Children and Mutually Beneficial Resource Exchange, Study 1

2024-03-26

Contents

1 Executive summary

This document houses the analyses for analysing the Study 1 data for the children and mutually beneficial resource exchange project.

2 Guide to dependent variable scoring:

Tower task: 1 = Efficient; 2 = Inefficient; 3 = Gift; 4 = Selfish

Sticker exchange: 1 = Efficient; 2 = Gift; 3 = Selfish; 4 = Protest; 5 = No Response

3 Load data and generate demographic variables

```
library(openxlsx)
library(dplyr)
library(stargazer)
library(psych)
library(vcd)
library(multcomp)
library(sjstats)
library(rms)
library(car)
library(ggplot2)
library(tidyverse)
library(readxl)
library(WebPower)
library(pwr)
library(interactions)
library(patchwork)
library(scales)

setwd(dirname(rstudioapi::getActiveDocumentContext()$path))

cdata <- read.xlsx("c_neg_2019_12_11.xlsx", sheet = 1)

# remove scratch data points, they have no recorded age
cdata <- subset(cdata, age > 0)

cdata$gender <- ifelse(cdata$gender == "g", "girl", "boy")

# table(cdata$gender, cdata$age)

# Total N

sum(table(cdata$gender, cdata$age))
```

```
## [1] 65
```

```
# List gender by age

table(cdata$gender, cdata$age)
```

```
##
##         3  4  5
##   boy   9 12  8
##   girl 11 12 13
```

```
age_summary <- group_by(cdata, age)

age_df <- dplyr::summarise(age_summary, mean.pct = mean(months, na.rm = T), sd.pct = sd(months,
    na.rm = T), n.pct = n())

round(age_df, digits = 2)
```

```
## # A tibble: 3 x 4
##     age mean.pct sd.pct n.pct
```

```
##   <dbl>    <dbl>  <dbl> <dbl>
## 1     3     43.0   4.21    20
## 2     4     54.9   3.82    24
## 3     5     67.7   3.66    21
```

4 Generate table of efficient exchange attempts by age (Study 1 portion of Table 1)

```
# Tower task Distribution of responses
response <- table(cdata$exchange, cdata$age)

response
```

```
##
##      3  4  5
##   1 13 15 18
##   2  4  6  1
##   3  0  1  0
##   4  3  2  2
```

```
# Proportions
round(prop.table(response, margin = 2), 2)
```

```
##
##        3    4    5
##   1 0.65 0.62 0.86
##   2 0.20 0.25 0.05
##   3 0.00 0.04 0.00
##   4 0.15 0.08 0.10
```

```
# Code efficient exchange variable, efficient exchange = 1
cdata$eff_exch <- ifelse(cdata$exchange == 1, 1, 0)

# Impute data for child whose birthday is missing - 5 year old but specific
# birthdate not known; assume 5.5 years old
cdata$age3 <- ifelse(cdata$number == "P79", 5.5, cdata$age)

# Impute data for child whose birthday is missing - 3 year old but specific
# birthdate not known; assume 3.5 years old
cdata$age3 <- ifelse(cdata$number == "P20", 3.5, cdata$age3)

# Sticker exchange 1 = exchange stickers on spontaneously, 2 = exchange after
# first reminder, 3 = exchange after second reminder, 4 = no response
cdata$st1 <- ifelse(cdata$sp_sticker == 1, 1, 0)
cdata$st2 <- ifelse(cdata$sticker_1 == 1, 2, 0)
cdata$st3 <- ifelse(cdata$sticker_2 == 1, 3, 0)

# Add across rows
cdata$stickers <- rowSums(cdata[, c("st1", "st2", "st3")], na.rm = T)

cdata$stickers <- ifelse(cdata$stickers == 0, 4, cdata$stickers)

# Create an easy-to-read version
cdata$stickers_cat <- ifelse(cdata$stickers == 1, "Initial", ifelse(cdata$stickers ==
```

```
    2, "1st reminder", ifelse(cdata$stickers == 3, "2nd reminder", ifelse(cdata$stickers ==
    4, "No response", NA))))

# Re-order levels
cdata$stickers_cat <- factor(cdata$stickers_cat, levels = c("Initial", "1st reminder",
    "2nd reminder", "No response"))
```

5 Logistic regression

```
# Logistic regression, Tower task
s1 <- glm(eff_exch ~ age, data = cdata, family = binomial)

summary(s1)
```

```
##
## Call:
## glm(formula = eff_exch ~ age, family = binomial, data = cdata)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -1.1602     1.4083  -0.824    0.410
## age           0.5178     0.3557   1.456    0.145
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 78.547  on 64  degrees of freedom
## Residual deviance: 76.350  on 63  degrees of freedom
## AIC: 80.35
##
## Number of Fisher Scoring iterations: 4
```

```
exp(s1$coefficients)
```

```
## (Intercept)         age
##   0.3134209   1.6783691
```

```
cdata$eff_stickers <- ifelse(cdata$stickers_cat != "No response", 1, 0)

# Logistic regression, Sticker exchange
s3 <- glm(eff_stickers ~ age, data = cdata, family = binomial)

summary(s3)
```

```
##
## Call:
## glm(formula = eff_stickers ~ age, family = binomial, data = cdata)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -3.9926     1.4382  -2.776  0.00550 **
## age           1.0029     0.3525   2.845  0.00444 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 90.094  on 64  degrees of freedom
## Residual deviance: 80.953  on 63  degrees of freedom
## AIC: 84.953
##
## Number of Fisher Scoring iterations: 4
```

```
exp(s3$coefficients)
```

```
## (Intercept)         age
##  0.01845204  2.72623270
```

6 Age at which majority of children make the mutually beneficial resource exchange

```
newdata <- data.frame(age = seq(3, 5, by = .01))

probabilities <- s3 %>% predict(newdata, type = "response")

# Predict age for Sticker exchange
newdata$prob_S <- predict(s3, newdata = newdata, type = "response")
age_majority_S <- min(newdata$age[newdata$prob_S > 0.5])
age_majority_S
```

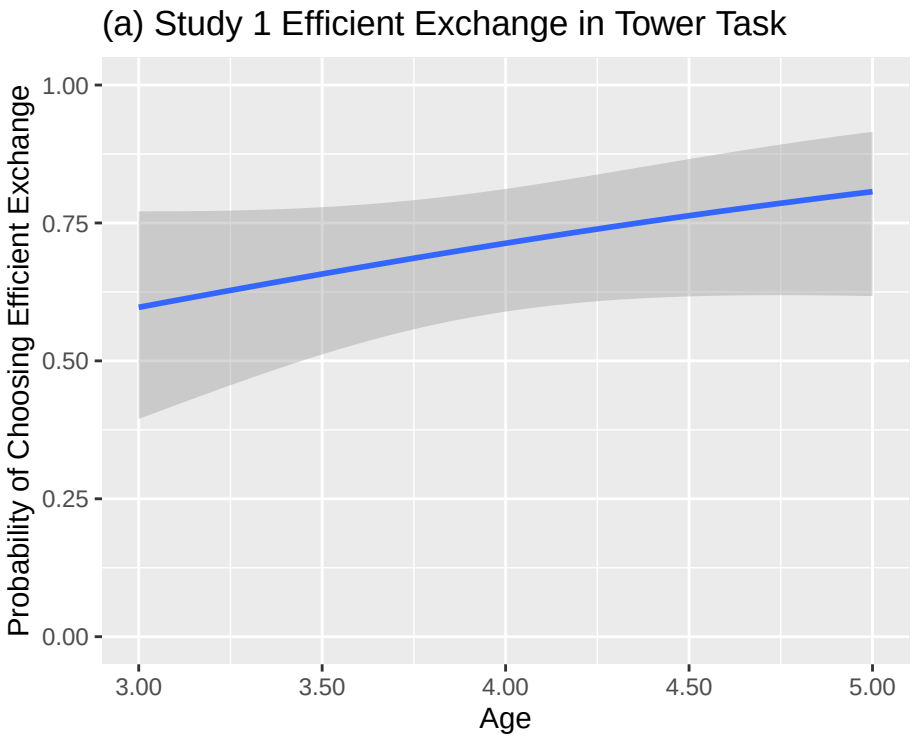
```
## [1] 3.99
```

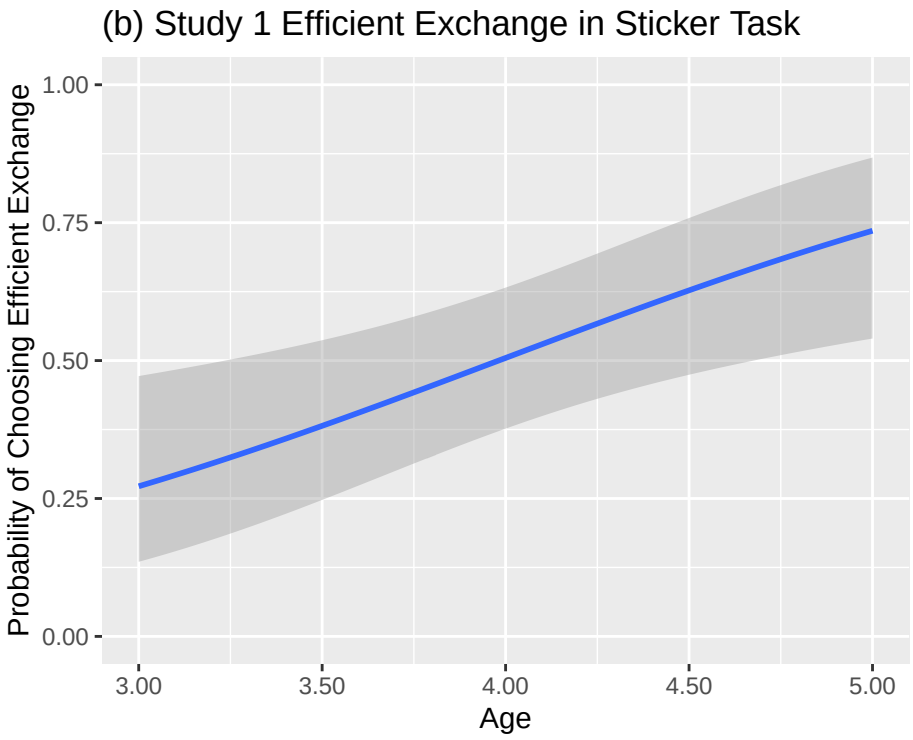
7 Figure 1a, 1b

```
p1 <- cdata %>%
  ggplot(aes(age, eff_exch)) +
  geom_smooth(method = "glm", method.args = list(family = "binomial")) +
  labs(
    title = "(a) Study 1 Efficient Exchange in Tower Task",
    x = "Age",
    y = "Probability of Choosing Efficient Exchange"
    ) + scale_y_continuous(labels = label_number(accuracy = 0.01), limits = c(0, 1)) +
   scale_x_continuous(labels = label_number(accuracy = 0.01))

#p1

p2 <- cdata %>%
  ggplot(aes(age, eff_stickers)) +
  geom_smooth(method = "glm", method.args = list(family = "binomial")) +
  labs(
    title = "(b) Study 1 Efficient Exchange in Sticker Task",
    x = "Age",
    y = "Probability of Choosing Efficient Exchange"
    ) + scale_y_continuous(labels = label_number(accuracy = 0.01), limits = c(0, 1)) +
   scale_x_continuous(labels = label_number(accuracy = 0.01))
```

```r
#p2

# Display plots vertically
combined_plots <- patchwork::wrap_plots(p1, p2, ncol = 1)

# Print the combined plot
print(combined_plots)
```

```
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```






```
ggsave("Fig1.png", width = 5, height = 8, units = "in")
```

```
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```

8 Supplementary analyses - Table indicating number of prompts until efficient exchange in Sticker exchange

```
table(cdata$stickers_cat, cdata$age)
```

```
##
##                3  4  5
##   Initial      2  1  3
##   1st reminder 2  5  5
##   2nd reminder 2  5  8
##   No response  14 13  5
```

9 Correlation between efficient exchange in tower and sticker task

```
cor.test(cdata$eff_stickers, cdata$age3)
```

```
##
##  Pearson's product-moment correlation
##
## data:  cdata$eff_stickers and cdata$age3
## t = 3.1172, df = 63, p-value = 0.002751
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.1335547 0.5595574
## sample estimates:
##       cor
## 0.3655465
```

10 Pre-registered analyses

```
# Chi-squared test, Tower task
# Collapse ages 4 and 5 as in pre-registration document

cdata$age_cat <- ifelse(cdata$age == 3, "young", "old")

cdata$age_cat <- factor(cdata$age_cat, levels = c("young", "old"))

exch_tab2 <- table(cdata$eff_exch, cdata$age_cat)

exch_tab2
```

```
##
##     young old
##   0     7  12
##   1    13  33
```

```r
chisq.test(exch_tab2)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  exch_tab2
## X-squared = 0.14926, df = 1, p-value = 0.6992
```

```r
# Logistic regression, Tower task
s2 <- glm(eff_exch ~ age_cat, data = cdata, family = binomial)

summary(s2)
```

```
##
## Call:
## glm(formula = eff_exch ~ age_cat, family = binomial, data = cdata)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.6190     0.4688    1.32    0.187
## age_catold    0.3926     0.5774    0.68    0.497
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 78.547  on 64  degrees of freedom
## Residual deviance: 78.090  on 63  degrees of freedom
## AIC: 82.09
##
## Number of Fisher Scoring iterations: 4
```

```r
exp(s2$coefficients)
```

```
## (Intercept)  age_catold
##    1.857143    1.480769
```

```r
# Table of responses by age (3 vs 4 and 5)
sticker_tab <- table(cdata$stickers_cat, cdata$age_cat)

sticker_tab
```

```
##
##                young old
##   Initial          2   4
##   1st reminder     2  10
##   2nd reminder     2  13
##   No response     14  18
```

```r
chisq.test(sticker_tab)
```

```
## Warning in chisq.test(sticker_tab): Chi-squared approximation may be incorrect
```

```
##
##  Pearson's Chi-squared test
##
## data:  sticker_tab
## X-squared = 5.8109, df = 3, p-value = 0.1212
```

```r
cdata$stickers_cat2 <- ifelse(cdata$stickers_cat == "no response", "no response", "efficient trade")

sticker_tab2 <- table(cdata$stickers_cat2, cdata$age_cat)

sticker_tab2
```

```
##
##                   young old
##   efficient trade    20  45
```

```r
chisq.test(sticker_tab2)
```

```
##
##  Chi-squared test for given probabilities
##
## data:  sticker_tab2
## X-squared = 9.6154, df = 1, p-value = 0.00193
```

```r
# Chi-squared test, Sticker exchange
s4 <- glm(eff_stickers ~ age_cat, data = cdata, family = binomial)

s4
```

```
##
## Call:  glm(formula = eff_stickers ~ age_cat, family = binomial, data = cdata)
##
## Coefficients:
## (Intercept)   age_catold
##     -0.8473       1.2528
##
## Degrees of Freedom: 64 Total (i.e. Null);  63 Residual
## Null Deviance:       90.09
## Residual Deviance: 85.01     AIC: 89.01
```

```r
exp(s4$coefficients)
```

```
## (Intercept)  age_catold
##   0.4285714   3.5000000
```

11 Supplementary analyses - Effect size calculation

```r
# Effect size for efficient choice, in d Chi squared analyses
exch_tab <- table(cdata$eff_exch, cdata$age)

x <- chisq.test(exch_tab)

as.numeric(sqrt(x$statistic/(sum(exch_tab) * 2)))  # for df = 2, .07 is considered small, .21 is con
```

```
## [1] 0.1613057
```

```r
# Logistic regression
s1$coefficients[2]/1.81
```

```
##       age
## 0.2860898
```

```r
# Effect size for sticker exchange Chi squared analyses

# Repeat analyses, without grouping ages 4 and 5
sticker_tab3 <- table(cdata$stickers_cat2, cdata$age)

sticker_tab3
```

```
##
##                    3  4  5
##   efficient trade 20 24 21
```

```r
x <- chisq.test(sticker_tab3)

as.numeric(sqrt(x$statistic/(sum(sticker_tab3) * 2)))  # for df = 2, .07 is considered small, .21 is
```

```
## [1] 0.05547002
```

```r
# Logistic regression
s2$coefficients[2]/1.81
```

```
## age_catold
##  0.2168849
```

12 Supplementary analyses - A prior power calculation for Study 2

```r
# Efficient choice Chi squared
pwr.chisq.test(w = 0.1613057, df = 2, sig.level = 0.05, power = 0.8)
```

```
##
##      Chi squared power calculation
##
##               w = 0.1613057
##               N = 370.2868
##              df = 2
##       sig.level = 0.05
##           power = 0.8
##
## NOTE: N is the number of observations
```

```r
# Logistic regression From g*power: 146

# Sticker exchange Chi squared
pwr.chisq.test(w = 0.2647981, df = 2, sig.level = 0.05, power = 0.8)
```

```
##
##      Chi squared power calculation
##
##               w = 0.2647981
##               N = 137.4067
##              df = 2
##       sig.level = 0.05
##           power = 0.8
##
## NOTE: N is the number of observations
```

```
# Logistic regression From g*power: 64

# Generic test with moderate effect size Chi squared
pwr.chisq.test(w = 0.3, df = 2, sig.level = 0.05, power = 0.8)
```

```
##
##      Chi squared power calculation
##
##               w = 0.3
##               N = 107.0521
##              df = 2
##       sig.level = 0.05
##           power = 0.8
##
## NOTE: N is the number of observations
```

```
# Logistic regression, odds ratio of 2 From g*power: 82
```

13 Supplementary analyses - examining if efficient exchange is above chance (i.e., 25%) for Tower task

```
# Tabulate the frequency of each choice for 3 year olds
response_3 <- table(factor(subset(cdata, age == 3)$exchange, levels = 1:4))
response_3
```

```
##
##  1  2  3  4
## 13  4  0  3
```

```
# Perform the chi-squared goodness-of-fit test
chisq.test(response_3)
```

```
##
##  Chi-squared test for given probabilities
##
## data:  response_3
## X-squared = 18.8, df = 3, p-value = 0.0003007
```

```
# Tabulate the frequency of each choice for 4 year olds
response_4 <- table(factor(subset(cdata, age == 4)$exchange, levels = 1:4))
response_4
```

```
##
##  1  2  3  4
## 15  6  1  2
```

```
# Perform the chi-squared goodness-of-fit test
chisq.test(response_4)
```

```
##
##  Chi-squared test for given probabilities
##
## data:  response_4
## X-squared = 20.333, df = 3, p-value = 0.0001448
```

```
# Tabulate the frequency of each choice for 5 year olds
response_5 <- table(factor(subset(cdata, age == 5)$exchange, levels = 1:4))
response_5
```

```
##
##  1  2  3  4
## 18  1  0  2
```

```
# Perform the chi-squared goodness-of-fit test
chisq.test(response_5)
```

```
##
##  Chi-squared test for given probabilities
##
## data:  response_5
## X-squared = 41.667, df = 3, p-value = 4.722e-09
```

Children and Mutually Beneficial Resource Exchange, Study 2

Fong, Kirkland, Puah, and Jang

2024-03-26

Contents

1 Executive summary

This document houses the analyses for the Study 2 data for the children and mutually beneficial resource exchange project.

1.1 Guide to dependent variable scoring:

Tower task: 1 = Efficient; 2 = Inefficient; 3 = Gift; 4 = Selfish; 0 = No Response

Sticker task: 1 = Efficient; 2 = Inefficient; 3 = Gift; 4 = Selfish; 0 = No Response

2 Load data and generate demographic variables

```r
library(openxlsx)
library(dplyr)
library(stargazer)
library(psych)
library(vcd)
library(multcomp)
library(sjstats)
library(rms)
library(car)
library(ggplot2)
library(tidyverse)
library(readxl)
library(WebPower)
library(pwr)
library(multcomp)
library(flextable)
library(scales)

setwd(dirname(rstudioapi::getActiveDocumentContext()$path))

cdata <- read.xlsx("c_neg_S2_2022_09_23.xlsx", sheet = "rdata")

# remove scratch data points
cdata <- subset(cdata, exclude == 0)

# table(cdata$gender, cdata$age)

# Total N
sum(table(cdata$gender, cdata$age))
```

```
## [1] 121
```

```r
# List gender by age
table(cdata$gender, cdata$age)
```

```
##
##      3  4  5
##   F 20 20 20
##   M 20 20 21
```

```r
# Mean and SD age in months
age_summary <- group_by(cdata, age)

age_df <- summarise(age_summary, mean.pct = mean(months), sd.pct = sd(months), n.pct = n())

age_df <- round(age_df, digits = 2)

flextable(age_df)
```

```
## Warning: fonts used in ‘flextable‘ are ignored because the ‘pdflatex‘ engine is
## used and not ‘xelatex‘ or ‘lualatex‘. You can avoid this warning by using the
## ‘set_flextable_defaults(fonts_ignore=TRUE)‘ command or use a compatible engine
## by defining ‘latex_engine: xelatex‘ in the YAML header of the R Markdown
## document.
```

age	mean.pct	sd.pct	n.pct
3	41.85	3.63	40
4	53.23	3.44	40
5	64.80	3.25	41

3 Generate table of efficient exchange attempts by age (Study 2 portion of Table 1)

```
# Tower task Recode tower task response to single variable
cdata$tower <- cdata$g_eff

cdata$tower <- ifelse(cdata$tower == 0, cdata$g3, cdata$tower)
cdata$tower <- ifelse(cdata$tower == 0, cdata$g2, cdata$tower)
cdata$tower <- ifelse(cdata$tower == 0, cdata$g1, cdata$tower)

table(cdata$tower, cdata$age)
```

```
##
##      3  4  5
##   0  3  3  0
##   1 19 26 38
##   2  2  1  1
##   3 16 10  1
##   4  0  0  1
```

```
# 1 = Efficient; 2 = Inefficient; 3 = Gift; 4 = Selfish; 0 = No Response

factor_levels <- c("No response", "Efficient", "Inefficient", "Gift", "Selfish")

cdata$tower_cat <- dplyr::recode(cdata$tower, `1` = "Efficient", `2` = "Inefficient",
    `3` = "Gift", `4` = "Selfish", `0` = "No response")

desired_order <- c("Efficient", "Inefficient", "Gift", "Selfish", "No response")

cdata$tower_cat <- factor(cdata$tower_cat, levels = desired_order)

response <- table(cdata$tower_cat, cdata$age)

response
```

```
##
##                3  4  5
##   Efficient   19 26 38
##   Inefficient  2  1  1
##   Gift        16 10  1
##   Selfish      0  0  1
##   No response  3  3  0
```

```
# Proportions
round(prop.table(response, margin = 2), 2)
```

```
##
##                    3    4    5
##   Efficient   0.48 0.65 0.93
##   Inefficient 0.05 0.03 0.02
##   Gift        0.40 0.25 0.02
##   Selfish     0.00 0.00 0.02
##   No response 0.07 0.07 0.00
```

```
# Sticker task Recode sticker task response to single variable
cdata$sticker <- cdata$s_eff

cdata$sticker <- ifelse(cdata$sticker == 0, cdata$s3, cdata$sticker)
cdata$sticker <- ifelse(cdata$sticker == 0, cdata$s2, cdata$sticker)
cdata$sticker <- ifelse(cdata$sticker == 0, cdata$s1, cdata$sticker)

# 1 = Efficient; 2 = Inefficient; 3 = Gift; 4 = Selfish; 0 = No Response

cdata$sticker_cat <- dplyr::recode(cdata$sticker, `1` = "Efficient", `2` = "Inefficient",
    `3` = "Gift", `4` = "Selfish", `0` = "No response")

cdata$sticker_cat <- factor(cdata$sticker_cat, levels = desired_order)

table(cdata$sticker_cat, cdata$age)
```

```
##
##                3  4  5
##   Efficient    3 11  7
##   Inefficient  4  3  4
##   Gift         0  0  0
##   Selfish      3  4  0
##   No response 30 22 30
```

```
# Proportions
round(prop.table(table(cdata$sticker_cat, cdata$age), margin = 2), 2)
```

```
##
##                    3    4    5
##   Efficient   0.07 0.28 0.17
##   Inefficient 0.10 0.07 0.10
##   Gift        0.00 0.00 0.00
##   Selfish     0.07 0.10 0.00
##   No response 0.75 0.55 0.73
```

4 Logistic regression

```
# Tower task
mod2 <- glm(g_eff ~ age, data = cdata, family = 'binomial')

summary(mod2)
```

```
##
## Call:
## glm(formula = g_eff ~ age, family = "binomial", data = cdata)
##
```

```
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -3.7823     1.0903  -3.469 0.000522 ***
## age           1.1809     0.2868   4.118 3.83e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 150.60  on 120  degrees of freedom
## Residual deviance: 130.26  on 119  degrees of freedom
## AIC: 134.26
##
## Number of Fisher Scoring iterations: 4
```

```
exp(mod2$coefficients)
```

```
## (Intercept)         age
##  0.02276957  3.25714630
```

```
# Sticker exchange
mod4 <- glm(s_eff ~ age, data = cdata, family = "binomial")

summary(mod4)
```

```
##
## Call:
## glm(formula = s_eff ~ age, family = "binomial", data = cdata)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.9246     1.2678  -2.307   0.0211 *
## age           0.3342     0.2997   1.115   0.2647
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 111.68  on 120  degrees of freedom
## Residual deviance: 110.41  on 119  degrees of freedom
## AIC: 114.41
##
## Number of Fisher Scoring iterations: 4
```

```
exp(mod4$coefficients)
```

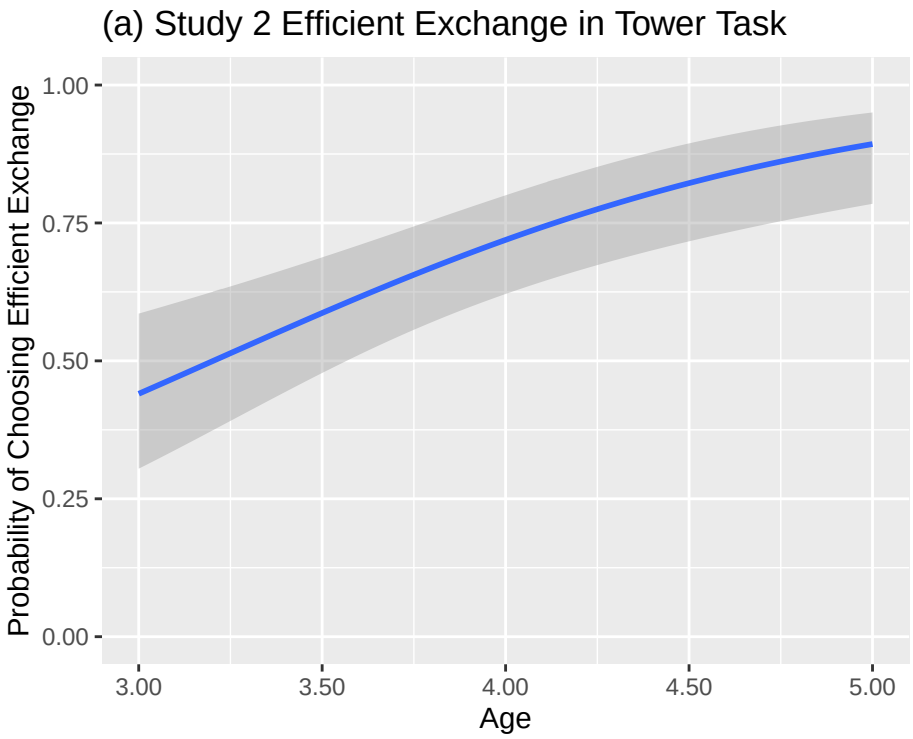
```
## (Intercept)         age
##  0.05368825  1.39683927
```

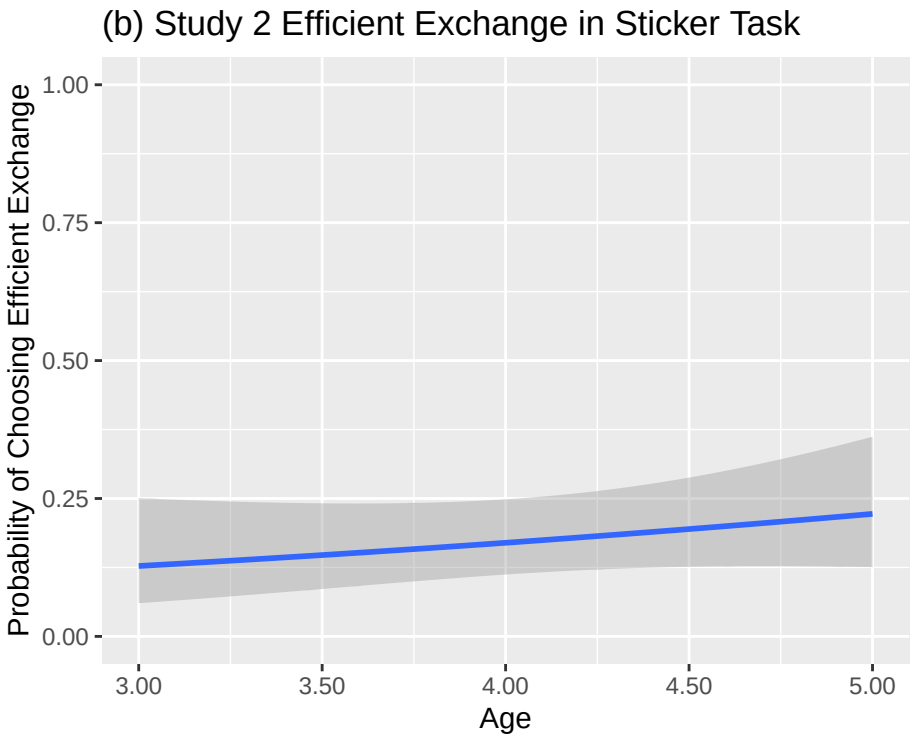
5 Figure 2

```
p3 <- cdata %>%
  ggplot(aes(age, g_eff)) +
```

```
  geom_smooth(method = "glm", method.args = list(family = "binomial")) +
  labs(
    title = "(a) Study 2 Efficient Exchange in Tower Task",
    x = "Age",
    y = "Probability of Choosing Efficient Exchange"
    ) + scale_y_continuous(labels = label_number(accuracy = 0.01), limits = c(0, 1)) +
   scale_x_continuous(labels = label_number(accuracy = 0.01))

p4 <- cdata %>%
  ggplot(aes(age, s_eff)) +
  geom_smooth(method = "glm", method.args = list(family = "binomial")) +
  labs(
    title = "(b) Study 2 Efficient Exchange in Sticker Task",
    x = "Age",
    y = "Probability of Choosing Efficient Exchange"
    ) + scale_y_continuous(labels = label_number(accuracy = 0.01), limits = c(0, 1)) +
   scale_x_continuous(labels = label_number(accuracy = 0.01))

# Display plots vertically
combined_plots <- patchwork::wrap_plots(p3, p4, ncol = 1)

#p3

#p4

# Print the combined plot
print(combined_plots)
```

```
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```






```
ggsave("Fig2.png", width = 5, height = 8, units = "in")
```

```
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```

6 Age at which majority of children make the mutually beneficial resource exchange

```
newdata <- data.frame(age = seq(3, 5, by = .01))

probabilities <- mod2 %>% predict(newdata, type = "response")

# Predict age for tower task
newdata$prob_T <- predict(mod2, newdata = newdata, type = "response")
age_majority_T <- min(newdata$age[newdata$prob_T > 0.5])
age_majority_T
```

```
## [1] 3.21
```

```
probabilities <- mod4 %>% predict(newdata, type = "response")

# Predict age for tower task
newdata$prob_S <- predict(mod4, newdata = newdata, type = "response")
age_majority_S <- min(newdata$age[newdata$prob_S > 0.5])
```

```
## Warning in min(newdata$age[newdata$prob_S > 0.5]): no non-missing arguments to
## min; returning Inf
```

```
age_majority_S
```

```
## [1] Inf
```

7 Supplementary analyses - Correlation between efficient exchange in tower and sticker task

```
cor.test(cdata$s_eff, cdata$g_eff)
```

```
##
##  Pearson's product-moment correlation
##
## data:  cdata$s_eff and cdata$g_eff
## t = 0.82038, df = 119, p-value = 0.4136
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.1049085  0.2501405
## sample estimates:
##       cor
## 0.07499232
```

8 Table of the number of attempts before reaching efficient choice

```r
# Recode tower task response to single variable
cdata$tower <- 0

cdata$tower <- ifelse(cdata$g1 == 1, "Initial", cdata$tower)
cdata$tower <- ifelse(cdata$g2 == 1, "1st prompt", cdata$tower)
cdata$tower <- ifelse(cdata$g3 == 1, "2nd prompt", cdata$tower)
cdata$tower <- ifelse(cdata$tower == 0, "No efficient response", cdata$tower)

cdata$tower <- factor(cdata$tower, levels = c("Initial", "1st prompt", "2nd prompt", "No efficient r

table(cdata$tower, cdata$age)
```

```
##
##                          3  4  5
##   Initial                2  7  8
##   1st prompt            11 15 25
##   2nd prompt             6  4  5
##   No efficient response 21 14  3
```

```r
# Recode sticker task response to single variable
cdata$sticker <- 0

cdata$sticker <- ifelse(cdata$s1 == 1, "Initial", cdata$sticker)
cdata$sticker <- ifelse(cdata$s2 == 1, "1st prompt", cdata$sticker)
cdata$sticker <- ifelse(cdata$s3 == 1, "2nd prompt", cdata$sticker)
cdata$sticker <- ifelse(cdata$sticker == 0, "No efficient response", cdata$sticker)

cdata$sticker <- factor(cdata$sticker, levels = c("Initial", "1st prompt", "2nd prompt", "No efficie

table(cdata$sticker, cdata$age)
```

```
##
##                          3  4  5
##   Initial                2  9  7
##   1st prompt             1  1  0
##   2nd prompt             0  1  0
##   No efficient response 37 29 34
```

9 Pre-registered analyses

```r
# Chi-squared test, Tower task

# Categorise 5 year olds vs. 3 and 4 year olds
cdata$age_5 <- ifelse(cdata$age == 5, 1, ifelse(is.na(cdata$age), NA, 0))

# 5 year olds vs 4 and 3 year olds
response <- table(cdata$g_eff, cdata$age_5)

response
```

```
##
##      0  1
##   0 35  3
##   1 45 38
```

```r
chisq.test(response)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  response
## X-squared = 15.054, df = 1, p-value = 0.0001045
```

```r
# Logistic regression, Tower task
mod1 <- glm(g_eff ~ age_5, data = cdata, family = 'binomial')

summary(mod1)
```

```
##
## Call:
## glm(formula = g_eff ~ age_5, family = "binomial", data = cdata)
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.2513     0.2254   1.115 0.264809
## age_5         2.2877     0.6407   3.571 0.000356 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 150.60  on 120  degrees of freedom
## Residual deviance: 131.11  on 119  degrees of freedom
## AIC: 135.11
##
## Number of Fisher Scoring iterations: 5
```

```r
exp(mod1$coefficients)
```

```
## (Intercept)       age_5
##    1.285714    9.851852
```

```r
# Chi-squared test, Sticker exchange

# Categorise 5 year olds vs. 3 and 4 year olds
cdata$age_5 <- ifelse(cdata$age == 5, 1, ifelse(is.na(cdata$age), NA, 0))

# Distribution of efficient allocation responses, 5 year olds vs.3- and 4- year olds

response2 <- table(cdata$s_eff, cdata$age_5)

response2 # rows 0 = inefficient or other kind of exchange; 1 = efficient exchange
```

```
##
##      0  1
##   0 66 34
##   1 14  7
```

```r
# Test differences in efficient trades by age
chisq.test(response2)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  response2
## X-squared = 1.2221e-29, df = 1, p-value = 1
```

```r
# Logistic regression, Sticker exchange
mod3 <- glm(s_eff ~ age_5, data = cdata, family = "binomial")

mod3
```

```
##
## Call:  glm(formula = s_eff ~ age_5, family = "binomial", data = cdata)
##
## Coefficients:
## (Intercept)        age_5
##    -1.55060     -0.02985
##
## Degrees of Freedom: 120 Total (i.e. Null);  119 Residual
## Null Deviance:       111.7
## Residual Deviance: 111.7     AIC: 115.7
```

```r
exp(mod3$coefficients)
```

```
## (Intercept)       age_5
##   0.2121212   0.9705882
```

Table S1

Number of prompts to efficient sticker exchange in Study 1

	Age		
	3	4	5
Initial response	2	1	3
1st prompt	2	5	5
2nd prompt	2	5	8
No efficient response	14	13	5

Note. 'No efficient response' is different from 'No response' in Table 1 in that it includes all responses that were not efficient, including inefficient exchange, gift, selfish taking, or no response at all from the child.

Table S2

Number of prompts to efficient block exchange in Study 2

	Age		
	3	4	5
Initial response	2	6	8
1st prompt	11	15	25
2nd prompt	6	4	5
No efficient response	21	14	3

Note. 'No efficient response' is different from 'No response' in Table 1 in that it includes all responses that were not efficient, including inefficient exchange, gift, selfish taking, or no response at all from the child.

Table S3

Number of prompts to efficient sticker exchange in Study 2

	Age		
	3	4	5
Initial response	2	9	7
1st prompt	1	1	0
2nd prompt	0	1	0
No efficient response	37	28	34

Note. 'No efficient response' is different from 'No response' in Table 1 in that it includes all responses that were not efficient, including inefficient exchange, gift, selfish taking, or no response at all from the child.