice and recorded trials. Each trial of serial lists contained ten words presented one at a time. The first word appeared immediately after a command was entered by the participant, and stayed on the screen for two seconds. Each word that followed immediately appeared after two seconds. After ten words, the screen presenting "Begin Recall Now" and "Press 1 to End Recall" flashed on the screen. This screen appeared for one minute, unless the participant pressed the "1" key, in which case the screen would go blank.

After eight trials the directions for the concurrent presentation was read. The only difference for the concurrent presentation consisted of all ten words presented simultaneously for 20 seconds instead of one at a time for two seconds each. Again, the "Begin Recall Now" screen prompted the participants to begin writing down the words for each trial. Participants wrote their answers on a sheet of paper and flipped it over for each proceeding list.

Following the recall task, a demographic survey collected the age, gender, and class standing of each participant. This survey, which was recorded using pencil and paper, also had a question asking if consent was given to use the data for our study. Individuals could respond "yes," implying the data could be used, or "no," implying their data could not be used. Debriefing was included as well as informing the participants about the recall task and

what it was intended to accomplish. Before and after the task, individuals were told they did not need to participate.

Results

Figure 1 shows the average (*SD*) number of correct responses to concurrent and serial stimuli as a function of presentation order. For the individuals performing serial followed by concurrent stimuli (Group 1), participants have an increased score on concurrent stimuli (*M* = 46.33, *SD* = 10.18). This is the largest mean for any stimulus type for either presentation order. The average correct responses for concurrent stimuli, by the concurrent followed by serial presentation participants (Group 2) is the lowest average score of accuracy (*M* = 41.17, *SD* = 8.01). Serial stimuli for Group 1 (*M* = 44.04, *SD* = 9.83) and Group 2 (*M* = 43.17, *SD* = 8.10) are both relatively close and fall between the concurrent scores of each group.
As the current study is set to determine any differences in presentation order, stimulus type, and gender, a two-way mixed ANOVA was calculated. The descriptive statistics for gender as a function of presentation order and stimulus type are shown in Table 1. This data shows that Group 1 men have the highest average number of correct responses to concurrent stimuli. Group 1 men also have the largest average number of correct responses to serial stimuli. However, Group 2 men have the lowest average scores to serial as well as concurrent stimuli, when compared to Group 1 men and Group 1 and 2 women.

The two-way mixed ANOVA shows no main effect of the within factor of stimulus type $F (1/94) = .027, p = .871$. Data for all interactions of significance, and error, for this ANOVA are presented in Table 2, which shows the within-subjects factors, and Table 3, showing the between subjects factors. Gender $F (1/47) = .328, p = .57$ and presentation order $F (1/47) = 2.65, p = .111$, the between subjects factors, also show no significant main effect. As Table 3 shows the stimulus type and presentation order interaction shows a significant effect at $p = .073$, if significance level is at $p < 0.1$.

Discussion

Analyzing the results of the mixed ANOVA showed no significant effect of stimulus type, presentation order, gender, or any of their interactions. However, a medium effect was found for the interaction of stimulus type by presentation order. The results showed that participants in Group 1 and Group 2 both had increased scores as they moved from one presentation type to the other, but not at a significant level. This finding leads to the possibility that presentation of one stimuli followed by the other stimuli could allow for a learning process in a temporal manner. This could allow individuals to have more responses that are accurate in the second stimulus list. With a medium effect size it may be possible that if the number of participants increased, a significant effect may be seen for the presentation order and stimulus type interaction.

Looking at the results of the presentation order by stimulus type interaction, a greater accuracy rate for Group 1 is possibly related to performing the serial presentation followed by the concurrent presentation and learning the procedure. According to Cowan (2001), if participants are allowed to see a list for a longer time, they are going to make larger chunks. Since Group 1 saw the concurrent lists second in the presentation order, they may have learned the procedure by performing the serial lists; and then performed better once doing

the concurrent lists because it makes chunking more likely. Chunking has been found to increase accuracy during recall (Eagle, 1967). Group 2 learned the procedure using the concurrent list first; so they may not have performed as well as Group 1 on the second list, which was serial for Group 2 individuals. If learning is what lead to an increase in the average number of correct responses for both groups on the second set of stimulus lists, then doing the concurrent list second may increase the number of correct responses at a higher rate than performing the serial presentation second.

Bhatarah, Ward, Smith and Hayes (2009) found that faster presentation rates decreased the accuracy of recall. The current study did not find a significant difference between concurrent and serial presentation. However, presentation of the serial list, one word at a time, prior to the concurrent stimuli lists, may allow the participants in Group 1 to have increased accuracy on the concurrent lists. This may be due to learning the procedure and then having a longer exposure to the concurrent list, which could increase the likelihood of chunking (Cowan, 2001). Since both Group 1 and Group 2 had a slight increase in the number of accurate responses on their second presentation, it is possible that learning of the procedure may be likely. Counterbalancing the word lists and not just the presentation order would be a benefit to future research. Then it would be possible to see if the second half of the task had an increased number of words that could be recalled easier, or if learning is why the participants performed better on the second set of presentations.

Gender differences for stimulus type and presentation order did not show any significant effect either. However, men in Group 1 did have increased average accuracy scores on both serial and concurrent lists, compared to men in Group 2, and women in both groups. It was expected to find no significant difference in the average number of accurate responses by men compared to women. Thus, this portion of the hypothesis is correct.

One important aspect to this study is that it found no significant difference between individuals' scores of accuracy for the two stimulus types. This might lead to more use of concurrent stimuli in recall procedures. The lack of a significant difference between average accuracy scores of individuals for each stimulus type does show that the two presentations may use the same method of processing into long-term memory for words rehearsed when the presentation began, and processing of recent words in working memory.

Comparing accuracy scores of concurrent and serial presentation does allow for increased generalizability in the recall literature. There are few studies that have compared the average correct responses to stimuli in a concurrent compared to a serial presentation. Not one study was found that used ten words presented in each type as this one did. It is also possible that a significant effect may have been found if close matches were counted as correct responses along with the correctly spelled matches.

Further work on this procedure could make use of questioning the participants on what strategy they used while the presentation of words occurred. If participants explained that they used chunking or covert rehearsal, the data may explain learning strategies and the differences in accuracy for each type. Chunking has been shown to increase accuracy scores in comparison to rehearsal (Eagle, 1967). Otherwise, giving them directions that do not allow a specific strategy could be implemented. Using articulatory suppression, a process of making the participant repeatedly say a word, or words, during the presentation of stimuli, could be used to control for chunking and rehearsal in both of these presentations (Russo &

Grammatopoulou, 2003). Also, delaying the recall portion of the task may show differences in the accuracy of stimuli presentation. If participants are given time to rehearse the words during a delay, between presentation and recall, it is possible that a difference in the encoding of serial and concurrent stimuli would possibly show a difference in accuracy (Campoy, 2008).

This study had a large population of participants receiving extra credit. It may confound results for the fact that only those people who need or want extra credit will participate. Recruiting in three classes that did not offer extra credit resulted in zero participants. In order to generalize the findings a population of students not receiving extra credit may be necessary. The temperature in the lab where the procedure was performed was also variable. The heat from no air-conditioning could cause changes in responses for the procedure. During the day, the room had an increased temperature, especially on warm days. This may affect the accuracy of responses as well. Further study of IFR and different presentation types is necessary.

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Table 1: *Average (SD) Number of Correct Responses to Serial and Concurrent Stimuli as a Function of Gender and Presentation Order*

Stimulus Type	Men			Women		
	Serial Then Concurrent	Concurrent Then Serial	Total	Serial Then Concurrent	Concurrent Then Serial	Total
Serial	47.86	42.23	44.20	42.47	44.27	43.18
	(8.36)	(8.36)	(8.73)	(10.18)	(7.72)	(9.18)
Concurrent	50.29	39.69	43.40	44.71	42.91	44.00
	(11.57)	(8.38)	(17.73)	(9.43)	(7.57)	(8.65)

Table 2: *ANOVA Tests of Within-Subjects Factors and Effect Size*

Source	Sum of Squares	Mean df	Square	F	Sig.	Partial Eta Squared
Stimulus Type	.785	1	.785	.027	.871	.001
Stimulus Type by Order	99.287	1	99.287	3.370	.073	.071
Stimulus Type by Gender	1.304	1	1.304	.044	.834	.001
Stimulus Type by Order by Gender	2.533	1	2.533	.086	.771	.002
Error (Stimulus Type)	1296.275	44	29.461			

Table 3: *ANOVA Tests of Between-Subjects Factors and Effect Size*

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Order	355.749	1	355.749	2.650	.111	.057
Gender	44.081	1	44.081	.328	.570	.007
Order by Gender	356.219	1	356.219	2.654	.110	.057
Error	5905.944	44	134.226			
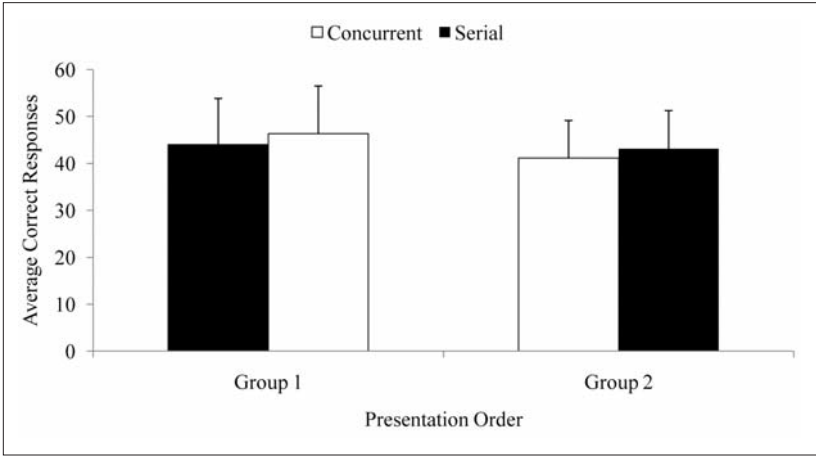
Figure 1. Average accurate responses to serial and concurrent stimuli as a function of presentation order. Error bars represent standard deviation.

The Effects of Feedback on Student Performance While Performing Multiple Tasks Simultaneously

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ABSTRACT

Research shows that feedback or knowledge of results can increase performance on multiple activities. In order for feedback to be successful, it should follow closely in time to the behavior. The current study is a between-group design where the experimental group received visual feedback in the form of a point total about their accuracy in performing a computer task and the control group was not presented with the point totals. While the experimental group did have higher average point totals, the results were not statistically significant. Gender served as the second independent variable and there was not a significant difference between the average total points for men and women. There was not a significant interaction between the two variables.

THE EFFECTS OF FEEDBACK ON STUDENT PERFORMANCE WHILE PERFORMING MULTIPLE TASKS SIMULTANEOUSLY

Knowledge of results (KR) is "feedback containing the level of performance obtained" ("Feedback," 2000, p.172). Several studies have investigated the effect of knowledge of results on the performance of different tasks. Information about how knowledge of results can influence performance is beneficial for the fields of education and behavior modification. Some educational facilities are currently putting this scientific information into practice. Pokorny and Pickford (2010) researched student perceptions of feedback on academic performance and found that lengthy written feedback is not affective in response to a final paper or project. Students reported that an instructor's feedback is most beneficial when followed closely behind the assignment.

Several populations have been used to study the effects of knowledge of results or feedback. Individuals with either physical or mental handicaps are often the subjects of feedback studies, one study by Hemayattalab and Rostami (2010) examined the effects of knowledge of results in dart throwing abilities of children with cerebral palsy. They used an ANOVA to test their results and found that those in the feedback condition were able to learn new motor tasks. In a study conducted by Carroll (1973), normal male participants ages 18 to 29 completed different perceptual-motor tasks with and without performance feedback. The

group receiving immediate feedback on their performance became faster at completing the task as the trials progressed. Motor tasks were most commonly used in studies but Szalma, Hancock, Dember and Warm (2006) conducted a study were undergraduates viewed a chemical process on a computer screen and were then asked if that process led to a reaction. This study separated the types of feedback provided, one group was only given feedback when they were correct and another group was only given feedback when they responded when a response was not necessary. Szalma et al. discovered the perceptual sensitivity scores (accuracy rates) increased with feedback of either type.

While most studies found that knowledge of results or feedback lead to improved performance, Tiu (2006) found that the distribution of scores for those receiving feedback matched the distribution for those who did not receive feedback when the task was remembering obscure facts. A similar study conducted by Smith and Kimball (2010) examined the effects of feedback by using the test retest method of trivial facts. They found that if the participant answered correctly the first time, delayed feedback functioned to preserve the initially correct response. However, the Smith and Kimball (2010) study also showed that delayed feedback is not beneficial in correcting errors from the first testing session.

The current study attempts to investigate the effects of feedback on performance using a multitsking computer program, SynWin (Activity Research Center, 2001). During the first experimental section, the participant was presented with two tasks to complete; a letter recognition task and an addition problem. The second experimental section added two more tasks, a gas gauge to reset, and a tonal discrimination task. Based on their performance of the tasks, participants in the experimental condition received feedback in the form of a point total in the center of their screen, and the control group did not.

Based on existing literature, the hypothesis for the current study is participants who receive continuous feedback will have higher accuracy rates in the form of average point totals than those who receive no feedback. Also, the point totals should decrease in the second experimental section because there are more tasks to complete. The manipulated independent variable for this study is whether or not the participants receive feedback about their performance. In addition, gender serves as quasi-independent variable, but the researchers do not think it will have a significant effect on the data. Average accuracy rates measured by point totals serve as the dependent variable. Point totals were compiled based on correct and incorrect responses to the tasks; incorrect responses resulted in loss of points, making it possible to have a negative score.

METHOD

Participants

A total of 32 undergraduates from South Dakota State University participated: 10 men and 22 women. The participants were randomly assigned to either the control (5 men, 13 women) or experimental (5 men, 9 women) condition depending on which session time they were scheduled. Participants were recruited from undergraduate psychology classes. Some students received compensation from their course instructors for their participation in this study. Upon completion of the study, each participant's name was entered into a raffle

drawing with the chance to win a coupon or gift card to Cubby's Sports Bar and Grill, SDSU Dairy Bar, and Brookings Cinema 5. Students with a current diagnosis of any form of psychiatric or behavioral disorder, students under the influence of alcohol, illegal substances, any antidepressant or anti-anxiety drug or cold medicine, students with a history of epilepsy or seizures, students taking any medication for Attention Deficit Disorder, and students under the age of eighteen did not have their results included in the final data analysis. The Institutional Review Board approved the current study.

Materials

Computers were used to show the participants the SynWin (Activity Research Center, 2001) program containing the experiment. The program recorded responses to all the tasks in addition to the total points for both conditions. The demographic information sheet served as an implied consent form that the participants completed and returned.

Procedures

Both groups performed the same tasks under the same environmental conditions; the only difference was the experimental group was provided with visual feedback in the form of a score in the middle of their screen. This score provided the participants with continuous visual feedback about their accuracy in completing the tasks.

The information sheet was read aloud and the participants were told that their consent was implied by their completion and submission of their demographic information sheet. A short demographic information sheet containing questions about the participant's age, major, and gender, was then completed and sealed in individual manila envelopes. The participants were given three minutes to practice and become familiar with the SynWin program and the tasks to be completed. In the upper left corner was a letter recognition task, and the upper right corner had the math problem, as seen in Figure 1. Immediately following the practice, the participants began the 15-minute experimental session with only the two tasks. The second part of the experiment followed the same pattern as the first part, but included two additional tasks. The lower left corner had a gauge that needed to be reset and the lower right corner had an alert circle to be clicked when the participant heard a high tone from a background of low tones. During the tasks, the experimental group received visual feedback in the form of point totals. Once all participants finished the second 15-minute experimental part, they were debriefed as to the hypothesis of the study

RESULTS

The average total points are presented in figures 2 and 3 for each of the independent variables. Figure 2 examines the average point totals between the no feedback and feedback conditions. The experimental group has a higher total point average than the control group, but there is large variation between the two groups (M=3059.79, SD= 1220.91; M=2050, SD=1515.548435 respectively). A two-way between ANOVA using experimental condition and gender as the two variables, shows there is no significant main effect of experimental condition on average point totals [$F_{(1,28)}=1.877, p=.182$].

Figure 3 displays the effects of gender. The average total points for men and women are close, but men have slightly higher average total points than women do (M=2709.6, SD=1685.71; M=2392.77, SD=1383.41 respectively). In addition to the similar average total points, there is a large amount of variability within both groups. The results of a two-way between ANOVA did not find a significant main effect of gender on average point totals [F(1,28)=.119, p=.732]. Table 1 also displays that there is not a significant interaction between experimental condition and gender [F(1,28)=1.794, p=1.91].

DISCUSSION

In the current study, those receiving feedback had higher average point totals than did those in the control group who did not receive visual feedback. There were no main effects of either independent variable nor an interaction between the two, as determined by a two-way between ANOVA, which could be due to the large variability within the measure of behavior. A literature review indicated that gender did not influence the effects of feedback and the current study did not find a significant difference between the average total points of men and women.

Chiviacowsky, Wulf, Walley, and Borges (2009) examined the effects of feedback during a motor task completed by older adults. The task involved tossing beanbags onto a target, which had different points to be earned for getting the bag in a specific area of the target. One group received feedback about their highest scoring trials and the other group received feedback on their lowest scoring trials. Results from that study showed that as the trials progressed, the group who received "good" feedback became more accurate with their tosses. Their findings were not statistically significant. The current study was similar in that there was not a significant effect. A possible explanation for the lack of significant effects in either study could be the high degree of variability within the behaviors.

Another possible explanation for the lack of significance in the current study could be that the computer task is not as affected by feedback as are gross-motor tasks. The majority of the research in the area of feedback involves gross-motor tasks, but Rantz, Dickinson, Sinclair, and Van Houten (2009) conducted a study to determine whether or not feedback lead to greater accuracy in completing a pre-flight checklist during flight simulation training. Rantz et al. (2009) found that graphic and verbal feedback lead to more list items correctly completed. The Rantz et al. (2009) study demonstrates that feedback can be beneficial for non-motor tasks.

Neth, Khemlani, and Gray (2008) investigated the effects of local verses global feedback on a multitasking computer program called Tardast. In their study, global feedback was given continuously in the form of a satisfactory scale, and the global feedback condition was given as a summary of level of performance at the end of the task. Neth, Khemlani, and Gray (2008) found both conditions improved as the trials progresses but that those who received local feedback had significantly higher satisfactory scores than those who received global feedback. Knowing that others have found that feedback has an effect on multitasking behavior, there is another possible explanation for the lack of significant findings in the current study. It is possible that the feedback in this particular study was insufficient in

producing the desired outcomes. Although only the experimental group was provided with the continuous score about their accuracy rates in responding, both groups received audio feedback for some correct and incorrect responses. For a correct, or point-earning response on the letter recognition task and the addition problem, participants heard a coin clink sound. When they responded incorrectly on either of those two tasks they heard an aversive tone. The research design did not draw attention to these sounds, but it is possible that the participants in the control group interpreted the audio feedback and adjusted their responding accordingly.

In further research, examining visual feedback alone might yield a greater difference between the experimental and control conditions, and it could decrease the variability within the measure. An increase in sample size for other feedback studies might be beneficial in approaching statistically significant results. A different dependent variable such as average reaction times in a study similar to the current one might be more affective at picking up differences between groups if these differences are present. Continued research on the effects of feedback on computer related tasks or learning tasks is needed in order to determine if feedback can be useful for improving accuracy in areas that are non-motor related.

Table 1: Results of a Two-Way ANOVA Between examining Gender and Condition

Source	Sum of Squares	df	Mean Square	F	Sig.
Gender	232760.119	1	232760	0.119	0.732
Condition	3658386.83	1	3658387	1.877	0.182
Gender * Condition	3496592.24	1	3496592	1.794	0.191
Within	54578044.79	28	1949216		
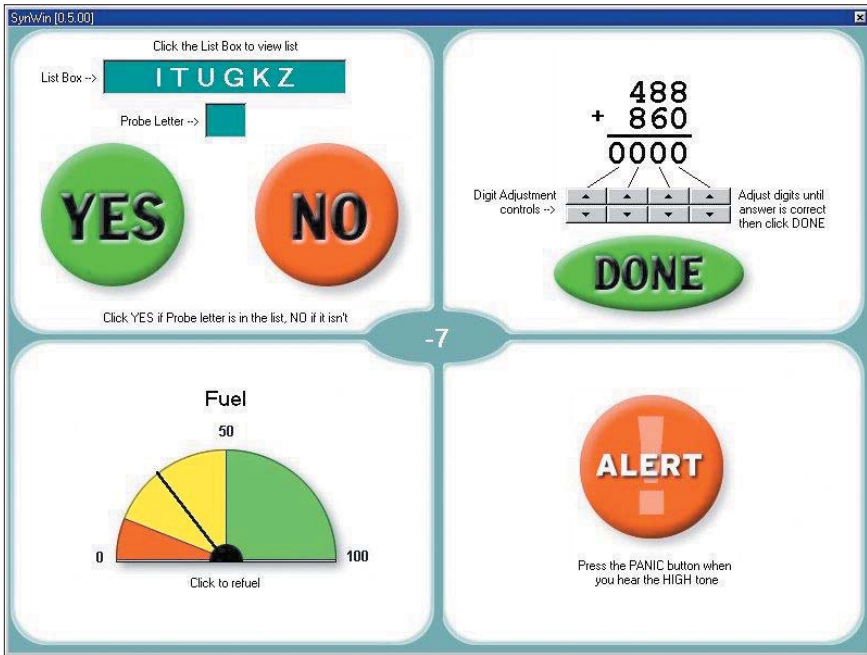
Figure 1. A screen shot of the SynWin program for the experimental condition is shown.
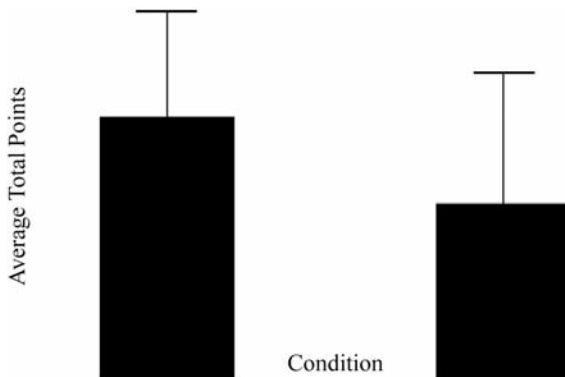
Figure 2. The average total points for the experimental and control conditions. Error bars represent the standard deviation.
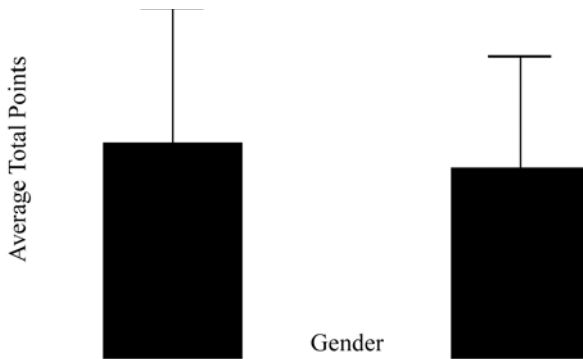
Figure 3. The average total points for men and women. Error bars represent the standard deviation.

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Tracking Bare Sand Mobilization Arising from Landscape Manipulations in the Grasslands Destabilization Experiment (GDEX) in the Nebraska Sandhills Using Imaging Spectroscopy

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ABSTRACT

The Grassland Destabilization Experiment (GDEX) is a landscape scale manipulative experiment initiated in 2004 in the Nebraska Sandhills to evaluate changes in surface properties following the abrupt loss of stabilizing vegetation.

The GDEX features five treatments allocated among ten plots of 120 m in diameter (1.13 ha). The Aggressive Bare Sand protocol included chemical defoliation and subsequent shallow disking and raking in 2004 to devegetate the plot with periodic physical disturbance to maintain bare sand. The Long Term Disturbance (Press) protocol includes an initial chemical defoliation in May 2005 and seasonal spring reapplications, but no physical disturbance. Short Term Disturbance (Pulse) treatment had chemical defoliation initially in 2005 and again in 2008; thus, 2006, 2007, and 2009 are "recovery" years. There are two sets of controls: Grazed and Ungrazed. Eight plots (two replicates of each treatment) located contiguously within a fence are the focus of our investigation: *Ungrazed Control*, *Pulse*, *Press*, and *Bare Sand*. (We excluded the two Grazed Control plots that were located outside the fence away from the other treatments.)

Erosion pin networks were established in each plot to track net (gain-loss) sand movement. Remote sensing data were acquired using the AISA Eagle imaging spectrometer in late June from 2006 through 2009. We tracked the spread of bare sand within and outside of the treatment plots by thresholding the upper range of values in the green (517 nm), red (666 nm), red edge (713 nm), and near infrared (856 nm) portions of the electromagnetic spectrum.

The average reflectance across the full spectral range of the imagery (396-980 nm) at the erosion pin locations increased in the *Press* and *Bare Sand* treatments from 0.25 in 2006 to 0.30 in 2009; it decreased over the same period in Pulse treatments from 0.19 to 0.17 and in *Ungrazed Controls* from 0.17 to 0.14. Increases in the areal extent of bare sand in the neighborhood of the plots between 2006 and 2009 were an average of 5,742 m2 for *Press* treatments and 713 m2 for *Bare Sand* treatments. Four years elapsed before sustained sand mobilization occurred. We expect sand in the *Bare Sand* and *Press* treatments to continue to move as long as experimental treatments are maintained.

INTRODUCTION

Over 30% of the High Plains Aquifer lies under the 58,000 km2 of the Nebraska Sandhills (Bleed and Flowerday 1998). The stability of this aquifer has socioeconomic ramifications for Nebraska, a leader in irrigated agriculture, and its neighboring states. The Sandhills Biocomplexity Project, funded in 2003 by the National Science Foundation, was launched to study how the interactions of sand, grass, and water contribute to the stability of the largest dunefield in the Western Hemisphere. The last major Aeolian activity in the Sandhills took place between 950 and 650 years BP and corresponded to a regional megadrought (Mason et al., 2004). This area is most appropriate for study due to the regional scientific interest in the High Plains aquifer and the causal mechanisms that maintain dune stability in the face of lesser droughts and other surface disturbances (Gosselin et al., 2006).

In this paper we characterize spectral responses to surface disturbances of the eight plots over a four-year period. The first objective is to present the changes in spectral response across a 580 nm range. Bare sand is far more reflective than photosynthetic tissue; thus, we used increases in reflectance in four distinct narrow (9.5 nm) spectral bands as measures of vegetative cover loss. The second objective includes three measurements: (1) the area of bare sand as a function of time and treatment; (2) the areal extent of post-treatment vegetative regrowth; and (3) the increase of bare sand area outside the original treatment plots due sand movement. This third measurement captures the phenomenon of blowout: surface destabilization that allows for windborne sand to leave the original plot and spread into the adjacent area, generally in the direction of the prevailing winds. Winds of the Great Plains are often strong enough to mobilize bare dune sand; vegetation density is the key hindrance to dune mobility, and vegetation density depends on moisture (Miao et al., 2007).

DATA AND METHODS

Image time series

Fly-overs of the GDEX were performed by the CHAMP (CALMIT Hyperspectral Aerial Mapping Program; http://www.calmit.unl.edu/champ) at the University of Nebraska-Lincoln during the last week of June 2006-2009 (Table 1). Acquisitions were timed to capture the peak canopy greenness (though not the peak aboveground biomass), but the actual date of acquisition was constrained by sensor availability and recent weather. The AISA Eagle+ imaging spectroradiometer provided 63 bands between 400-980nm. Radiance measurements were geolocated and converted to reflectance by the CHAMP using the FLAASH software.

Table 1: Image Dates and Climatological Context

Year	Date	Day of Year	AGDD (oC)	APPT (mm)
2006	26 June	177	1594	242
2007	30 June	181	1594	391
2008	30 June	182	1275	299
2009	29 June	180	1409	245

Monitoring sites

Erosion pin networks had been established by other GDEX researchers to track net (gain-loss) sand movement. A geolocated network was established within each treatment plot for a total of 364 graduated pieces of aluminum conduit emplaced across the eight plots. We used these locations to monitor variations in surface reflectance over the four-year period, but we did not analyze here the corresponding erosion data.

Meteorological data

Daily precipitation and temperature data were obtained for the Barta Brothers Ranch automated station maintained by the High Plains Regional Climate Center (hprcc.unl.edu). We calculated accumulated growing degree days (AGDD) from 01 January of each year using a base temperature of 0 oC (=273.15 K) following de Beurs and Henebry (2004). We calculated the accumulated precipitation as the running sum of daily precipitation.

Masking high reflectance

We identified areas of bare sand within and adjacent to the treatment plots by masking out those data that fell below a critical threshold. Due to interannual climatic variability (Table 1), we chose the optimal threshold for each band for each year rather than selecting a general threshold across years. Masks were generated at four wavelengths, each representing a narrow slice of the electromagnetic spectrum useful for vegetation analysis: green (517 nm), red (666 nm), red edge (713 nm), near infrared or NIR (856 nm). Reflectance from healthy vegetation in the visible wavelengths (400-680 nm) is generally highest in green and lowest in red. Red light is strongly absorbed by green vegetation for use in photosynthesis, but strongly reflected by bare sand; thus, a temporal trend of increasing red reflectance indicates decreasing vegetative cover. The red edge in vegetation spectra spans roughly 700-720nm covering the transition from the low reflectance/high absorption of the red to the high reflectance/low absorption of the NIR. Measurements in this transition are good indicators of photosynthetic activity and overall vegetation health (Gitelson et al., 1995). NIR covers approximately 750-1000nm and is useful for distinguishing healthy from distressed vegetation.

Using the ENVI package (v4.6; ITTVIS 2009), we contrasted the boundaries of original 120m diameter plots as blue against the black and white mask images. This technique allowed us to discern at a glance the original plots outlined in color, bare sand in white, and vegetated areas in black (Figure 1). ENVI's Region of Interest (ROI) tool was then used to determine the number of white (bare sand) pixels and thus the areal extent of bare sand. We also determined area of blowouts, where the bare sand has mobilized and been deposited beyond the extent of the original plot. Overall area can differ from original size plus blowout; some plots show regrowth depending on treatment type.
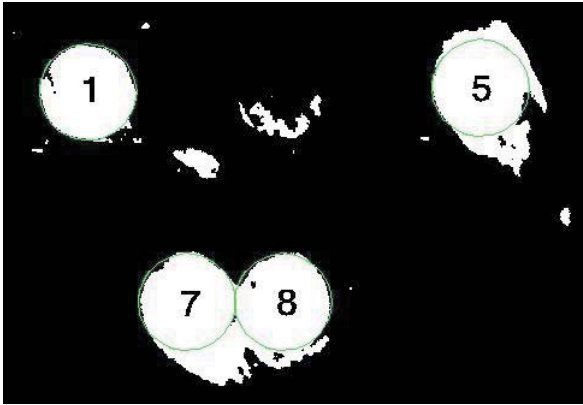
Figure 1. High reflectance mask in green (513-522 nm) for 2009. Numbers indicate plot designations: *Press* treatment in 1 & 8; *Bare Sand* in 5 & 7.

RESULTS

Spectral Response Changes

The average Green reflectance at erosion pin locations increased in *Press* and *Bare Sand* treatments by 0.05 between 2006 and 2009, while *Pulse* and *Ungrazed Control* plots decreased 0.02 (Figure 2A). For Red, *Press* and *Bare Sand* showed an increase of 0.09, while *Pulse* and *Ungrazed Control* decreased 0.04 (Figure 2B). For Red Edge, *Press* and *Bare Sand* plots increased 0.08, while *Pulse* and *Ungrazed Control* decreased 0.02 (Figure 2C).

The average NIR reflectance in *Press* and *Bare Sand* plots increased by 0.06, but *Pulse* and *Ungrazed Control* remained constant (Figure 2D). Analysis of the entire spectral range showed a reflectance value of 0.25 in 2006 increasing to 0.30 in 2009 in *Press* and *Bare Sand* plots. It decreased over the same period in Pulse and Ungrazed Control treatments by 0.03 (Figure 3).

Note the decrease in reflectance in 2007 that is consistent across treatments (Figure 3). This decrease reflectance indicates increased vegetative cover, which is attributed to plentiful precipitation (391 mm in 2007 vs. the 289 mm average for 30 June for 2000-2009).
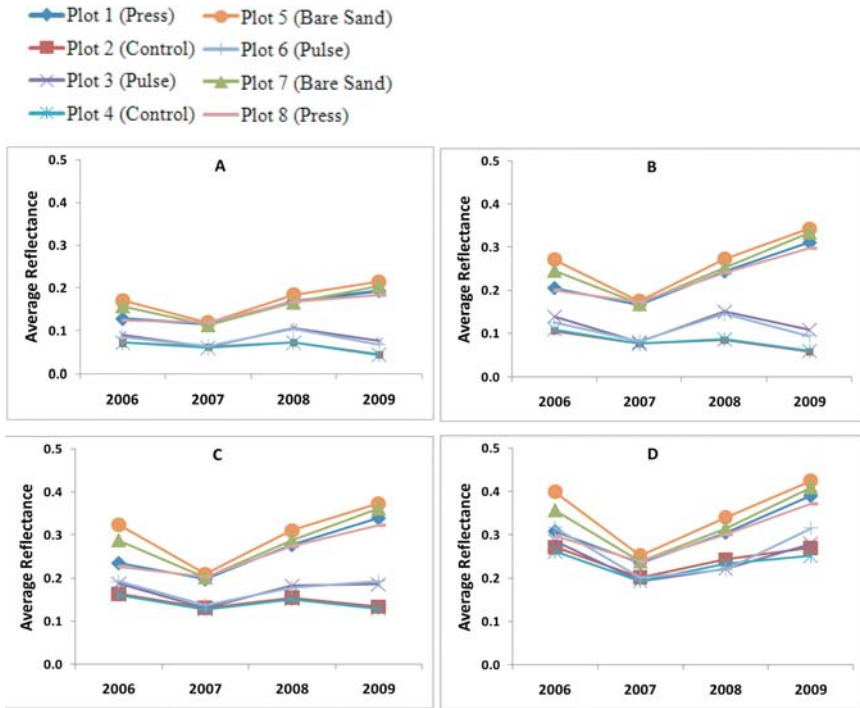
Figure 2: Average plot reflectance by band: (A) Green (513–522 nm); (B) Red (671–680 nm); (C) Red Edge (709–718 nm); (D) NIR (852–861 nm).
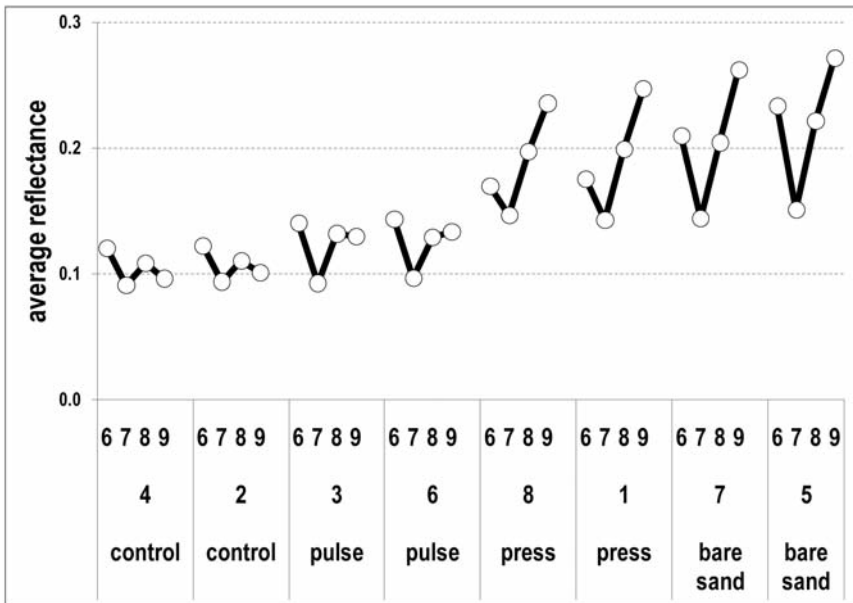
Figure 3. Average plot reflectance ordered by intensity. The hierarchical x-axis displays year of acquisition (200x), plot designation, and plot treatment.

Areal Changes

The original area of each treatment plot as established in 2004 was 11,300 m2. Table 2 shows bare sand area detected by all four bands in 2009. *Pulse* and *Ungrazed Control* plots exhibited no bare sand area in all four bands in 2009. Total area of *Press* plots decreased at an average of 4,298 m2 per plot; whereas, the exposed area of *Bare Sand* plots increased by an average of 623 m2.

Table 2: Total Bare Sand Area in 2009

Plot & Treatment	Bare Sand Area (m2)
1 *(Press)*	7,056
5 *(Bare Sand)*	12,004
7 *(Bare Sand)*	11,842
8 *(Press)*	6,948

Plots 5 and 7 (both *Bare Sand* treatments) were the only plots to feature blowout detected in all four bands, totaling 2,527 m2 and 1,814 m2 respectively. No identifiable blowouts were evident in *Pulse* or *Ungrazed Control* plots. Rather, the *Pulse* plots were almost entirely revegetated and the *Ungrazed Control* plots never exhibited bare sand patches.

The occurrence of blowout depended on treatment and site history. Plot 5 (*Bare Sand* treatment), which was constructed on an existing blowout, showed sand movement before four years had elapsed. In contrast, Plot 7 (also *Bare Sand* treatment) showed little movement before the fourth year. Plots 1 and 8, both *Press* treatments also showed divergent blowout results, perhaps due to local terrain differences. In each spectral subset, Plot 8 showed roughly four times the blowout area of Plot 1.
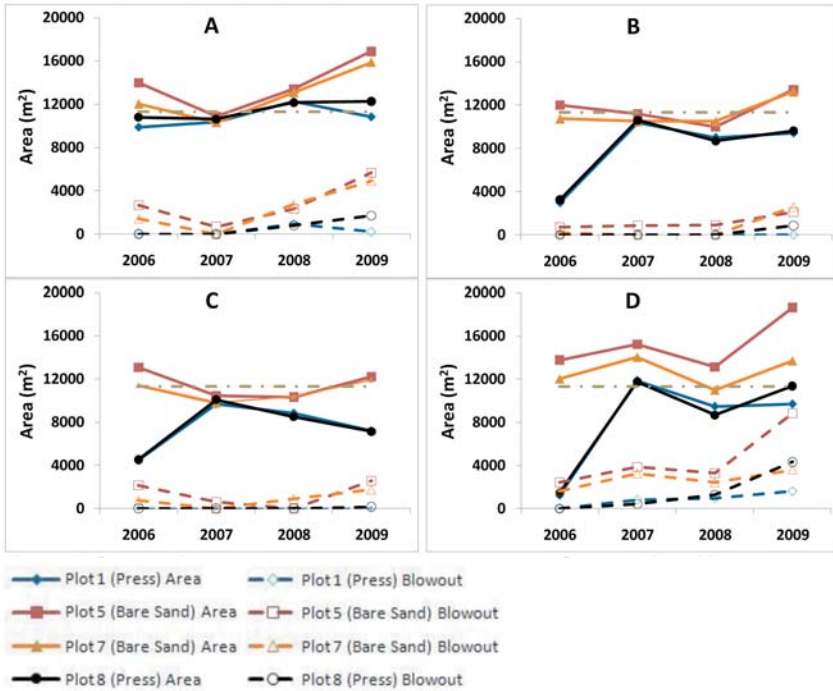
Figure 4: Changes in bare sand area and blowout area: (A) Green (513 – 522nm); (B) Red (671 – 680nm); (C) Red Edge (709 – 718nm); and (D) NIR (852 – 861nm). Solid lines indicate bare sand area and dashed lines indicate area of blowout. Dashed tan line shows original 11300 m2 plot size in 2004.

DISCUSSION & CONCLUSION

Plot reflectance relates to plot treatment; the differences being most prevalently exhibited by results in NIR. *Bare Sand* plots demonstrate divergence in reflectance through 2008 followed by convergence in 2009. In nearly all bands/years, plot order of reflectance remained constant, *Bare Sand* and *Press* plots ordering first and second. Peculiar is the

behavior of *Pulse* plots reflectances in the NIR band in 2009. After having reflectance lower than even the *Control* plots in 2008, in 2009 the *Pulse* plots pass the *Control* plots and produce reflectance values closer to those of *Press* and *Bare Sand* plots in any other band/year combination. All bands show decreased reflectance in 2007. This may result from above average rainfall. *Press* and *Bare Sand* values were nearly identical, as were those of *Pulse* and *Control* plots. It is unclear if the high precipitation that caused lower reflectances in 2007 had a similar effect on 2008 data or whether it was due to lower evapotranspiration caused by a cooler spring (Table 1). Another possible explanation is differences in the AISA sensor setup or processing.

 Press plots (repeated herbicide applications but no physical disturbance) exhibit the sharpest gains in overall area, yet show substantial revegetation beginning in 2008 with no increase in 2009. *Bare Sand* plots (initial herbicide plus periodic disking and raking) tended to vary less but did not regain the same area or blowout values after the wet year of 2007 until 2009. All plots showed areal decreases in 2008 in the red, red edge, and NIR bands. However, all plots in the green band showed areal increase. This is explained by the presence of prairie grass, which reflects relatively more in the green wavelengths than it does in red, red edge or NIR.

 Overall plot area in 2007 generally decreased for *Bare Sand* plots while it increased for *Press* plots. This trend also holds true for corresponding blowout values. Increased moisture was unable to impact the original plot areas but did substantially reduce blowout, leading to lower total area values for *Bare Sand* plots, which feature more blowout area.

 Another AISA Eagle+ acquisition is schedule for June 2010. However, there has been a change in the GDEX protocol. Plots 5 and 7, formerly *Bare Sand* treatments are being purposely revegetated to study the stabilization process. During the first half of 2010 Plot 7 is being planted with woody vegetation while Plot 5 is being seeded with grasses and forbs. Thus, as the GDEX morphs into GREX, we will be able to track the progress of the restabilization using the techniques described above.

ACKNOWLEDGEMENTS

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Working Mothers: Cognitive and Behavioral Effects on Children

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ABSTRACT

Children face several cognitive and behavioral effects that are the result of maternal employment during their early developmental years. In this study, a questionnaire was distributed to thirty-two participants (twenty-eight female, four male) ranging in age from twenty-six to fifty-nine years. All participants had at least one child. Participants provided information about themselves, their spouse (when applicable), and their children, as well as their and their spouse's work. Several cognitive and behavioral differences were noted between children of working and nonworking mothers. Differences were found in school performance, participation in extracurricular activities, and abnormal behavioral issues.

INTRODUCTION

Throughout history women have been regarded as the weaker gender, both physically and intellectually. As a result women's roles tended to center around the home and raising children. Over time women have gradually entered the workforce and have gained increasingly prestigious positions. With more women currently in the workforce than ever before, fewer children are being raised by stay-at-home mothers and more are spending prolonged hours at childcare facilities. This exploratory study analyzed the cognitive and behavioral effects on children, in small Midwestern communities, that result from having mothers in the workforce during children's early developmental years.

Seventy-one percent of American mothers with children under the age of eighteen are in the labor force, meaning that they are either employed or are seeking employment (Health Resources and Services Administration, 2007). Not only are more mothers entering the workforce than ever before, but mothers are working longer hours. More hours spent on the job means fewer hours spent with children. This may lead to several cognitive and behavioral implications for children.

Children with working mothers are usually placed in group childcare, which results in them receiving less one-on-one attention and instruction. This may have significant cognitive effects later in childhood. Behavioral effects may also arise. A longitudinal study completed in 2001 found significant cognitive differences between children who had working mothers and children who had stay-at-home mothers. The study examined the effect of maternal employment early in a child's life on the child's behavioral and cognitive outcomes during elementary school. The researchers found that maternal employment in the first year of a

child's life had a negative effect on cognitive outcomes for the child by age three or four. These cognitive effects could still be seen by age seven or eight. Interestingly, the amount of time that mothers worked did not appear to affect cognitive outcomes, as no differences were found in children of mothers working part-time compared with mothers working full-time. The researchers also found a correlation between mothers working during a child's first year of life and behavioral problems by the child later in childhood (Han, Waldfogel, and Brooks-Gunn).

Mothers entering the workforce might also have a positive effect on children. Dual-earning families are able to provide much more for their children. With increased financial opportunities come increases in healthcare, nutrition, and educational opportunities. Researchers have found that mothers report many positive effects of working. A group of researchers at South Bank University examined what women felt were the effects on their family that arose because of their employment. Working mothers in the study felt that they were helping to meet the needs of their families by providing financially, but that on occasion their family relationships did suffer as a result of their employment. Many working mothers also felt that they were being good role models for their children. In addition, they felt that they highly valued what time they were able to spend with their children. Mothers informed the researchers that at times working had a negative impact on their children because after work mothers were sometimes too tired to interact as much with children as the children would have liked. Also, working sometimes got in the way of completing activities with children that mothers and children would have liked to do (Reynolds, Callender, and Edwards, 2003).

The decision to become a working mother or a stay-at-home mother is an important one. Giele (2008) surveyed and then interviewed female college graduates in the United States in an attempt to learn if certain characteristics made career women more likely to remain in the home after they became mothers. Giele found that homemakers felt that being a mother was their most important life role. In contrast, working mothers felt that careers were their main role and that family was an additional part of their lives that helped make life more meaningful.

Although profiling mothers is helpful in researching effects on children, examining both children's and mothers' perceptions of the mothers' employment is also important. A study by Nomaguchi and Milkie (2006) examined whether or not people's perceptions of their parents was affected by their mother's employment (or lack thereof) during their childhood. Regardless of hours worked, children of mothers who worked reported less discipline from their mothers than those whose mothers did not work outside the home. Those with working mothers also reported less support and more verbal assaults than those whose mothers did not work (Nomaguchi and Milkie, 2006).

In addition to differences in discipline and support that children receive, maternal employment may also affect school performance. A study by Gennetian, Lopoo, and London (2008) used statistics gathered in a survey of urban mothers to assess how mothers' working affected adolescents' school performance and participation in school-related activities. They found that children of stay-at-home mothers were more likely to have above average school performance. Children of working mothers were not more likely to perform poorly in school, but they were less likely to perform above average. Children of employed others were also found to be more likely to skip school than children of non-working mothers (Gennetian, Lopoo, and London, 2008).

METHODS

All information was obtained through the use of a three page questionnaire. The questionnaire was distributed to thirty-two participants in the state of South Dakota and Minnesota between March 3 and March 14, 2010. The participants were from various communities including Avon and Springfield, South Dakota, and were selected only if they were a parent to at least one child. All participants were volunteers found in a variety of public settings including a grocery store, a restaurant, and a nursing home. Participants were asked if they were parents and then if they would complete a questionnaire. Participants had an unlimited amount of time to complete the questionnaire and were encouraged to ask questions if they found any part of the questionnaire to be unclear.

Participants in the study were asked a series of questions regarding their demographics, employment status, spouse, and children. They were asked their gender, age, number of children, ages and gender of children, and the employment status of their spouse. They were asked several questions regarding the amount of time they spend at work and the amount of work that they bring home. They were asked to report the impact that their work has on their child. They were also asked to provide opinions about different available forms of child care and the quality of child care that they feel their child receives. Participants also reported how many hours per week their child spends in out-of-home child care. The survey included questions about cognitive and behavioral issues that children may have experienced and school and extracurricular activity participation. Specifically, participants were asked to report how well their child performs in school (mostly A's, mostly B's, etc.), if they participate in extracurricular activities, if they choose to participate in extracurricular activities, and if they feel that their child has ever displayed abnormal behavioral problems. Participants were asked to explain their answers to each of these questions. Participants also reported the effect of their work on the support and discipline that their child receives.

RESULTS

Demographically, the participants in this study ranged in age from twenty-six to fifty-nine years and were all Caucasian. There were a total of twenty-eight female participants ranging in age from twenty-six to fifty-nine years and four male participants ranging in age from twenty-eight to fifty years.

Research findings revealed that only 12% of participants worked less than ten hours per week. 3% worked eleven to twenty hours per week, 15% worked twenty to thirty hours per week, and 40% worked thirty-one to forty hours per week. In addition, 30% worked more than forty hours per week.

Concerning the employment status of both the participants and their spouses, it was found that in 34% of cases one parent served as a full-time homemaker, while the other parent worked. 19% of participants reported working part-time and enrolling their child in daycare and 47% of participants reported working full-time and enrolling their child in daycare.

Research found that an overwhelming majority (85%) of participants brought home zero to five hours of work each week in addition to their on-site work. 6% of participants

reported six to ten hours, 6% reported eleven to fifteen hours, and 3% reported bringing home sixteen to twenty hours of work per week.

67% of participants in the study reported that their child currently attended out-of-home child care or had in the past. 33% reported that their child had never attended out-of-home care. Of children who attended out-of-home care, a majority (52%) spend between thirty-one and forty hours per week there. 24% spend twenty to thirty hours and 19% spend more than forty hours. 5% of children who attend out-of-home care spend less than five hours per week there.

100% of participants in the study reported that they considered family to be more important than work. 76% of parents with children attending out-of-home child care reported that their child received high-quality care, while 83% of parents who stay home with their child reported that they received high quality care. Also, 17% of stay-at-home parents reported that their child received medium quality care, while 24% of parents with children in out-of-home care reported medium quality care. No participants reported that their child received low quality care.

Participants also reported the impact on children of having working parents. Of parents whose children attend out-of-home care, 90% felt that their work had a positive impact on their children, while 5% felt that it had a negative effect, and 5% felt that it had no effect. Of parents who stayed at home with their children, 70% stated that it had a positive effect on children, while 10% reported a negative effect, and 20% reported no effect.

Regarding the effects of out-of-home care, differences were found in the amount of support and discipline children receive. As illustrated in Figure 1, 32% of participants reported that having their child in out-of-home care affected the support that their child received, while 68% reported that it did not. 50% of participants stated that out-of-home care affected the discipline their child received, while 50% reported that it did not.
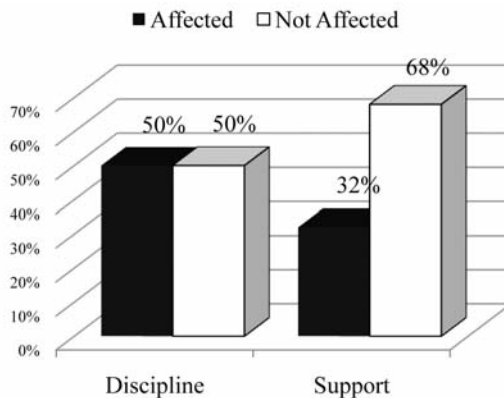
Figure 1: Affect of maternal employment on discipline and support that children receive as reported by working mothers

Differences were also found in children's school performance between those who attended out-of-home care and those who did not. As illustrated in Figure 2, of those children

who did not attend out-of-home care, 40% were reported to perform above average in school, 40% were reported to perform between average and above average, and 20% were reported to perform at an average level. Of children who attended out-of-home care, 60% were reported to perform above average in school, 15% between average and above average, and 25% at an average level.
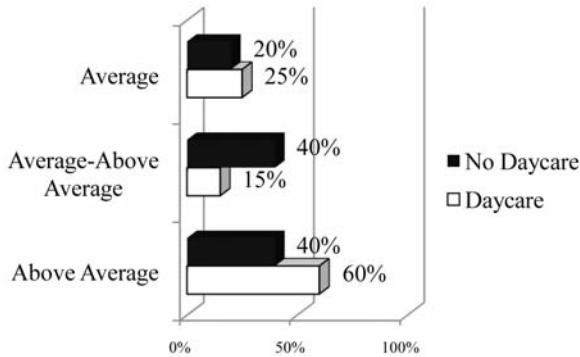

Figure 2: Differences in school performance in children as reported by working and stay-at-home mothers

Differences were found in participation in extracurricular activities. These differences are illustrated in Figure 3. Children who attended out-of-home care were more likely than those who stayed at home with a parent to participate in extracurricular activities. 90% of children who attended out-of-home care participated, while 83% of those who stayed at home with a parent participated.
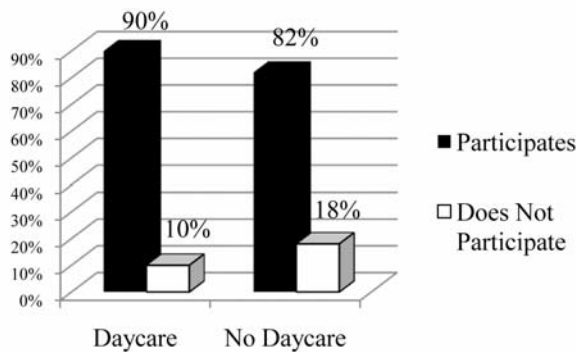
Figure 3: Children's participation in extracurricular activities as reported by working and stay-at-home mothers

Regarding behavioral problems of children, as seen in Figure 4, differences were reported between children who attended out-of-home care and those who stayed at home with a parent. Of participants whose children attended out-of-home care, 42% reported behavior problems with their children. None of the parents who stayed at home with their children reported extraordinary problems with their children's behavior.
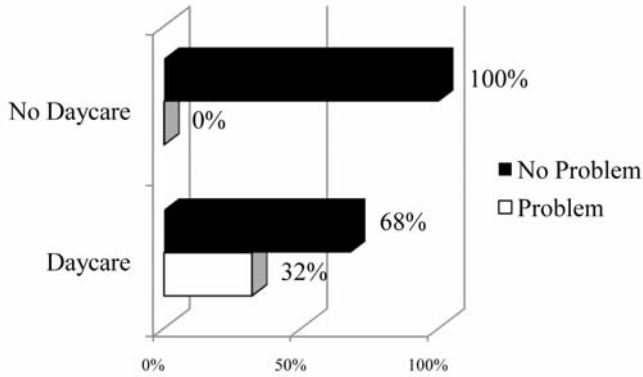
Figure 4: Behavior problems as reported by both working and stay-at-home mothers

DISCUSSION

Compared with earlier research, findings in this study were mixed, but in general they were fairly consistent with earlier findings. This study found that all mothers, both working and not, felt that family was always more important than work, while Giele (2008) found that working mothers felt that their careers were their main life role. This finding is interesting in that although all of the participants reported feeling that family was more important than work, they did not all report always putting family ahead of work.

Participants in this study reported several effects on their children that resulted because of their employment. The results of this study show that thirty-two percent of participants reported that the support their children received was affected by the use of out-of-home care. Also, fifty percent of participants reported discipline being affected. Similarly, Nomaguchi and Milkie (2006) found that children that attended out-of-home care received less discipline and less support from their mothers. These results are not surprising considering the amount of time worked by parents. In fifty-two percent of cases, both parents worked at least forty hours per week. Because so much time is spent working, it is likely that more discipline must be left to children's caregivers and less to the parents. Also, although all of the participants stated that they felt family was more important that work, it is likely that children of parents who work many hours would feel they receive less support because they spend less time in the care of their parents.

This study also found that a majority of working mothers (seventy percent) felt that their employment had a positive impact on their child. In addition, ten percent felt that their employment had a negative effect and twenty percent felt it had no effect. Of stay-at-home mothers, ninety percent felt that not working had a positive effect on their children. Researchers at South Bank University found that working mothers reported both positive and negative impacts on their children. As the research shows, there are both positive and negative impacts of maternal employment. Many of the mothers in this study that reported working had a positive impact explained that if they did not work their families would likely face financial difficulties and their children would have less access to opportunities. Many also stated that they considered themselves to be positive role models for their children because they balanced work and family.

Although there were many positive implications attributable to maternal employment, this study also revealed some negative effects. For instance, in this study, none of the stay-at-home mothers reported behavior problems in their children, whereas forty-two percent of working mothers did report problems. Han, Waldfogel, and Brooks-Gunn (2001) found that maternal employment sometimes led to behavioral problems in children. This finding could be related to children being cared for by several people (both out-of-home care providers and parents). Children likely receive varying amounts and types of discipline in this situation, which could lead to confusion and ultimately behavior problems.

In addition to disciplinary differences, this study found that children of stay-at-home mothers were reported to not perform as well in school as children of working mothers. While sixty percent of working mothers reported that their children performed above average in school, only forty percent of stay-at-home mothers reported above average school performance. Gennetian, Lopoo, and London (2008) completed a study that examined school performance and participation in extracurricular activities. Unlike this study, their study found that children of stay-at-home mothers were more likely to have above average school performance. This study found that children who attended out-of-home care were more likely to participate in extracurricular activities, with ninety percent of children participating compared to eighty-two percent of children with stay-at-home mothers. These findings were consistent with those of Gennetian, Lopoo, and London and may indicate that children who attend out-of-home care might be more accustomed to social situations and therefore be more out-going and more likely to participate in extracurricular activities.

This study focused almost entirely on stay-at-home mothers. Future studies might consider stay-at-home fathers, which are becoming more commonplace, as a means of comparison to stay-at-home mothers. They might also include a larger sample size and a more extensive geographic area.

LIMITATIONS

Limitations to this study included, but are not limited to, small sample size, limited geographic area, lack of formal statistical analysis, and accuracy of participant's self-reports.

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