

Study 2: Reinforcement-Punishment Analysis

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Study 2: Within-Subjects Reinforcement and Punishment Effects of Liquid and Monetary Incentives

This is an analysis of the subject performance of study 2 of reinforcement and punishment effects of liquid feedback with monetary gains and losses. In the study, subjects perform the cued task-switching paradigm, where they have to classify a letter (vowel/consonant) or digit (odd/even). During the baseline runs, they don't receive any feedback and are told to respond "as quickly and accurately as possible." During the incentive runs, they receive a drop of liquid (2 mL) to indicate successful attainment of monetary reward in a single trial. Each subject performs 6 incentive runs: 3 reinforcement (all liquids and monetary gains) and 3 punishment avoidance (all liquids and avoidance of monetary losses). Liquids are blocked.

Criterion RT is calculated on subject performance during the baseline run (30%), and is the same for both reinforcement and punishment conditions.

Loading relevant packages

```
library(ggplot2)
library(RColorBrewer)
library(gridExtra)
library(dplyr)
library(tidyr)
library(lme4)
library(lmerTest)
library(sjPlot)
library(pander)
source("summarySEwithin2.R")
```

Path directories of data input/output

```
# data directories
data.path<-paste0("/Users/debbieyee/Dropbox/CCPLabProjects/Liquid_Feedback/",
                  "Reinforce-Punish_Combined/Study2/Data/SubjectData/TrimmedData/",
                  "Study2_ConsolidatedRewardData.csv")
runkey.path<-paste0("/Users/debbieyee/Dropbox/CCPLabProjects/Liquid_Feedback/",
                    "Reinforce-Punish_Combined/Study2/Data/SubjectData/TrimmedData/",
                    "Study2_ConsolidateRunKey.csv")
figure.path<-paste0("/Users/debbieyee/Dropbox/CCPLabProjects/Liquid_Feedback/",
                    "Reinforce-Punish_Combined/Study2/Analysis/Figures/")
```

Format the data for analysis

```
# Read in the data
data<-read.csv(data.path,header = TRUE) %>% select(-X)
runkey<-read.csv(runkey.path, header = TRUE) %>%
  select(subID,block,liquid)

# Formatting incentive data
incentive<- data %>% inner_join(y = runkey, by = c("subID","block")) %>%
  mutate(subRewarded=(RT<critRT & ACC==1)*1,
         ERR=ifelse(ACC==0,1,0),
         block = factor(block, levels=c(7:12), labels=c(1:6)),
         money=factor(reward, levels=c("Reward1","Reward2","Reward4"), labels=c("$","$$","$$$")),
         moneyCode=factor(reward, levels=c("Reward1","Reward2","Reward4"), labels=c(-1,0,1)),
         liqCode=factor(liquid, levels=c("saltwater","neutral","juice"), labels=c(-1,0,1)),
         liqCodeJvN=factor(liquid, levels=c("saltwater","neutral","juice"), labels=c(0,-1,1)),
         liqCodeSvN=factor(liquid, levels=c("saltwater","neutral","juice"), labels=c(-1,1,0)),
         feedbackCode = factor(feedback, levels=c("Pos","Neg"), labels=c(0,1)),
         feedback = factor(feedback, levels=c("Pos","Neg"), labels=c("Positive","Negative")))
incentive$moneyCode<-as.numeric(levels(incentive$moneyCode)[incentive$moneyCode])
incentive$liqCode<-as.numeric(levels(incentive$liqCode)[incentive$liqCode])
incentive$liqCodeJvN<-as.numeric(levels(incentive$liqCodeJvN)[incentive$liqCodeJvN])
incentive$liqCodeSvN<-as.numeric(levels(incentive$liqCodeSvN)[incentive$liqCodeSvN])
incentive$feedbackCode <- as.numeric(levels(incentive$feedbackCode)[incentive$feedbackCode])
```

Summarise/Consolidate Incentive Data

```
# by money only
data.money.means<-incentive %>% group_by(subID,money) %>%
  filter(!is.na(subRewarded)) %>%
  summarise(n=n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanErr = mean(ERR))

# by liquid only
data.liq.means = incentive %>% group_by(subID, liquid) %>%
  filter(!is.na(subRewarded)) %>%
  summarise(n=n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanErr = mean(ERR))

# by feedback only
data.feedback.means<-incentive %>% group_by(subID,feedback) %>%
  filter(!is.na(subRewarded)) %>%
  summarise(n=n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanErr = mean(ERR))

# money and feedback
data.MF.means = incentive %>% group_by(subID, money,feedback) %>%
  filter(!is.na(subRewarded)) %>%
  summarise(n=n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanErr = mean(ERR)) %>%
  ungroup(subID) %>% mutate(subID=as.factor(subID))

# liquid and feedback
data.LF.means = incentive %>% group_by(subID,liquid,feedback) %>%
  filter(!is.na(subRewarded)) %>%
```

```

summarise(n=n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanErr = mean(ERR)) %>%
ungroup(subID) %>% mutate(subID=as.factor(subID))

# money, liquid, feedback
incentive9.means = incentive %>% group_by(subID, liquid, money, feedback) %>%
  filter(!is.na(subRewarded)) %>%
  summarise(n = n(), meanRR = mean(subRewarded), meanACC = mean(ACC), meanERR = mean(ERR)) %>%
  mutate(moneycode = as.numeric(as.character(factor(money, levels=c("$", "$$", "$$$$"),
                                                    labels=c(-1,0,1)))),
         liqcode = as.numeric(as.character(factor(liquid, levels=c("saltwater", "neutral", "juice"),
                                                    labels=c(-1,0,1))))) %>%
  ungroup(subID) %>% mutate(subID=as.factor(subID))

```

Reward Rate: Monetary Rewards

```
RR.sum<-summarySEwithin2(data = data.money.means, measurevar = "meanRR",  
                          withinvars = c("money"), idvar = "subID")
```

```
##
```

```
## Attaching package: 'data.table'
```

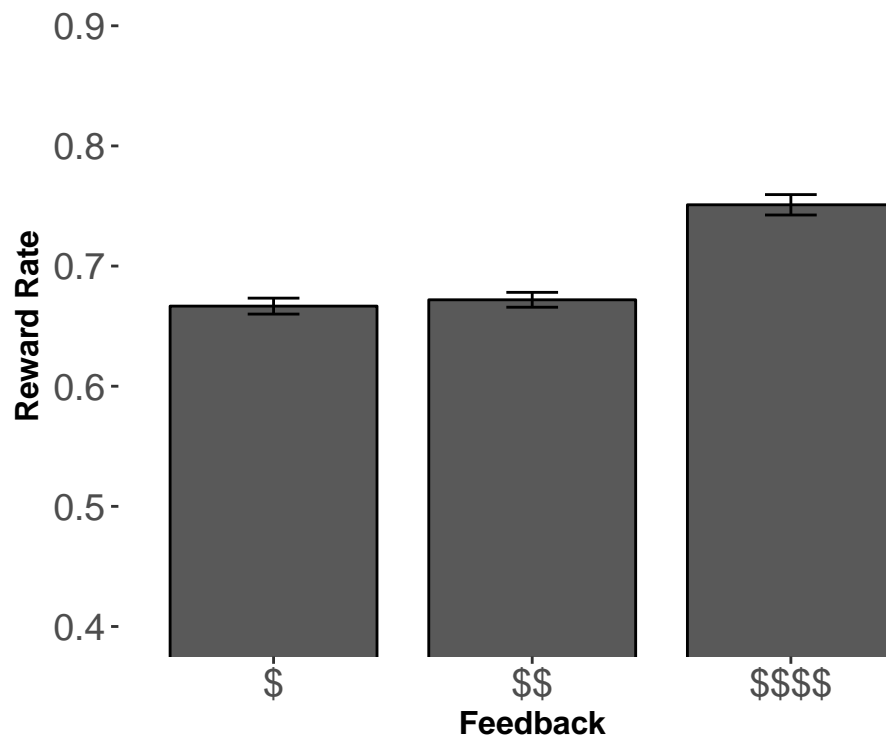
```
## The following objects are masked from 'package:dplyr':
```

```
##
```

```
##      between, first, last
```

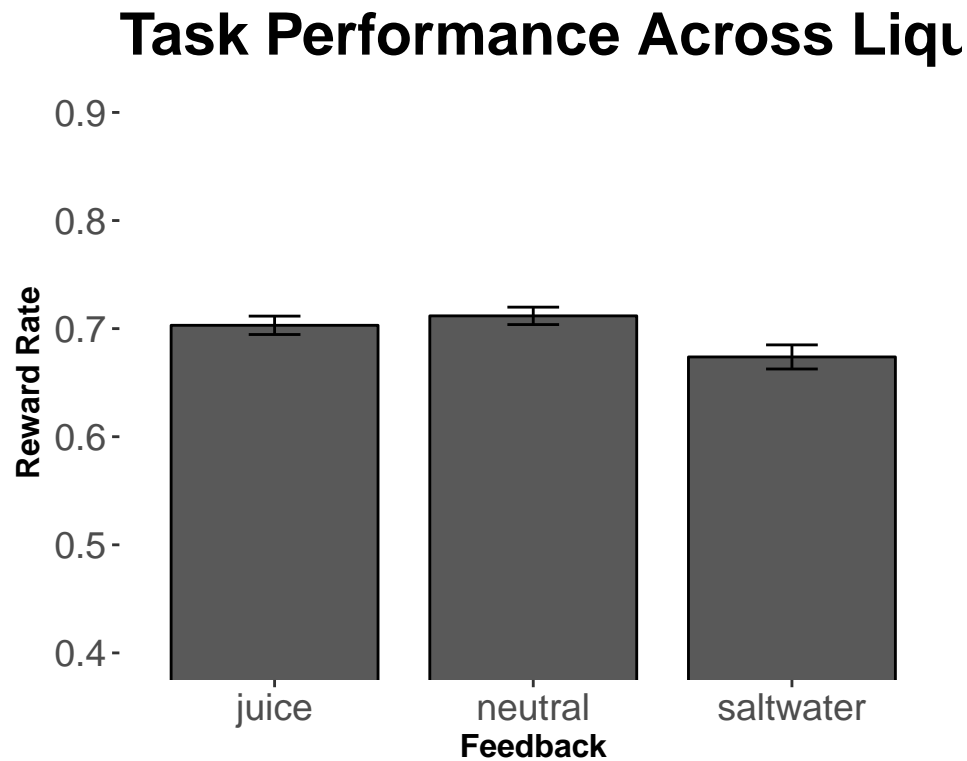
```
p.RR.1<-ggplot(RR.sum, aes(x=money, y=meanRR)) +  
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +  
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +  
  labs(x="Feedback",y="Reward Rate") +  
  #ggtitle("Task Performance Across Money") +  
  #scale_x_discrete(labels=c("win","avoid losing")) +  
  coord_cartesian(ylim=c(.4,.9)) +  
  theme(panel.background = element_blank(), panel.grid.major= element_blank(),  
        panel.grid.minor=element_blank(),  
        plot.title=element_text(size=22,face="bold", vjust=2),  
        axis.title=element_text(size=12,face = "bold"),  
        axis.text=element_text(size=14),  
        legend.position="none")
```

```
p.RR.1
```



Reward Rate: Liquid Incentives

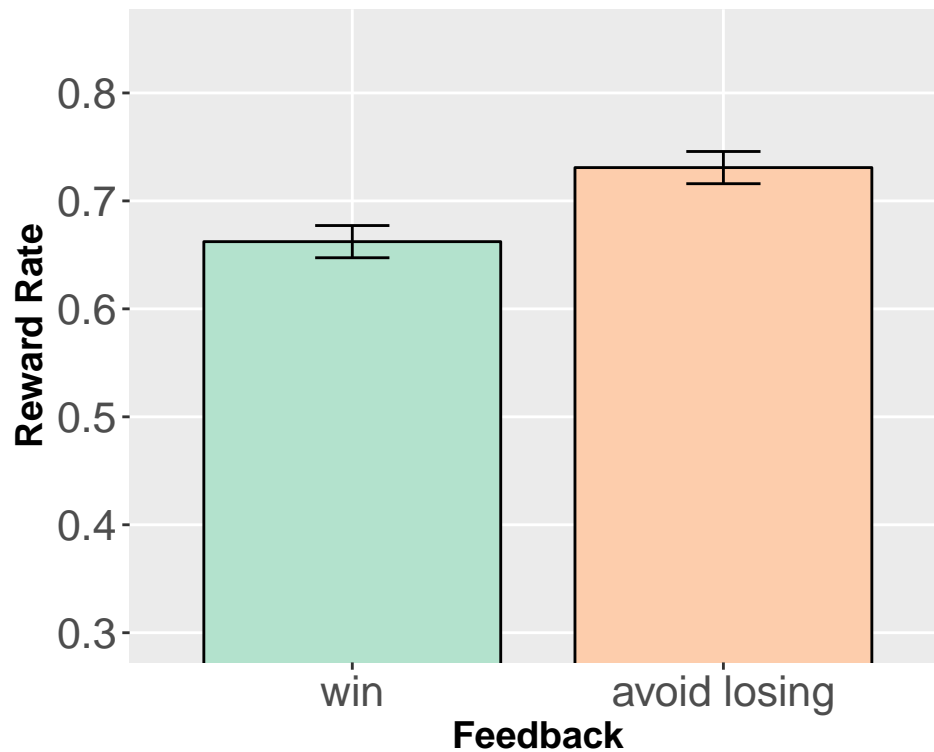
```
RR.sum<-summarySEwithin2(data = data.liq.means, measurevar = "meanRR",
                          withinvars = c("liquid"), idvar = "subID")
p.RR.2<-ggplot(RR.sum, aes(x=liquid, y=meanRR)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  labs(x="Feedback",y="Reward Rate") +
  ggtitle("Task Performance Across Liquids") +
  #scale_x_discrete(labels=c("win","avoid losing")) +
  coord_cartesian(ylim=c(.4,.9)) +
  theme(panel.background = element_blank(), panel.grid.major= element_blank(),
        panel.grid.minor=element_blank(),
        plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        legend.position="none")
p.RR.2
```



Reward Rate: Win vs. Loss Avoidance Framework

Plot: Win vs. Avoid Losses

```
RR.sum<-summarySEwithin2(data = data.feedback.means, measurevar = "meanRR", withinvars = c("feedback"))
p.RR.3<-ggplot(RR.sum, aes(x=feedback, y=meanRR, fill=feedback)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  scale_fill_brewer(palette="Pastel2") +
  geom_errorbar(position=position_dodge(width=0.8),
    aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  labs(x="Feedback",y="Reward Rate") +
  #ggtitle("Task Performance Across Money") +
  scale_x_discrete(labels=c("win","avoid losing")) +
  coord_cartesian(ylim=c(.3,.85)) +
  theme(
    panel.grid.minor=element_blank(),
    plot.title=element_text(size=22,face="bold", vjust=2),
    axis.title=element_text(size=14,face = "bold"),
    axis.text=element_text(size=16),
    legend.position="none")
p.RR.3
```

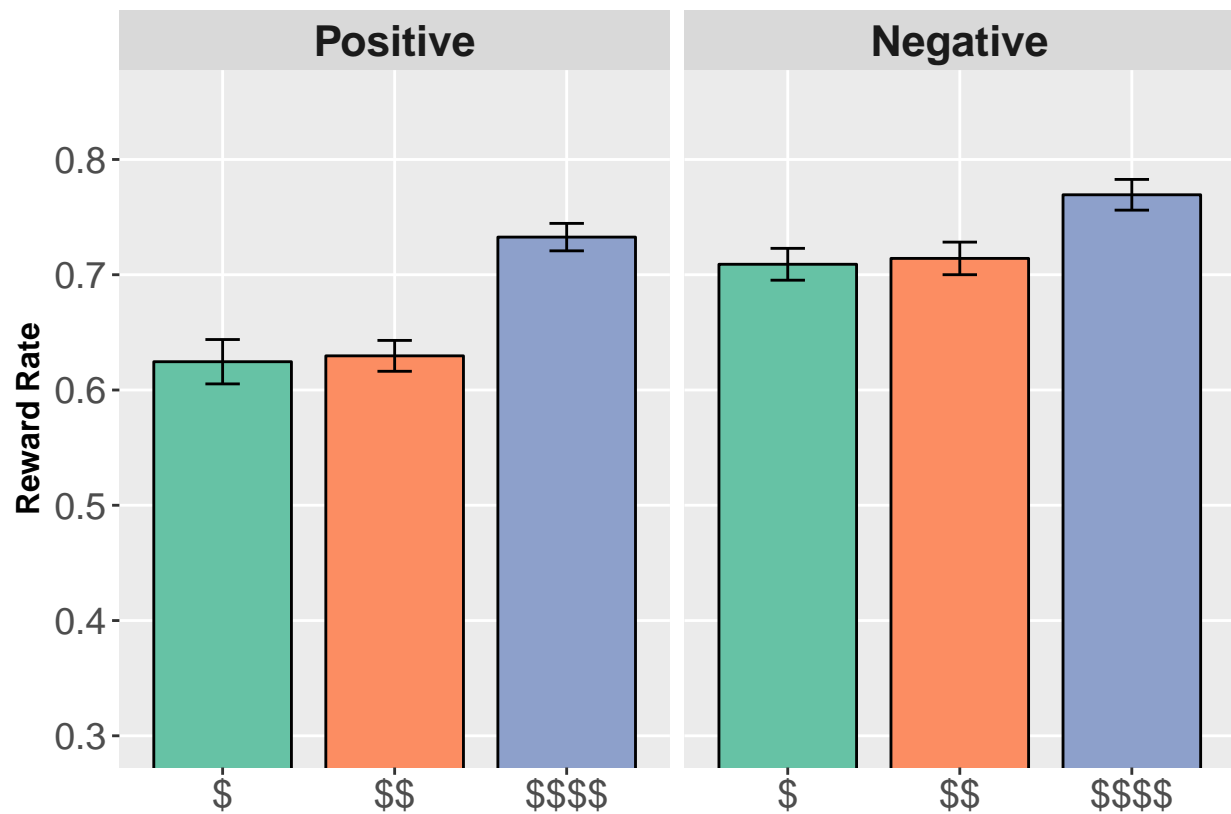


Plot: Win vs. Avoid Losses by Monetary Reward

```
RR.sum<-summarySEwithin2(data = data.MF.means, measurevar = "meanRR",
                          withinvars = c("money","feedback"), idvar = "subID")
pandoc.table(RR.sum)
```

```
##
## -----
## money    feedback    N    meanRR    meanRRNormed    sd    se    ci
## -----
## $        Negative    45    0.7091    0.7091    0.09265    0.01381    0.02784
##
## $        Positive    45    0.6245    0.6245    0.1292    0.01926    0.03881
##
## $$       Negative    45    0.7142    0.7142    0.09476    0.01413    0.02847
##
## $$       Positive    45    0.6296    0.6296    0.08981    0.01339    0.02698
##
## $$$$     Negative    45    0.7694    0.7694    0.08939    0.01333    0.02686
##
## $$$$     Positive    45    0.7326    0.7326    0.07989    0.01191    0.024
## -----
```

```
p.RR.4<-ggplot(RR.sum, aes(x=money, y=meanRR, fill=money)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  #scale_fill_brewer(palette="Pastel2") +
  scale_fill_brewer(palette="Set2") +
  facet_grid(.~feedback) +
  labs(x=" ",y="Reward Rate") +
  #scale_x_discrete(labels=c("win","avoid losing")) +
  #scale_x_discrete(labels=c("$","$$","$$$$")) +
  #ggtitle("Task Performance Across Money") +
  coord_cartesian(ylim=c(.3,.85)) +
  theme(#panel.background = element_blank(), panel.grid.major= element_blank(),
        panel.grid.minor=element_blank(),
        plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        strip.text.x = element_text(size=16, face = "bold"),
        legend.position="none")
p.RR.4
```

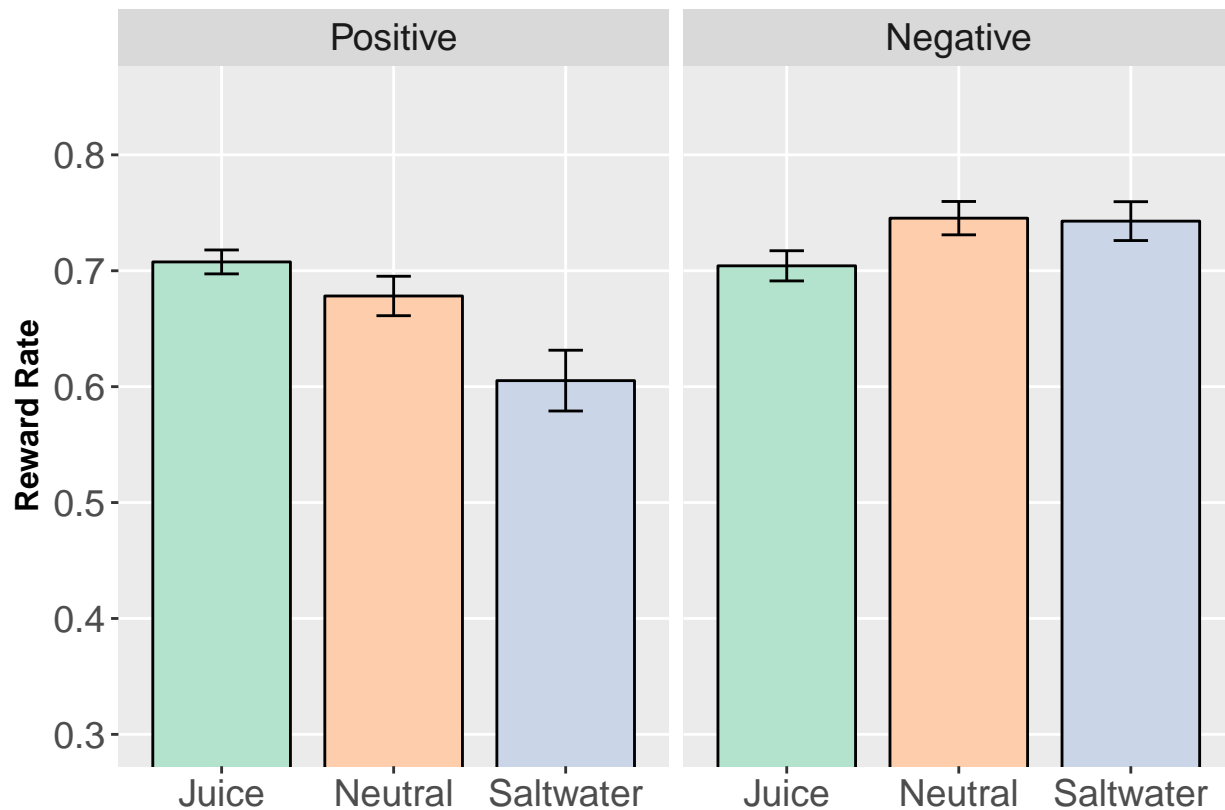


Plot: Win vs. Avoid Losses by Liquid

```
RR.sum<-summarySEwithin2(data = data.LF.means, measurevar = "meanRR",
                          withinvars = c("liquid","feedback"), idvar = "subID")
#RR.sum$liquid2<-factor(RR.sum$liquid, labels = c("Juice","Neutral","Saltwater"))
pandoc.table(RR.sum)
```

## -----								
##	liquid	feedback	N	meanRR	meanRRNormed	sd	se	ci
##	-----							
##	juice	Negative	45	0.7042	0.7048	0.08743	0.01303	0.02627
##	juice	Positive	44	0.7076	0.7047	0.06846	0.01032	0.02081
##	neutral	Negative	45	0.7454	0.746	0.09651	0.01439	0.029
##	neutral	Positive	45	0.6782	0.6788	0.1141	0.01701	0.03429
##	saltwater	Negative	45	0.7428	0.7434	0.1124	0.01675	0.03377
##	saltwater	Positive	45	0.6052	0.6058	0.1758	0.02621	0.05282
##	-----							


```
p.RR.5<-ggplot(RR.sum, aes(x=liquid, y=meanRR,fill=liquid)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  scale_fill_brewer(palette="Pastel2") +
  facet_grid(.~feedback) +
  labs(x=" ",y="Reward Rate") +
  #ggtitle("Task Performance Across Money") +
  scale_x_discrete(labels=c("Juice","Neutral","Saltwater")) +
  coord_cartesian(ylim=c(.3,.85)) +
  theme(panel.grid.minor=element_blank(),
        plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        legend.position="none",
        strip.text.x = element_text(size = 14))
p.RR.5
```



Plot: Win vs. Avoid Losses by Monetary Reward & Liquid

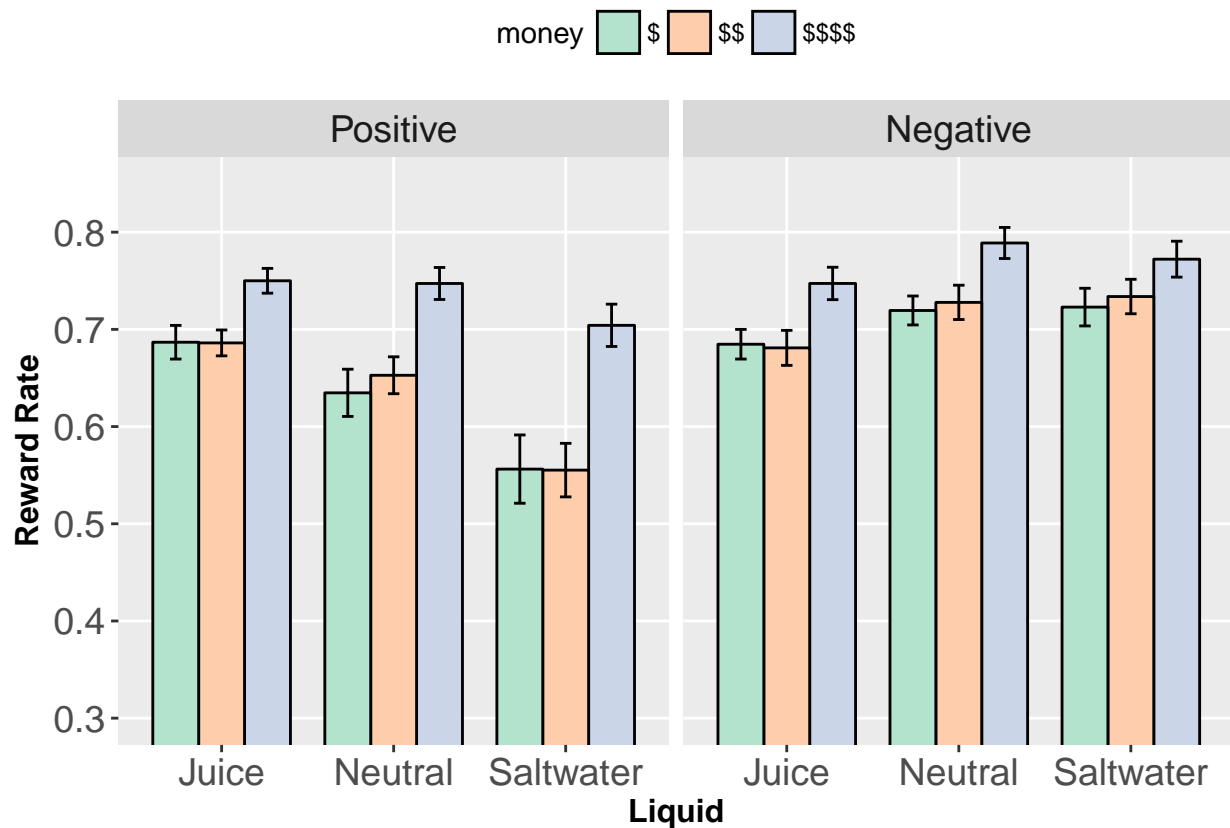
```
RR.sum=summarySEwithin2(data = incentive9.means, measurevar = "meanRR",
                        withinvars = c("liquid","feedback","money"), idvar="subID")
pandoc.table(RR.sum)
```

```
##
## -----
```

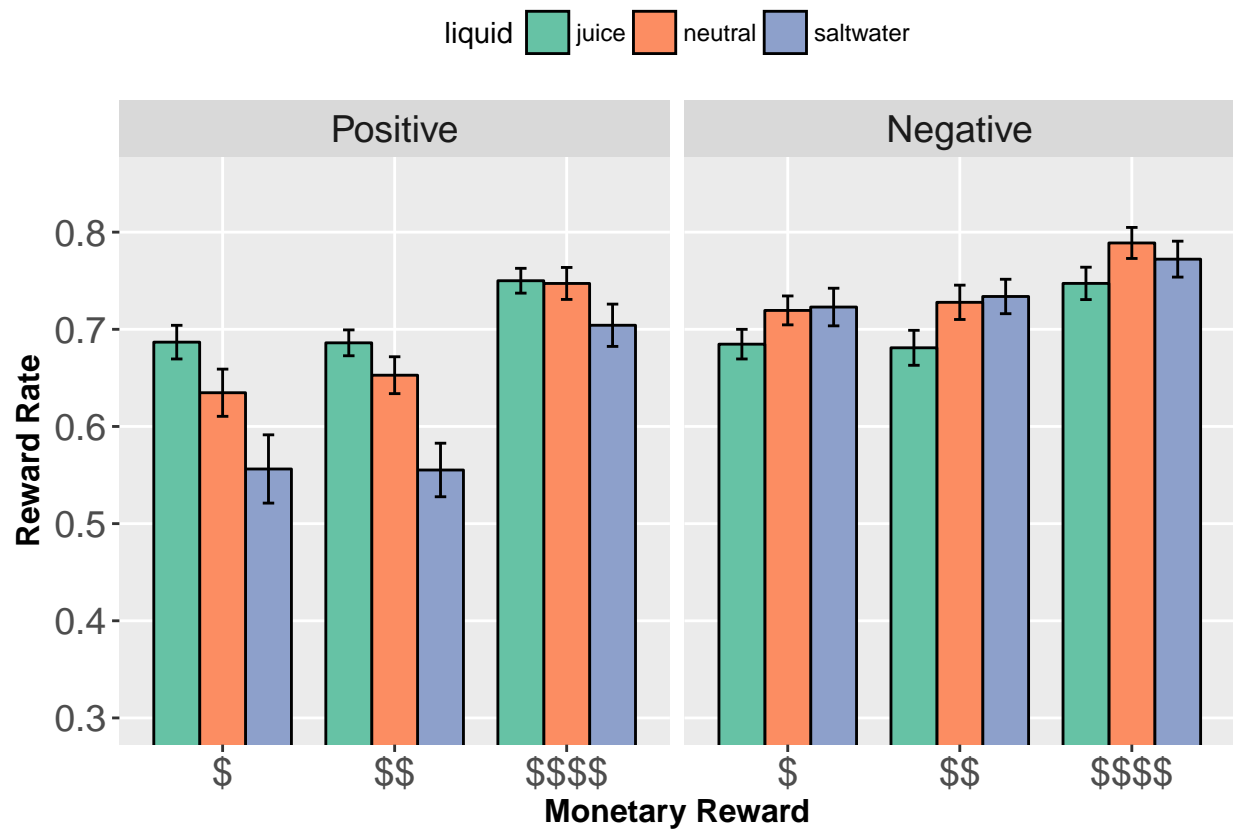
##	liquid	feedback	money	N	meanRR	meanRRNormed	sd	se
##	juice	Negative	\$	45	0.6847	0.6853	0.1023	0.01525
##	juice	Negative	\$\$	45	0.681	0.6816	0.1208	0.018
##	juice	Negative	\$\$\$\$	45	0.7473	0.7478	0.1118	0.01666
##	juice	Positive	\$	44	0.6868	0.6838	0.1149	0.01732
##	juice	Positive	\$\$	44	0.6861	0.6831	0.08833	0.01332
##	juice	Positive	\$\$\$\$	44	0.75	0.747	0.08468	0.01277
##	neutral	Negative	\$	45	0.7194	0.72	0.09982	0.01488
##	neutral	Negative	\$\$	45	0.7278	0.7284	0.1184	0.01766
##	neutral	Negative	\$\$\$\$	45	0.7889	0.7895	0.1071	0.01597
##	neutral	Positive	\$	45	0.6347	0.6353	0.163	0.02429
##	neutral	Positive	\$\$	45	0.6528	0.6534	0.1274	0.01899
##	neutral	Positive	\$\$\$\$	45	0.7472	0.7478	0.1104	0.01646
##	saltwater	Negative	\$	45	0.7229	0.7235	0.1299	0.01936
##	saltwater	Negative	\$\$	45	0.7338	0.7344	0.1189	0.01773
##	saltwater	Negative	\$\$\$\$	45	0.7722	0.7728	0.1239	0.01848
##	saltwater	Positive	\$	45	0.5563	0.5568	0.2357	0.03513
##	saltwater	Positive	\$\$	45	0.5552	0.5558	0.1849	0.02756
##	saltwater	Positive	\$\$\$\$	45	0.7042	0.7047	0.1459	0.02176
##	-----							
##	Table: Table continues below							
##	-----							
##	ci							
##	-----							
##	0.03074							
##	0.03628							
##	0.03358							
##	0.03492							
##	0.02686							

```
##
## 0.02575
##
## 0.02999
##
## 0.03558
##
## 0.03219
##
## 0.04896
##
## 0.03827
##
## 0.03317
##
## 0.03902
##
## 0.03573
##
## 0.03724
##
## 0.0708
##
## 0.05555
##
## 0.04385
## -----
```

```
p.RR.6<-ggplot(RR.sum, aes(x=liquid, y=meanRR, fill=money)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  scale_fill_brewer(palette="Pastel2") +
  facet_grid(.~feedback) +
  labs(x="Liquid", y="Reward Rate") +
  #ggtitle("Reward Rate Performance") +
  coord_cartesian(ylim=c(.3,.85)) +
  #scale_fill_discrete(name="Monetary Reward") +
  scale_x_discrete(labels=c("Juice", "Neutral", "Saltwater")) +
  #geom_hline(yintercept = .30, color="darkorchid4") +
  #annotate("text", 1.2, .85, label = "Reward Criterion (30%", color="darkorchid4") +
  #geom_segment(aes(x=.55,xend=.65,y=.85,yend=.85), color="darkorchid4") +
  #geom_hline(yintercept = reward_crit_low, color="darkorchid4", linetype="dashed") +
  #geom_hline(yintercept = reward_crit_high, color="darkorchid4", linetype="dashed") +
  #geom_rect(mapping = aes(xmin=.4,xmax=2.6,ymin=reward_crit_low,ymax=reward_crit_high), fill="darkorchid4") +
  #annotate("text", 1.39, .82, label = "Binomial Confidence Interval (95%", color="darkorchid4") +
  #geom_segment(aes(x=.55,xend=.65,y=.82,yend=.82), color="darkorchid4", linetype="dashed") +
  theme(panel.grid.minor=element_blank(),
        plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        legend.position="top",
        strip.text.x = element_text(size = 14))
p.RR.6
```



```
p.RR.6a<-ggplot(RR.sum, aes(x=money, y=meanRR,fill=liquid)) +
  geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRR-se, ymax=meanRR+se), width=.2) +
  scale_fill_brewer(palette="Set2") +
  facet_grid(.~feedback) +
  labs(x="Monetary Reward",y="Reward Rate") +
  #ggtitle("Reward Rate Performance") +
  coord_cartesian(ylim=c(.3,.85)) +
  #scale_fill_discrete(name="Monetary Reward") +
  scale_x_discrete(labels=c("$","$$","$$$")) +
  #geom_hline(yintercept = .30, color="darkorchid4") +
  #annotate("text", 1.2, .85, label = "Reward Criterion (30%)", color="darkorchid4") +
  #geom_segment(aes(x=.55,xend=.65,y=.85,yend=.85), color="darkorchid4") +
  #geom_hline(yintercept = reward_crit_low, color="darkorchid4", linetype="dashed") +
  #geom_hline(yintercept = reward_crit_high, color="darkorchid4", linetype="dashed") +
  #geom_rect(mapping = aes(xmin=.4,xmax=2.6,ymin=reward_crit_low,ymax=reward_crit_high), fill="darkorchid4") +
  #annotate("text", 1.39, .82, label = "Binomial Confidence Interval (95%)", color="darkorchid4") +
  #geom_segment(aes(x=.55,xend=.65,y=.82,yend=.82), color="darkorchid4", linetype="dashed") +
  theme(panel.grid.minor=element_blank(),
        plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        legend.position="top",
        strip.text.x = element_text(size = 14))
p.RR.6a
```



Generalized Linear Mixed Models: Reward Rate

Reward Rate as a function of Feedback

```
# omnibus model: reward rate by liquid and money
m.RR.null<-glmer(formula = subRewarded ~ (1+moneyCode+liqCode|subID),
                 data = incentive, family=binomial)
m.RR.1<-glmer(formula = subRewarded ~ moneyCode*liqCode*feedbackCode +(1+moneyCode+liqCode|subID),
              data = incentive, family=binomial)
summary(m.RR.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
##   Formula:
##   subRewarded ~ moneyCode * liqCode * feedbackCode + (1 + moneyCode +
##     liqCode | subID)
##   Data: incentive
##
##           AIC          BIC    logLik deviance df.resid
## 29853.6 29967.9 -14912.8 29825.6    25903
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.6850 -1.0166  0.4889  0.6737  1.4485
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   subID (Intercept) 0.34436  0.5868
##           moneyCode  0.02307  0.1519  0.09
##           liqCode    0.04428  0.2104  0.15 0.07
## Number of obs: 25917, groups: subID, 45
##
## Fixed effects:
##
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    0.74847    0.08971   8.344 < 2e-16 ***
## moneyCode      0.26094    0.03322   7.854 4.01e-15 ***
## liqCode        0.23974    0.03975   6.032 1.62e-09 ***
## feedbackCode   0.34124    0.02845  11.995 < 2e-16 ***
## moneyCode:liqCode -0.08016    0.02958  -2.710 0.00673 **
## moneyCode:feedbackCode -0.09341    0.03482  -2.683 0.00730 **
## liqCode:feedbackCode -0.33807    0.03492  -9.680 < 2e-16 ***
## moneyCode:liqCode:feedbackCode 0.09168    0.04278   2.143 0.03210 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) monyCd liqCod fdbckC mnyCd:lC mnyCd:fC lqCd:C
## moneyCode    0.068
## liqCode      0.123  0.040
## feedbackCod -0.149 -0.028 -0.034
## monyCd:lqCd  0.001  0.055  0.037 -0.005
## mnyCd:fdbckC -0.009 -0.494 -0.002  0.055 -0.050
```

```
## lqCd:fdbckC -0.012 -0.003 -0.415 0.022 -0.037 0.003
## mnyCd:lqC:C -0.001 -0.038 -0.024 0.002 -0.689 0.019 0.054
```

Reward Rate in Gain/Win Frame

```
m.RR.2<-glmer(formula = subRewarded ~ moneyCode*liqCode +(1+moneyCode+liqCode|subID),
              data = subset(incentive,feedback=="Positive"), family=binomial)
summary(m.RR.2)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
## Formula: subRewarded ~ moneyCode * liqCode + (1 + moneyCode + liqCode |
##         subID)
##   Data: subset(incentive, feedback == "Positive")
##
##           AIC          BIC    logLik deviance df.resid
## 15041.9 15116.6 -7510.9 15021.9    12950
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7587 -0.9418  0.4776  0.6853  2.8504
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   subID  (Intercept) 0.51351  0.7166
##           moneyCode  0.07584  0.2754  -0.28
##           liqCode    0.18095  0.4254  -0.30  0.36
## Number of obs: 12960, groups:  subID, 45
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    0.76454    0.10891   7.020 2.21e-12 ***
## moneyCode       0.27380    0.04827   5.673 1.41e-08 ***
## liqCode         0.26082    0.06850   3.807 0.00014 ***
## moneyCode:liqCode -0.09997    0.03082  -3.243 0.00118 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) monyCd liqCod
## moneyCode   -0.228
## liqCode     -0.272  0.287
## monyCd:liqCd  0.002  0.025  0.016
```

Reward in Gain/Win Frame by Monetary Reward

Here we look at the effects of the liquid at different monetary reward levels. Task performance differences are more affected in low monetary reward levels (lowest win condition). In low monetary reward conditions, there is a significant liquid effect. In medium monetary reward conditions there is also a significant liquid effect. In high monetary reward conditions, there is no longer a significant liquid effect. It is strange that there is no significant interaction - I wonder why that is?

```
# Money $ (Low)
m.RR.2.rew1<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
                  data = subset(incentive,feedback=="Positive" & moneyCode==1), family=binomial)
```



```
summary(m.RR.2.rew1)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Positive" & moneyCode == -1)
##
##      AIC      BIC   logLik deviance df.resid
##  5150.8   5182.7  -2570.4   5140.8     4315
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.2721 -0.9166  0.4914  0.7089  2.2569
##
## Random effects:
## Groups Name          Variance Std.Dev. Corr
## subID (Intercept) 0.7312   0.8551
##          liqCode    0.2790   0.5282  -0.42
## Number of obs: 4320, groups: subID, 45
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.57312    0.13244   4.327 1.51e-05 ***
## liqCode      0.32570    0.09039   3.603 0.000314 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## liqCode -0.347
```

```
# Money $$ (Medium)
```

```
m.RR.2.rew2<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
                    data = subset(incentive,feedback=="Positive" & moneyCode==0), family=binomial)
summary(m.RR.2.rew2)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Positive" & moneyCode == 0)
##
##      AIC      BIC   logLik deviance df.resid
##  5288.4   5320.2  -2639.2   5278.4     4315
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.8775 -0.9576  0.4995  0.7254  2.7847
##
## Random effects:
## Groups Name          Variance Std.Dev. Corr
## subID (Intercept) 0.4918   0.7013
##          liqCode    0.1965   0.4433  -0.24
```

```

## Number of obs: 4320, groups:  subID, 45
##
## Fixed effects:
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.60390    0.11023   5.478 4.29e-08 ***
## liqCode      0.32432    0.07898   4.107 4.02e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##           (Intr)
## liqCode -0.172

# Money $$$$ (High)
m.RR.2.rew4<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
  data = subset(incentive,feedback=="Positive" & moneyCode==1), family=binomial)
summary(m.RR.2.rew4)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Positive" & moneyCode == 1)
##
##      AIC      BIC   logLik deviance df.resid
## 4717.9   4749.8  -2354.0   4707.9     4315
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7227 -0.6147  0.4563  0.6230  1.8770
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## subID  (Intercept) 0.5230   0.7232
##        liqCode     0.1104   0.3323  -0.46
## Number of obs: 4320, groups:  subID, 45
##
## Fixed effects:
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept)  1.12918    0.11454   9.859 <2e-16 ***
## liqCode      0.09671    0.06846   1.413   0.158
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##           (Intr)
## liqCode -0.307

```

Reward Rate in Loss/Avoid Punishment Frame

```
m.RR.3<-glmer(formula = subRewarded ~ moneyCode*liqCode +(1+moneyCode+liqCode|subID),
              data = subset(incentive,feedback=="Negative"), family=binomial)
summary(m.RR.3)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
## Formula: subRewarded ~ moneyCode * liqCode + (1 + moneyCode + liqCode |
##         subID)
##   Data: subset(incentive, feedback == "Negative")
##
##           AIC          BIC    logLik deviance df.resid
##  14200.6   14275.2   -7090.3   14180.6     12947
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.2761 -0.8923  0.4652  0.6300  1.2638
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   subID   (Intercept)  0.44944   0.6704
##           moneyCode   0.01664   0.1290    0.03
##           liqCode     0.05899   0.2429    0.03 -0.17
## Number of obs: 12957, groups:  subID, 45
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    1.112602   0.102379  10.867 < 2e-16 ***
## moneyCode       0.168169   0.032927   5.107 3.27e-07 ***
## liqCode        -0.105041   0.045121  -2.328  0.0199 *
## moneyCode:liqCode 0.008761   0.031327   0.280  0.7798
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) monyCd liqCod
## moneyCode    0.031
## liqCode      0.018 -0.082
## monyCd:liqCd -0.001 -0.029  0.035
```

Reward in Loss/Avoid Punishment Frame by Monetary Reward

Here we look at the effects of the liquid at different monetary reward levels, as we did in Study 1. The pattern of results matches Study 1, which reveal that when Liquid is delivered as ‘punishment’ to signal failure to attain reward, these task performance differences are more affected in low monetary reward levels (lowest loss condition). In low monetary reward conditions, there is a significant liquid effect. In medium monetary reward conditions there is also a significant liquid effect. In high monetary reward conditions, there is no longer a significant liquid effect. It is strange that there is no significant interaction - I wonder why that is?

```
# Money $ (Low)
m.RR.3.rew1<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
```

```
data = subset(incentive,feedback=="Negative" & moneyCode== -1), family=binomial)
summary(m.RR.3.rew1)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Negative" & moneyCode == -1)
##
##      AIC      BIC   logLik deviance df.resid
##  4962.7   4994.6  -2476.4   4952.7     4305
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.3813 -1.0289  0.5073  0.6523  1.1540
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## subID (Intercept) 0.45339  0.6733
##      liqCode      0.01091  0.1045  -0.09
## Number of obs: 4310, groups: subID, 45
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  0.98495    0.10694   9.211  <2e-16 ***
## liqCode      -0.10083    0.04739  -2.128   0.0334 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr)
## liqCode -0.042
```

```
# Money $$ (Medium)
m.RR.3.rew2<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
data = subset(incentive,feedback=="Negative" & moneyCode==0), family=binomial)
summary(m.RR.3.rew2)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Negative" & moneyCode == 0)
##
##      AIC      BIC   logLik deviance df.resid
##  4942.1   4973.9  -2466.0   4932.1     4320
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.2770 -1.0192  0.4813  0.6590  1.3948
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## subID (Intercept) 0.43443  0.6591
```

```

##          liqCode      0.05931  0.2435  0.21
## Number of obs: 4325, groups:  subID, 45
##
## Fixed effects:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  1.01308    0.10501   9.648  <2e-16 ***
## liqCode      -0.12886    0.05797  -2.223   0.0262 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## liqCode 0.112

# Money $$$$ (High)
m.RR.3.rew4<-glmer(formula = subRewarded ~ liqCode + (1+liqCode|subID),
  data = subset(incentive,feedback=="Negative" & moneyCode==1), family=binomial)
summary(m.RR.3.rew4)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula: subRewarded ~ liqCode + (1 + liqCode | subID)
## Data: subset(incentive, feedback == "Negative" & moneyCode == 1)
##
##      AIC      BIC   logLik deviance df.resid
##  4425.0   4456.9  -2207.5   4415.0     4317
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.6820  0.2716  0.4405  0.5343  1.2344
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## subID (Intercept) 0.48487  0.6963
##          liqCode   0.09016  0.3003  0.04
## Number of obs: 4322, groups:  subID, 45
##
## Fixed effects:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  1.34058    0.11152  12.021  <2e-16 ***
## liqCode      -0.07465    0.06683  -1.117   0.264
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## liqCode 0.015

```

Response Time

```

#
# RT.sum=summarySEwithin2(data = dataRT.means, measurevar = "meanRT", withinvars = c("money","feedback"))

```

```

# p5a<-ggplot(RT.sum, aes(x=feedback, y=meanRT, fill=feedback)) +
#   geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
#   geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanRT-se, ymax=meanRT+se), width=.2) +
#   scale_fill_brewer(palette="Pastel2") +
#   facet_grid(.~money) +
#   labs(x=" ", y="Response Time") +
#   scale_x_discrete(labels=c("win", "avoid losing")) +
#   #ggtitle("Task Performance Across Money") +
#   coord_cartesian(ylim=c(500,600)) +
#   theme(#panel.background = element_blank(), panel.grid.major= element_blank(),
#         panel.grid.minor=element_blank(),
#         plot.title=element_text(size=22,face="bold", vjust=2),
#         axis.title=element_text(size=12,face = "bold"),
#         axis.text=element_text(size=14),
#         strip.text.x = element_text(size=16, face = "bold"),
#         legend.position="none")
# p5a
#
# ERR.sum=summarySEwithin2(data = data.means, measurevar = "meanErr", withinvars = c("money", "feedback"))
# p5b<-ggplot(ERR.sum, aes(x=feedback, y=meanErr, fill=feedback)) +
#   geom_bar(position=position_dodge(width=0.8), color="black", stat="identity", width=0.8) +
#   geom_errorbar(position=position_dodge(width=0.8), aes(ymin=meanErr-se, ymax=meanErr+se), width=.2) +
#   scale_fill_brewer(palette="Pastel2") +
#   facet_grid(.~money) +
#   labs(x=" ", y="Response Time") +
#   scale_x_discrete(labels=c("win", "avoid losing")) +
#   #ggtitle("Task Performance Across Money") +
#   coord_cartesian(ylim=c(0,.1)) +
#   theme(#panel.background = element_blank(), panel.grid.major= element_blank(),
#         panel.grid.minor=element_blank(),
#         plot.title=element_text(size=22,face="bold", vjust=2),
#         axis.title=element_text(size=12,face = "bold"),
#         axis.text=element_text(size=14),
#         strip.text.x = element_text(size=16, face = "bold"),
#         legend.position="none")
# p5b

```

Switch Cost Effects

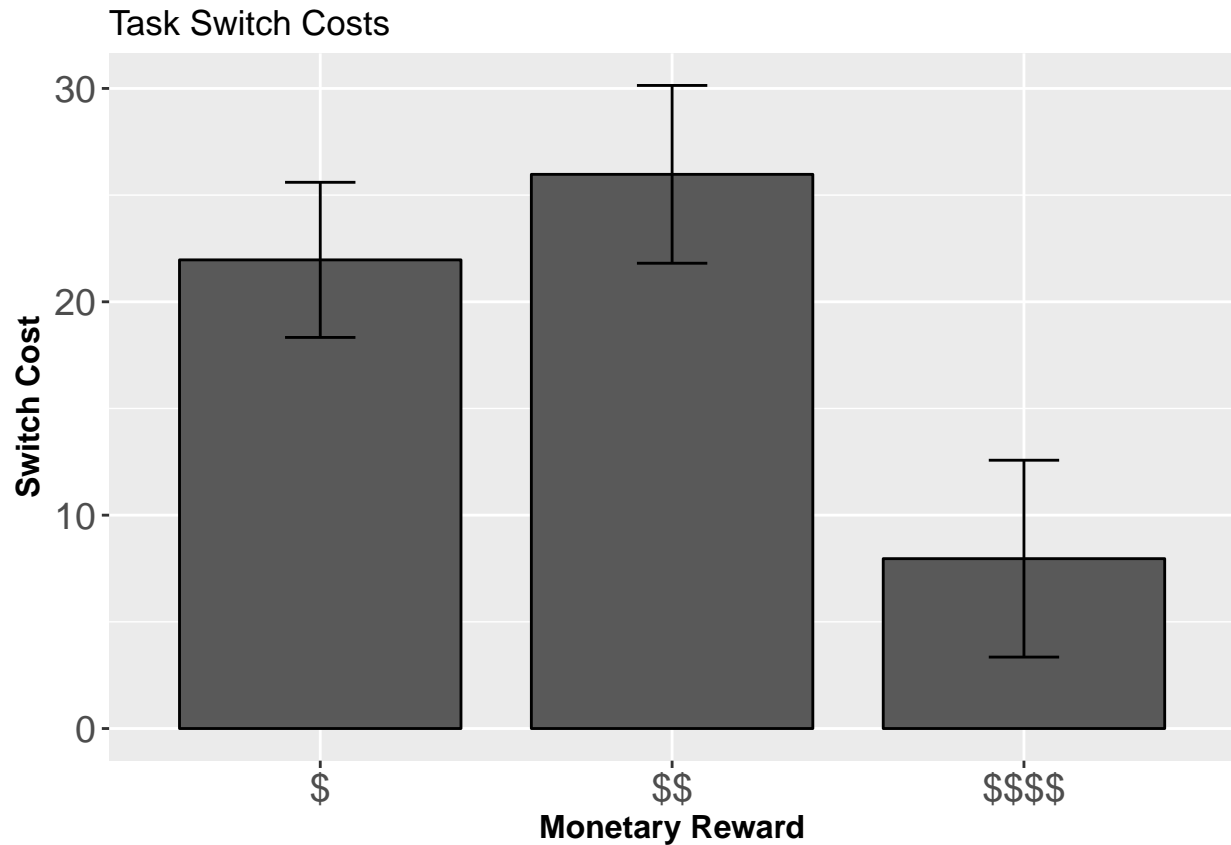
Plotting the Switch Costs

```
data.switch<-incentive %>% group_by(subID,money,taskSwitch) %>%
  filter(!is.na(subRewarded),trial!=1) %>%
  summarise(meanRT=mean(RT)) %>%
  mutate(taskSwitch=factor(taskSwitch, levels=c(0,1), labels=c("taskrepeat","taskswitch"))) %>%
  spread(key = taskSwitch, value=meanRT) %>%
  mutate(meanRT=taskswitch-taskrepeat)

RT.sum=summarySEwithin2(data=data.switch, measurevar = "meanRT", withinvars = c("money"),
                        idvar = "subID")
pandoc.table(RT.sum)
```

```
##
## -----
## money    N    meanRT    meanRTNormed    sd    se    ci
## -----
## $        45    21.97      21.97          24.39  3.635  7.326
##
## $$       45    25.97      25.97          27.95  4.166  8.396
##
## $$$$     45    7.961      7.961          30.95  4.613  9.298
## -----
```

```
p.switch.1<-ggplot(RT.sum, aes(x=money, y=meanRT)) +
  geom_bar(position=position_dodge(width=0.8), color="black",stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8),
               aes(ymin=meanRT-se, ymax=meanRT+se), width=.2) +
  #facet_grid(.~money) +
  xlab("Monetary Reward") + ylab("Switch Cost") +
  ggtitle("Task Switch Costs") +
  #coord_cartesian(ylim=c(400,600)) +
  scale_fill_discrete(name="Task Switch") +
  theme(#plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        #legend.position="none",
        strip.text.x = element_text(size = 12))
p.switch.1
```



Switch Costs by money and gain/loss frame

```
data.switch.frame<-incentive %>% group_by(subID,money,feedback,taskSwitch) %>%
  filter(!is.na(subRewarded),trial!=1) %>%
  summarise(meanRT=mean(RT)) %>%
  mutate(taskSwitch=factor(taskSwitch, levels=c(0,1), labels=c("taskrepeat","taskswitch"))) %>%
  spread(key = taskSwitch, value=meanRT) %>%
  mutate(meanRT=taskswitch-taskrepeat)

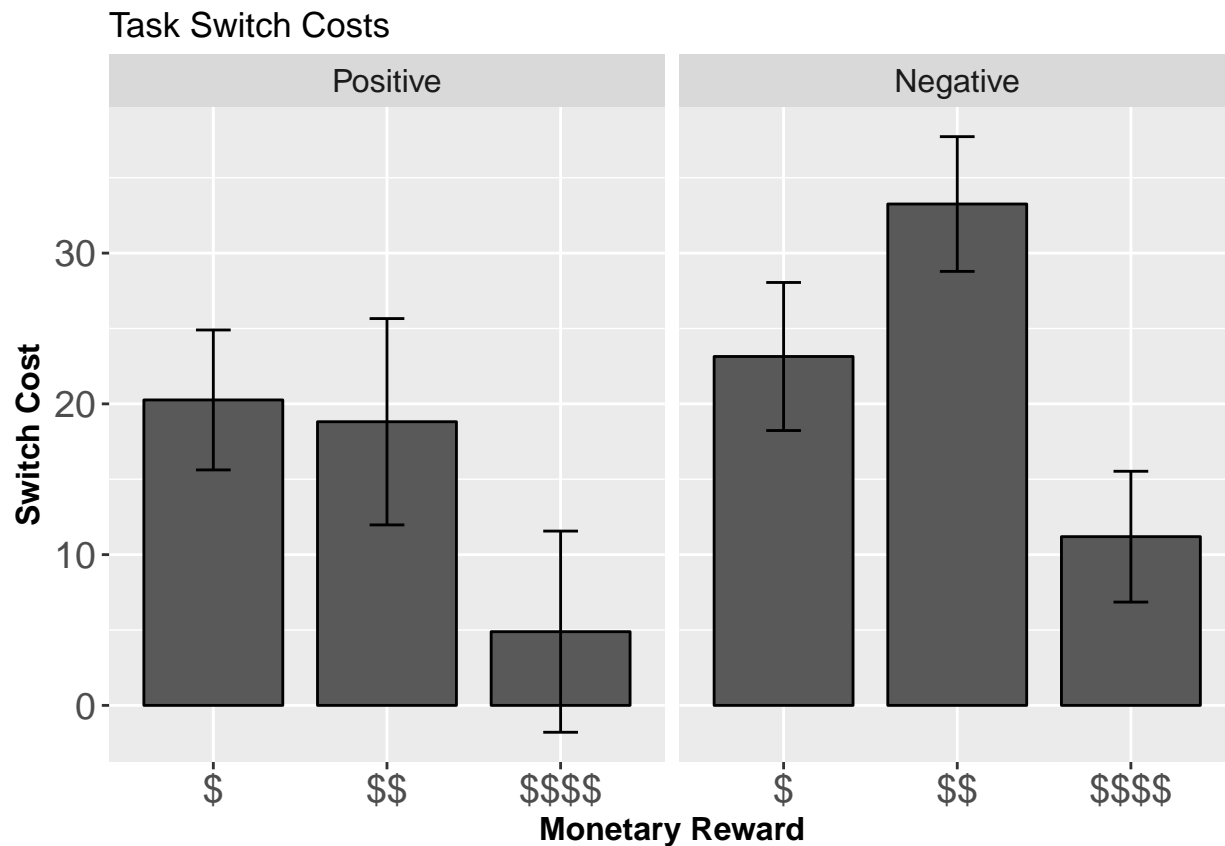
RT.sum=summarySEwithin2(data=data.switch.frame, measurevar = "meanRT",
  withinvars = c("money","feedback"), idvar = "subID")
pandoc.table(RT.sum)
```

```
##
## -----
## money feedback N meanRT meanRTNormed sd se ci
## -----
## $ Negative 45 23.14 23.14 32.94 4.911 9.897
## $ Positive 45 20.26 20.26 31.14 4.642 9.355
## $$ Negative 45 33.25 33.25 29.98 4.469 9.007
## $$ Positive 45 18.81 18.81 45.9 6.843 13.79
##
```



```
## $$$$ Negative 45 11.19 11.19 29.1 4.338 8.742
##
## $$$$ Positive 45 4.889 4.889 44.75 6.671 13.45
## -----
```

```
p.switch.2<-ggplot(RT.sum, aes(x=money, y=meanRT)) +
  geom_bar(position=position_dodge(width=0.8), color="black",stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8),
    aes(ymin=meanRT-se, ymax=meanRT+se), width=.2) +
  facet_grid(.~feedback) +
  xlab("Monetary Reward") + ylab("Switch Cost") +
  ggtitle("Task Switch Costs") +
  #coord_cartesian(ylim=c(400,600)) +
  scale_fill_discrete(name="Task Switch") +
  theme(#plot.title=element_text(size=22,face="bold", vjust=2),
    axis.title=element_text(size=12,face = "bold"),
    axis.text=element_text(size=14),
    #legend.position="none",
    strip.text.x = element_text(size = 12))
p.switch.2
```



Switch Costs by liquid and gain/loss frame

```
data.switch.frame<-incentive %>% group_by(subID,liquid,feedback,taskSwitch) %>%
  filter(!is.na(subRewarded),trial!=1) %>%
  summarise(meanRT=mean(RT)) %>%
```

```

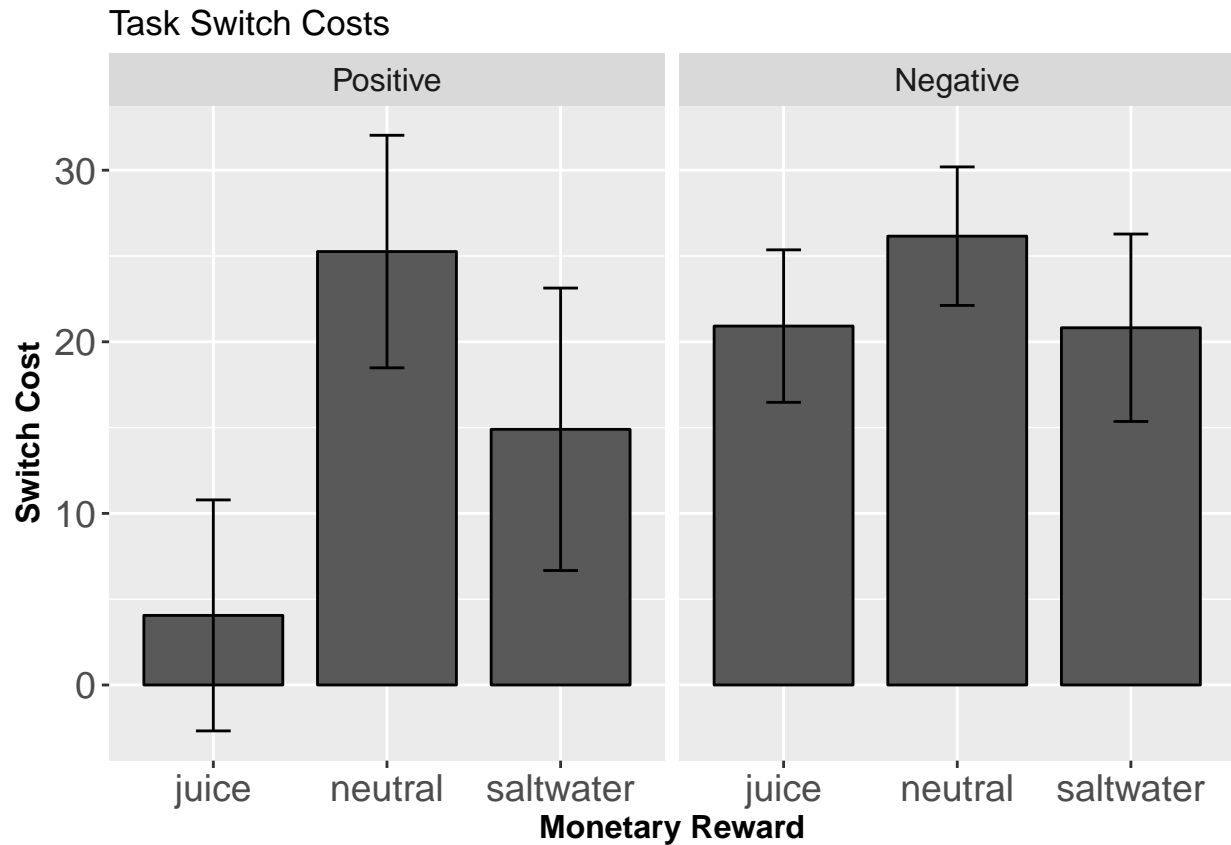
mutate(taskSwitch=factor(taskSwitch, levels=c(0,1), labels=c("taskrepeat","taskswitch")))) %>%
spread(key = taskSwitch, value=meanRT) %>%
mutate(meanRT=taskswitch-taskrepeat)

RT.sum=summarySEwithin2(data=data.switch.frame, measurevar = "meanRT",
                        withinvars = c("liquid","feedback"), idvar = "subID")
pandoc.table(RT.sum)

##
## -----
##   liquid    feedback    N    meanRT    meanRTNormed    sd    se    ci
## -----
##   juice     Negative    45    20.92      20.78          29.81  4.443  8.955
##
##   juice     Positive    44    4.055      4.755          44.65  6.731  13.57
##
##   neutral   Negative    45    26.16      26.02          27.08  4.036  8.135
##
##   neutral   Positive    45    25.26      25.12          45.46  6.776  13.66
##
##   saltwater Negative    45    20.82      20.68          36.64  5.462  11.01
##
##   saltwater Positive    45    14.9       14.76          55.21  8.23   16.59
## -----

p.switch.3<-ggplot(RT.sum, aes(x=liquid, y=meanRT)) +
  geom_bar(position=position_dodge(width=0.8), color="black",stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8),
                aes(ymin=meanRT-se, ymax=meanRT+se), width=.2) +
  facet_grid(.~feedback) +
  xlab("Monetary Reward") + ylab("Switch Cost") +
  ggtitle("Task Switch Costs") +
  #coord_cartesian(ylim=c(400,600)) +
  scale_fill_discrete(name="Task Switch") +
  theme(#plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        #legend.position="none",
        strip.text.x = element_text(size = 12))
p.switch.3

```



Switch Costs by money and gain/loss frame, 9 conditions

```
data.switch.frame<-incentive %>% group_by(subID,money,feedback,liquid,taskSwitch) %>%
  filter(!is.na(subRewarded),trial!=1) %>%
  summarise(meanRT=mean(RT)) %>%
  mutate(taskSwitch=factor(taskSwitch, levels=c(0,1), labels=c("taskrepeat","taskswitch"))) %>%
  spread(key = taskSwitch, value=meanRT) %>%
  mutate(meanRT=taskswitch-taskrepeat)

RT.sum=summarySEwithin2(data=data.switch.frame, measurevar = "meanRT",
  withinvars = c("money","feedback","liquid"), idvar = "subID")
pandoc.table(RT.sum)
```

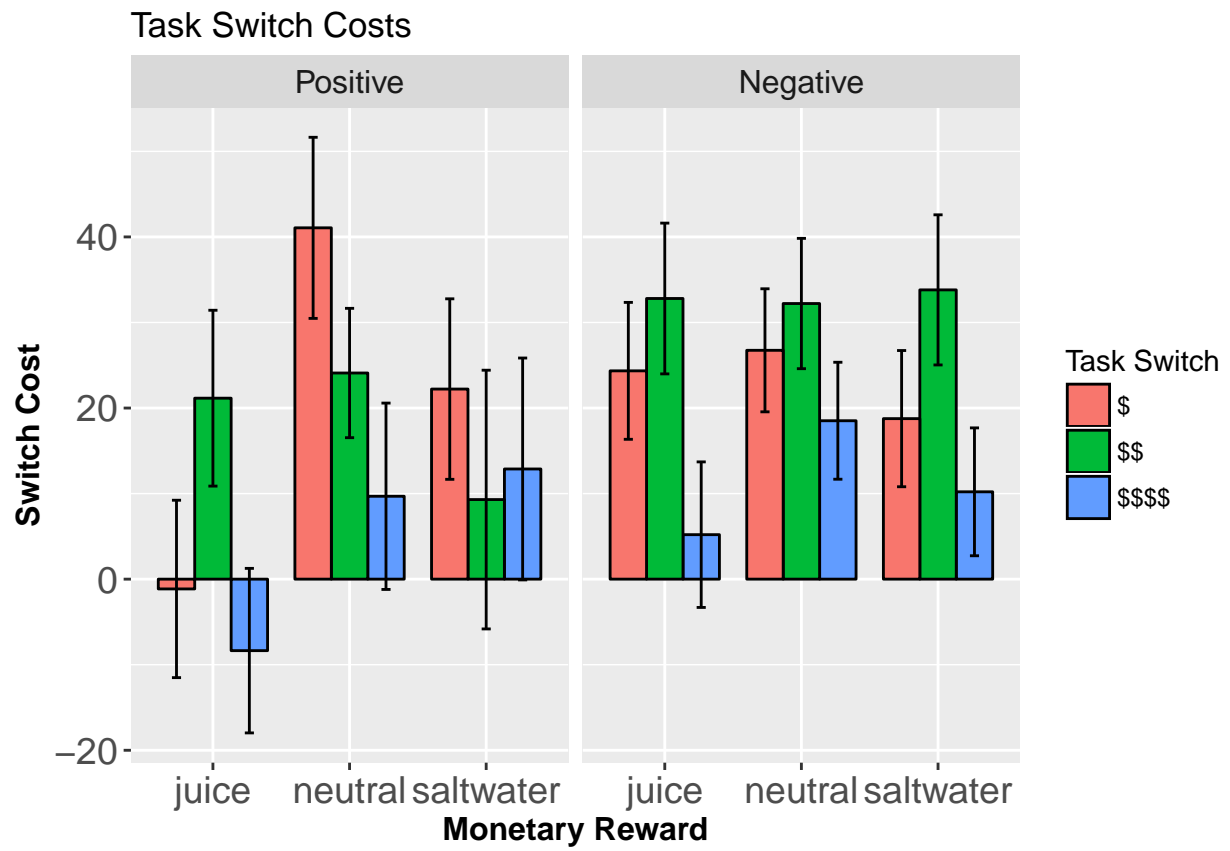
money	feedback	liquid	N	meanRT	meanRTNormed	sd	se	ci
\$	Negative	juice	45	24.35	24.21	53.68	8.002	16.13
\$	Negative	neutral	45	26.75	26.61	48.23	7.19	14.49
\$	Negative	saltwater	45	18.76	18.63	53.4	7.96	16.04
\$	Positive	juice	44	-1.144	-0.458	68.77	10.37	20.91

##	\$	Positive	neutral	45	41.06	40.93	71	10.58	21.33
##									
##	\$	Positive	saltwater	45	22.22	22.08	70.76	10.55	21.26
##									
##	\$\$	Negative	juice	45	32.8	32.67	59.11	8.812	17.76
##									
##	\$\$	Negative	neutral	45	32.22	32.08	51.1	7.617	15.35
##									
##	\$\$	Negative	saltwater	45	33.81	33.68	58.87	8.775	17.69
##									
##	\$\$	Positive	juice	44	21.15	21.84	68.17	10.28	20.72
##									
##	\$\$	Positive	neutral	45	24.09	23.96	50.71	7.56	15.24
##									
##	\$\$	Positive	saltwater	45	9.301	9.167	101.4	15.12	30.47
##									
##	\$\$\$\$	Negative	juice	45	5.2	5.066	57.06	8.507	17.14
##									
##	\$\$\$\$	Negative	neutral	45	18.52	18.38	45.84	6.834	13.77
##									
##	\$\$\$\$	Negative	saltwater	45	10.21	10.07	50.13	7.474	15.06
##									
##	\$\$\$\$	Positive	juice	44	-8.355	-7.669	63.79	9.616	19.39
##									
##	\$\$\$\$	Positive	neutral	45	9.689	9.555	73.06	10.89	21.95
##									
##	\$\$\$\$	Positive	saltwater	45	12.88	12.74	86.99	12.97	26.14
##	-----								

```

p.switch.4<-ggplot(RT.sum, aes(x=liquid, y=meanRT, fill=money)) +
  geom_bar(position=position_dodge(width=0.8), color="black",stat="identity", width=0.8) +
  geom_errorbar(position=position_dodge(width=0.8),
                aes(ymin=meanRT-se, ymax=meanRT+se), width=.2) +
  facet_grid(.~feedback) +
  xlab("Monetary Reward") + ylab("Switch Cost") +
  ggtitle("Task Switch Costs") +
  #coord_cartesian(ylim=c(400,600)) +
  scale_fill_discrete(name="Task Switch") +
  theme(#plot.title=element_text(size=22,face="bold", vjust=2),
        axis.title=element_text(size=12,face = "bold"),
        axis.text=element_text(size=14),
        #legend.position="none",
        strip.text.x = element_text(size = 12))
p.switch.4

```



GLMM on the Switch Costs

It appears that switch costs are modulated by task switches, monetary reward, as well as an interaction between the two

```
# Is Reward Rate predicted by task switches? yes.
```

```
m.switch.1<-glmer(formula = subRewarded ~ taskSwitch + (1|subID),  
                  data = incentive, family = binomial)  
summary(m.switch.1)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace  
## Approximation) [glmerMod]  
## Family: binomial ( logit )  
## Formula: subRewarded ~ taskSwitch + (1 | subID)  
## Data: incentive  
##  
##      AIC      BIC   logLik deviance df.resid  
## 30322.1 30346.6 -15158.0 30316.1    25914  
##  
## Scaled residuals:  
##      Min       1Q   Median       3Q      Max  
## -3.0687 -1.0922  0.5075  0.6851  1.2696  
##  
## Random effects:  
## Groups Name      Variance Std.Dev.  
## subID (Intercept) 0.3304   0.5748  
## Number of obs: 25917, groups: subID, 45  
##  
## Fixed effects:  
##              Estimate Std. Error z value Pr(>|z|)  
## (Intercept)  1.01406    0.08807  11.515  <2e-16 ***  
## taskSwitch  -0.23388    0.02793  -8.374  <2e-16 ***  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1  
##  
## Correlation of Fixed Effects:  
##              (Intr)  
## taskSwitch -0.166
```

```
#Full Model (money,liquid,task switch)
```

```
m.switch.2<-glmer(formula = subRewarded ~ taskSwitch*moneyCode*liqCode*feedbackCode  
                  + (1+moneyCode+liqCode|subID),  
                  data = incentive, family = binomial)  
summary(m.switch.2)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace  
## Approximation) [glmerMod]  
## Family: binomial ( logit )  
## Formula: subRewarded ~ taskSwitch * moneyCode * liqCode * feedbackCode +  
## (1 + moneyCode + liqCode | subID)  
## Data: incentive  
##  
##      AIC      BIC   logLik deviance df.resid  
## 29789.0 29968.6 -14872.5 29745.0    25895  
##
```

```

## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.9565 -0.9994  0.4885  0.6698  1.5600
##
## Random effects:
##      Groups Name      Variance Std.Dev. Corr
## subID (Intercept) 0.3465   0.5886
##      moneyCode   0.0232   0.1523   0.08
##      liqCode     0.0446   0.2112   0.14 0.07
## Number of obs: 25917, groups: subID, 45
##
## Fixed effects:
##
##              Estimate Std. Error z value
## (Intercept)      0.839503   0.092196   9.106
## taskSwitch      -0.179439   0.039122  -4.587
## moneyCode        0.215351   0.041350   5.208
## liqCode          0.222331   0.046814   4.749
## feedbackCode     0.404879   0.041119   9.847
## taskSwitch:moneyCode 0.090057   0.048018   1.875
## taskSwitch:liqCode 0.035131   0.048038   0.731
## moneyCode:liqCode -0.089029   0.042191  -2.110
## taskSwitch:feedbackCode -0.119866   0.056877  -2.107
## moneyCode:feedbackCode -0.062583   0.050364  -1.243
## liqCode:feedbackCode -0.334692   0.050449  -6.634
## taskSwitch:moneyCode:liqCode 0.016307   0.058968   0.277
## taskSwitch:moneyCode:feedbackCode -0.062319   0.069772  -0.893
## taskSwitch:liqCode:feedbackCode -0.008933   0.069788  -0.128
## moneyCode:liqCode:feedbackCode 0.115279   0.061821   1.865
## taskSwitch:moneyCode:liqCode:feedbackCode -0.043705   0.085628  -0.510
##
##              Pr(>|z|)
## (Intercept)      < 2e-16 ***
## taskSwitch       4.50e-06 ***
## moneyCode        1.91e-07 ***
## liqCode          2.04e-06 ***
## feedbackCode     < 2e-16 ***
## taskSwitch:moneyCode 0.0607 .
## taskSwitch:liqCode 0.4646
## moneyCode:liqCode 0.0348 *
## taskSwitch:feedbackCode 0.0351 *
## moneyCode:feedbackCode 0.2140
## liqCode:feedbackCode 3.26e-11 ***
## taskSwitch:moneyCode:liqCode 0.7821
## taskSwitch:moneyCode:feedbackCode 0.3718
## taskSwitch:liqCode:feedbackCode 0.8981
## moneyCode:liqCode:feedbackCode 0.0622 .
## taskSwitch:moneyCode:liqCode:feedbackCode 0.6098
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it

```

```
# Gain Frame
m.switch.3<-glmer(formula = subRewarded ~ taskSwitch*moneyCode*liqCode
                  + (1+moneyCode+liqCode|subID),
                  data = subset(incentive,feedback=="Positive"), family = binomial)
summary(m.switch.3)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: binomial ( logit )
##   Formula:
##   subRewarded ~ taskSwitch * moneyCode * liqCode + (1 + moneyCode +
##     liqCode | subID)
##   Data: subset(incentive, feedback == "Positive")
##
##           AIC          BIC    logLik deviance df.resid
## 15021.0 15125.6 -7496.5 14993.0    12946
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.9075 -0.9467  0.4782  0.6830  2.6981
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   subID (Intercept) 0.51608  0.7184
##           moneyCode  0.07652  0.2766  -0.29
##           liqCode    0.18204  0.4267  -0.31  0.36
## Number of obs: 12960, groups: subID, 45
##
## Fixed effects:
##
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      0.86174    0.11110   7.757 8.72e-15 ***
## taskSwitch      -0.19154    0.04011  -4.776 1.79e-06 ***
## moneyCode        0.22363    0.05462   4.094 4.23e-05 ***
## liqCode         0.23898    0.07321   3.264  0.0011 **
## taskSwitch:moneyCode  0.09885    0.04928   2.006  0.0449 *
## taskSwitch:liqCode   0.04400    0.04940   0.891  0.3732
## moneyCode:liqCode   -0.10693    0.04374  -2.445  0.0145 *
## taskSwitch:moneyCode:liqCode 0.01241    0.06068   0.204  0.8380
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) tskSwT monyCd liqCod tskSwTch:mC tskSwTch:lC mnyC:C
## taskSwitch   -0.185
## moneyCode    -0.200 -0.016
## liqCode      -0.249 -0.018  0.238
## tskSwTch:mC  -0.006  0.039 -0.462  0.001
## tskSwTch:lC  -0.009  0.048  0.001 -0.346  0.006
## monyCd:liqCd  0.000  0.002  0.031  0.017 -0.034   -0.023
## tskSwTch:C:C  0.000  0.006 -0.022 -0.010  0.045    0.037   -0.709
```

```
# Loss Frame
m.switch.4<-glmer(formula = subRewarded ~ taskSwitch*moneyCode*liqCode
                  + (1+moneyCode+liqCode|subID),
```



```
data = subset(incentive,feedback=="Negative"), family = binomial)
summary(m.switch.4)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: binomial ( logit )
## Formula:
## subRewarded ~ taskSwitch * moneyCode * liqCode + (1 + moneyCode +
## liqCode | subID)
## Data: subset(incentive, feedback == "Negative")
##
##      AIC      BIC   logLik deviance df.resid
## 14154.1 14258.7 -7063.0 14126.1   12943
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.6019 -0.9048  0.4587  0.6297  1.3562
##
## Random effects:
## Groups Name          Variance Std.Dev. Corr
## subID (Intercept) 0.45330  0.6733
## moneyCode 0.01695  0.1302    0.03
## liqCode 0.05930  0.2435    0.03 -0.16
## Number of obs: 12957, groups: subID, 45
##
## Fixed effects:
##
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      1.26973    0.10516 12.075 < 2e-16 ***
## taskSwitch      -0.30342    0.04161 -7.293 3.04e-13 ***
## moneyCode        0.15264    0.04288  3.560 0.000371 ***
## liqCode         -0.11981    0.05281 -2.268 0.023300 *
## taskSwitch:moneyCode 0.02941    0.05101  0.577 0.564252
## taskSwitch:liqCode 0.02733    0.05101  0.536 0.592145
## moneyCode:liqCode 0.02472    0.04566  0.541 0.588272
## taskSwitch:moneyCode:liqCode -0.02973    0.06253 -0.475 0.634431
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) tskSwt monyCd liqCod tskSwrch:mC tskSwrch:lC mnyC:C
## taskSwitch -0.212
## moneyCode 0.028 -0.033
## liqCode 0.008 0.021 -0.050
## tskSwrch:mC -0.011 0.053 -0.636 -0.001
## tskSwrch:lC 0.008 -0.033 -0.001 -0.516 -0.003
## monyCd:liqCd 0.000 0.000 -0.037 0.038 0.029 -0.036
## tskSwrch:C:C 0.000 -0.003 0.025 -0.025 -0.033 0.051 -0.726
```