Transmission Game: Simulation Code and Results (SCR)

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Abstract

Supporting Material for "Transmission Game": Computer simulation results, interpretation of these results and full Matlab code generating these results.

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SCR-1 Contents of this document

This documents presents the results of Matlab simulations, presenting theoretical implications of the game rules and the consequences of empirical choices made by participants. The document is structured as follows:

- Description of the general procdure used for simulations and some explanations of figure formats in this document (section 2)
- Theoretical simulations with mixtures of fully cooperating or competing participants (section 3)
- Simulations exploring strategies for reaching a collusive optimum (section 4)
- Exploring alternatives to the identified strategy (section 5)
- Testing the robustness of differences between strategies spacing competitive actions differently (section 6)
- Simulations based on the empirical data (section 7)
- Strategy-specific results based on empirical data (section 8)
- Results based on resampled empirical data (section 9)
- A full collection of the simulation code used to generate the presented results (section 10)

This document was generated in RStudio using knitR. The R code presented in this document was the code used to generate the figures. Referenced files are output files generated by the simulation.

SCR-2 Simulation procedure

SCR-2.1 Number of trials

If not otherwise specified, reported data are based on 1,000,000 trials per condition or level of the parameter at interest. The simulation code document lists all codes used to generate the data that is used as input for the calculations below.

SCR-2.2 Used libraries and session info

```
library(foreign)
library(dplyr)

##
## Attaching package:  'dplyr'
## The following objects are masked from 'package:stats':
##
##    filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(magrittr)
library(knitr)
library(tidyverse)

## -- Attaching packages --------------------------------------- tidyverse
1.3.0 --
## v ggplot2 3.3.2     v purrr   0.3.4
## v tibble  3.0.1     v stringr 1.4.0
## v tidyr   1.1.0     v forcats 0.5.0
## v readr   1.3.1
## -- Conflicts ------------------------------------------
tidyverse_conflicts() --
## x tidyr::extract()  masks magrittr::extract()
## x dplyr::filter()   masks stats::filter()
## x dplyr::lag()      masks stats::lag()
## x purrr::set_names() masks magrittr::set_names()

library(ggplot2)
library(ggfan)

## Warning: package 'ggfan' was built under R version 4.0.2

library(viridisLite)
library(viridis)

## Warning: package 'viridis' was built under R version 4.0.2

library(patchwork)

## Warning: package 'patchwork' was built under R version 4.0.2

sessionInfo()

## R version 4.0.1 (2020-06-06)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 7 x64 (build 7601) Service Pack 1
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=German_Germany.1252  LC_CTYPE=German_Germany.1252
## [3] LC_MONETARY=German_Germany.1252 LC_NUMERIC=C
## [5] LC_TIME=German_Germany.1252
##
```

```
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
##  [1] patchwork_1.0.1   viridis_0.5.1     viridisLite_0.3.0 ggfan_0.1.3
##  [5] forcats_0.5.0     stringr_1.4.0     purrr_0.3.4       readr_1.3.1
##  [9] tidyr_1.1.0       tibble_3.0.1      ggplot2_3.3.2     tidyverse_1.3.0
## [13] magrittr_1.5      dplyr_1.0.0       foreign_0.8-80    knitr_1.28
##
## loaded via a namespace (and not attached):
##  [1] tidyselect_1.1.0 xfun_0.14        haven_2.3.1      lattice_0.20-41
##  [5] colorspace_1.4-1 vctrs_0.3.1      generics_0.0.2   blob_1.2.1
##  [9] rlang_0.4.6      pillar_1.4.4     glue_1.4.1       withr_2.2.0
## [13] DBI_1.1.0        dbplyr_1.4.4     modelr_0.1.8     readxl_1.3.1
## [17] lifecycle_0.2.0  munsell_0.5.0    gtable_0.3.0     cellranger_1.1.0
## [21] rvest_0.3.5      evaluate_0.14    fansi_0.4.1      broom_0.5.6
## [25] Rcpp_1.0.4.6     scales_1.1.1     backports_1.1.7  jsonlite_1.7.1
## [29] fs_1.4.1         gridExtra_2.3    hms_0.5.3        stringi_1.4.6
## [33] grid_4.0.1       cli_2.0.2        tools_4.0.1      crayon_1.3.4
## [37] pkgconfig_2.0.3  ellipsis_0.3.1   xml2_1.3.2       reprex_0.3.0
## [41] lubridate_1.7.9  assertthat_0.2.1 httr_1.4.2       rstudioapi_0.11
## [45] R6_2.4.1         nlme_3.1-148     compiler_4.0.1
```

SCR-2.3 Plot types

SCR-2.3.1 Percentile plots of "infection" rates

The plot calculated below summarizes the data from 1,000,000 games simulated using the data collected from participants in Study 1. The Matlab code outputs files with percentile summaries of roundwise rates of purple players (henceforth interchangeably also called "infection rates" in analogy to the spread of a virus). Each row corresponds to a value marking the output of the "prctile"-function with the parameter varying from 0 to 1 in 200 increments of 0.5% (including 0 and 1, thus 201 rows). Each column corresponds to the state after each round, with the first column describing the initial state (named "After round 0" to stay consistent). The data is given in wide format. It is reshaped into long format below. The percentile parameters are added to the data set and used as quantile values to the ggfan-command. Columns names are manually assigned, but ultimately transformed into numbers.

```
dataRaw=read.delim(file="figdata/Study1----HalfPercentileInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03",
                                            "R04","R05","R06","R07",
                                            "R08","R09","R10","R11",
                                            "R12", "R13","R14","R15",
                                            "R16","R17","R18","R19","R20",
```

```
                                                "R21","R22","R23","R24","R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200


sintervals=c(0.1,0.25,0.67,0.95)
slabels=c("10%","25%","67%","95%")

ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,
                        breaks=sintervals,labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position="left")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Study 1")
```

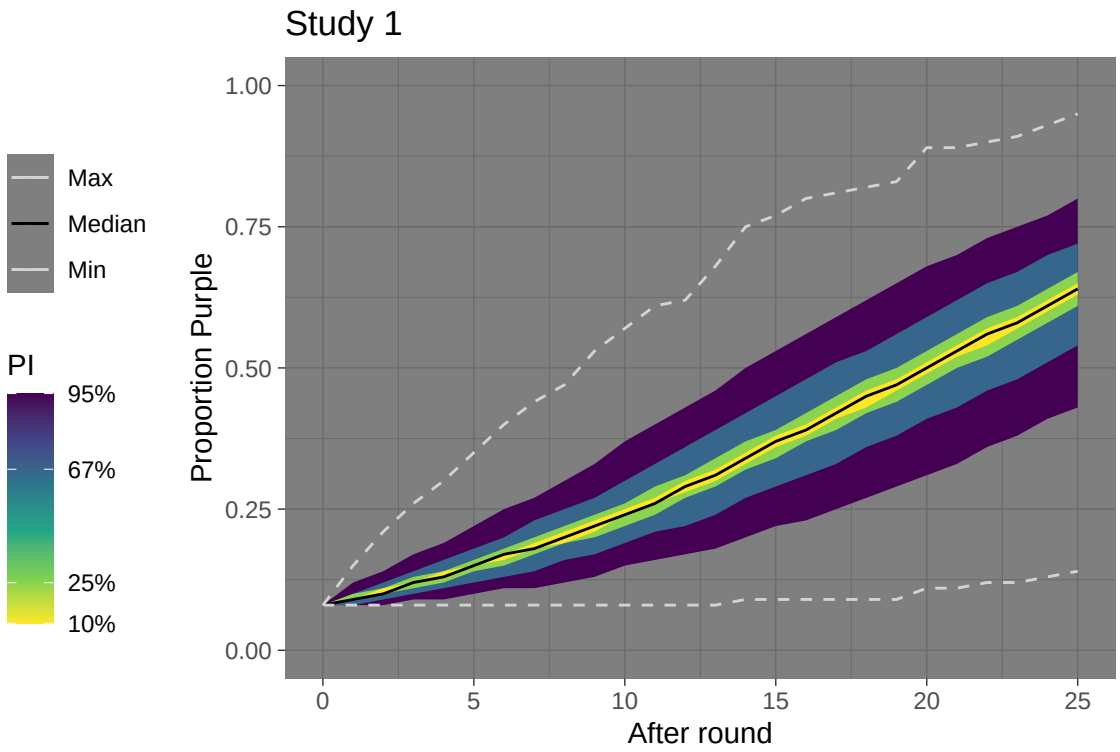

Figure SCR-1

Percentile plot: Example using data from Study 1. Shaded area mark intervals (prediction intervals, PI) that contain the specified inner percentage of results (number of purple players in the beginning and after each of the 25 rounds). For example, the 95% encompasses the are between the percentile values for 2.5% and 97.5 %. On each side, 2.5% of the observed simulation results were more extreme. The dashed line mark the maximum and minimum value observed across 1,000,000 simulations runs.

Figure SCR-1 shows the variability and central tendency (median) of simulation outcomes. Median, maximum, and minimum are shown as lines (connecting the 26 valid values; the lines between rounds are connected for illustration purposes, even if they are technically meaningless).

Areas correspond to certain percentages of simulated results in the middle of the observed distribution. Specifically, "10%" corresponds to the inner 10% of values, between 45% and 55% of the ordered distribution. In the same vein, 25% corresponds to the inner 25% of the distribution, other values shown are 67% and 95%. This means, that between the outline of the colored area and the extreme values, 2.5% of the total distribution lie in either case.

Not surprisingly, due to path dependency the spread increases over time. Given an infinite number of trials, the minima would be expected to form a straight line, the maxima a rectangular shape. Given the large number of trials, the median line would not change substantially in all likelihood. The 95%-CI for the mean proportion (not shown in

the figure) corresponds to an absolute deviation smaller than 0.1% for 1,000,000 trials (with a maximum for an observed proportion of 0.5).

The median is not always in the middle of the 10% interval, but it obviously could never escape it. This is due to the fact that each trial generates outcomes in 1% increments. Typical values are very compressed at the beginning of the game, so there are relatively many identical outcomes after the first rounds. All games are initialized with 8 purple players, thus all lines start at point (0,0.08).

SCR-2.3.2 Outcomes for behavioral patterns

The Matlab code classifies each set of a player's actions into one of four types:

1. **AllH** : AllH-patterns consist of H-choices from the first to the last round.
2. **Switch**: Switch-patterns alternate between H and G, the only exception are HthenG-patterns.
3. **HG**: H(then)G patterns start with H and from some round on switch to G for the rest of the game.
4. **AllG**: AllG-patterns consist of G-choices from the first to the last round.

For each of these patterns and each game the Matlab code records:

- the number of players with the pattern (can be 0)
- the proportion of blue ("healthy") players among those that play the pattern at the end of the game
- the average outcome for players with this pattern (a purple player scores 0)

This results in 12 collected values per game, with information available in the output files on mean, standard deviation, and percentiles. Figure SCR-2 shows a possible presentation for group-wise results.

```
dataRaw=read.delim(file="figdata/testPercdata.txt",
                   header=TRUE)

dataRaw$statType=c("Mean","Min","P0.5","P2.5","P16.5","P37.5","Median",
                   "P62.5","P83.5","P97.5","P99.5","Max")

dataTransformed<-dataRaw%>%
gather(key="condition",value="Outcome",-statType) %>%
spread(key=statType,value="Outcome")

colorsPal=viridis(option="magma",12)

ggplot(data=dataTransformed)+
```

```
  geom_crossbar(aes(x=condition,fill="99%PI",ymin=P0.5,ymax=P99.5,y=Median),
                width = 0.4,fatten=0)+
  geom_crossbar(aes(x=condition,fill="95%PI",ymin=P2.5,ymax=P97.5,y=P97.5),
                width = 0.3,fatten=0)+
  geom_crossbar(aes(x=condition,fill="67%PI",ymin=P16.5,ymax=P83.5,y=P16.5),
                width = 0.2,fatten=0)+
  geom_crossbar(aes(x=condition,fill="25%PI",ymin=P37.5,ymax=P62.5,y=Median),
                width = 0.1,fatten=0)+
  geom_pointrange(aes(x=condition,color="Min-Median-Max",ymin=Min,
                      ymax=Max,y=Median))+
  scale_color_manual(values=c("black","blue"),name="")+
  scale_fill_manual(values=c(colorsPal[[12]],colorsPal[[10]],colorsPal[[8]],
                             colorsPal[[6]]),name="")+
  theme_dark()
```

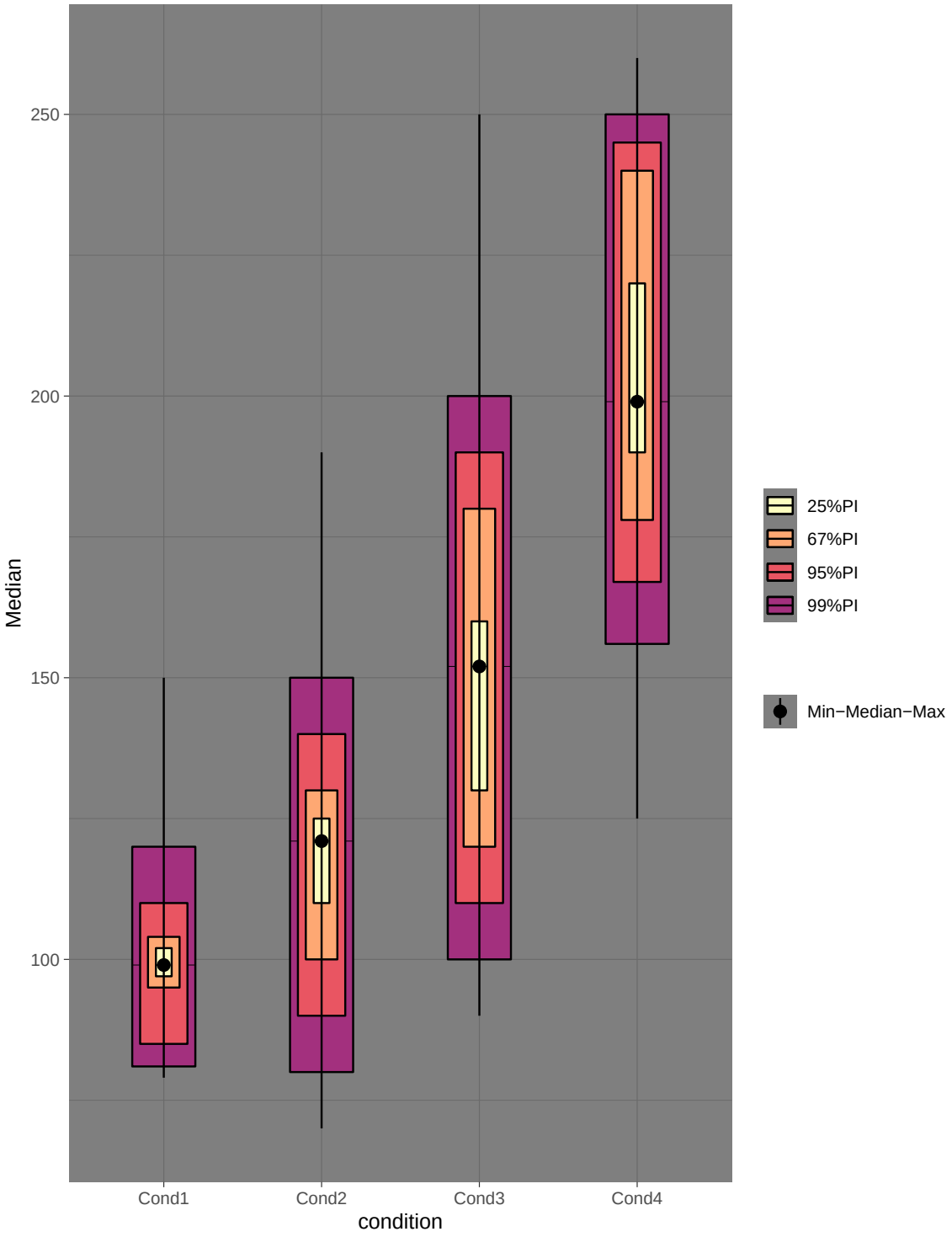

Figure SCR-2

Percentile plot for arbitrary data: This is for illustration purposes only: Data shows differen prediction intervals for group-specific outcomes. As in the previous figure, intervals represent fixed percentages of inner outcomes, marked as upper and lower side of nested rectangles.

SCR-3 Level of cooperation and game results

In a first set of simulations, we explore the outcome of games, in which players choose either fully cooperative strategies (AllG) or fully competitive strategies (AllH) with various compositions of populations.

SCR-3.1 Example: 50% H-players and 50% G-players

SCR-3.1.1 Infection rates

In a first example, we simulated 1,000,000 games with a population of 50 All-H players and 50 All-G players. Figure SCR-3 shows the expected rate of purple players (as proportion) throughout the simulated games. Note that all games start at 0.08 (without variance). The majority of players is purple by round 20 and most games reach infection rates between 60% and 70% at the end of the game. Most players would not receive any bonus money.

```
dataRaw=read.delim(
  file="figdata/PropStable-10----HalfPercentileInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200


sintervals=c(0.1,0.25,0.67,0.95)
slabels=c("10%","25%","67%","95%")

ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
```

```
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position="left")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("50% H-players and 50% G-players")
```

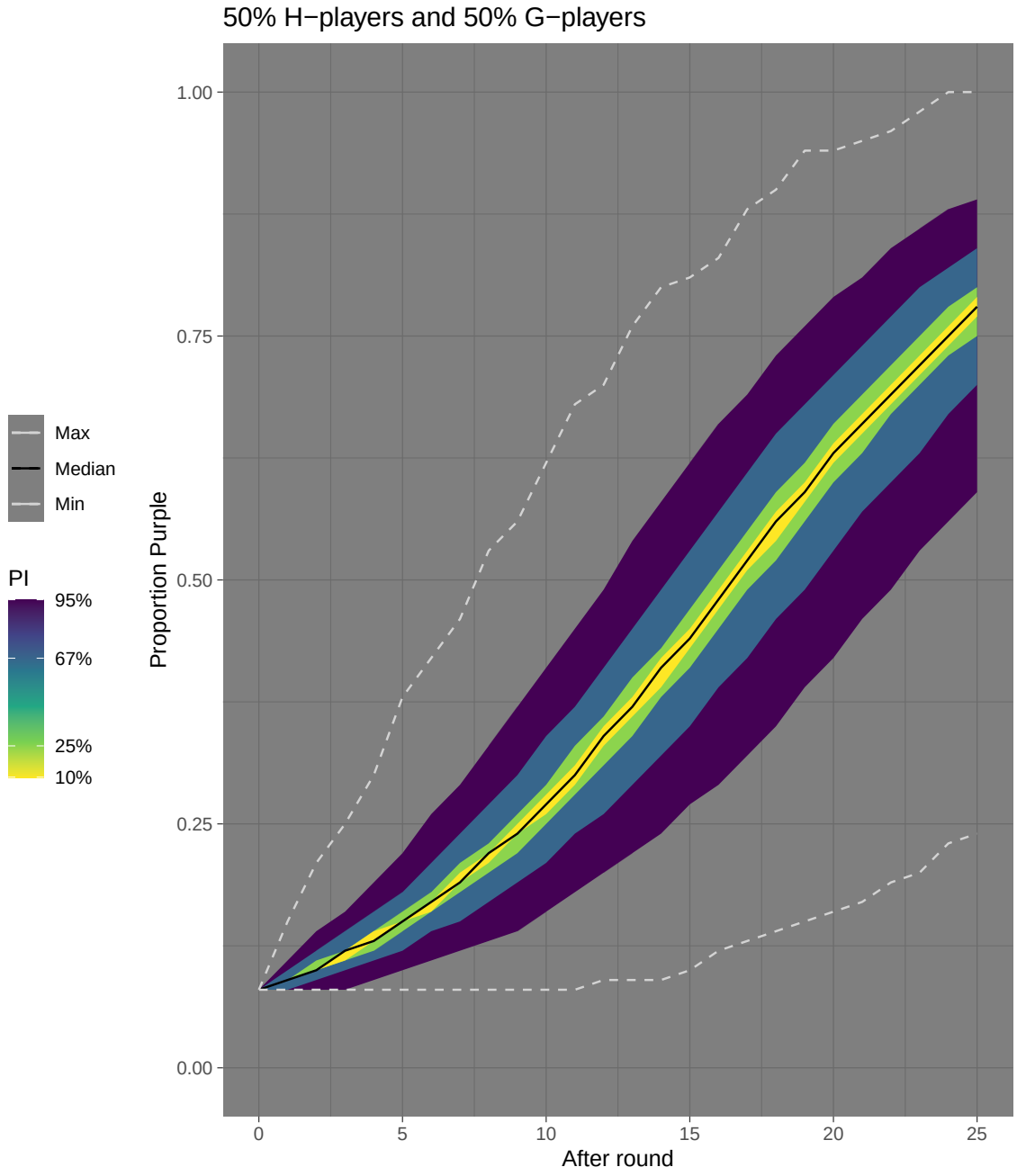

Figure SCR-3

Percentile plot for games with 50% AllG-players and 50% AllH-players.

SCR-3.1.2 Results for player types

It is worth while considering the results for the two player types. Figure SCR-4 and Figure SCR-5 summarize the results distributions. It is evident that AllG-players have a higher "survival rate" (proportion of staying blue till the end of the game) than All-H players, reflecting the smaller risk taken in each interaction. At the same time, even when considering this difference in rates, AllH-players have a higher expected outcome compared to AllG-players. In monetary terms, AllG players stand to win £1.00, because they invariably score 200 points. AllH players, in contrast, stand to win £5.00, and their survival rate is more than a fifth of the rate for AllG-players.

```
dataRaw1=read.delim(
  file="figdata/PropStable-10----HalfPercentileConditionalOutcomes.txt",
         header=FALSE,col.names=c("countH","countS","countF","countG",
                                  "survH","survS","survF","survG","expH",
                                  "expS","expF","expG"))


dataRaw2=read.delim(
  file="figdata/PropStable-10--MeanConditionalOutcomes.txt",
                   header=FALSE,col.names=c("countH","countS","countF",
                                            "countG","survH","survS",
                                            "survF","survG","expH","expS",
                                            "expF","expG"))


dataRaw3=read.delim(
  file="figdata/PropStable-10----HalfPercentileSumOutcome.txt",
                   header=FALSE,col.names=c("expAll"))

dataRaw4=read.delim(
  file="figdata/PropStable-10--MeanSumOutcomes.txt",
                   header=FALSE,col.names=c("expAll"))



dataRaw5=read.delim(
  file="figdata/PropStable-10--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
```

```
dataRaw6=read.delim(
  file="figdata/PropStable-10----HalfPercentileInfectionRate.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataCombined=data.frame(
  survH=c(dataRaw2$survH,dataRaw1$survH),
  survG=c(dataRaw2$survG,dataRaw1$survG),
  expH=c(dataRaw2$expH,dataRaw1$expH),
  expG=c(dataRaw2$expG,dataRaw1$expG),
  survAll=c(1-dataRaw5$R25,rev(1-dataRaw6$R25)),
  expAll=c(dataRaw4$expAll/100,dataRaw3$expAll/100)
)

chooseRows=c(1,2,3,7, 35, 77,  102, 127, 169, 197,201,202)

dataCombined=dataCombined[chooseRows,]
dataCombined$statType=c("Mean","Min","P0.5","P2.5","P16.5","P37.5","Median",
                        "P62.5","P83.5","P97.5","P99.5","Max")

dataTransformed<-dataCombined%>%
  select(c(survG,survH,survAll,statType))%>%
  rename(AllG=survG,
         AllH=survH,
         Population=survAll
  )%>%
gather(key="condition",value="Outcome",-statType) %>%
spread(key=statType,value="Outcome")

colorsPal=viridis(option="magma",12)

ggplot(data=dataTransformed)+
  geom_crossbar(aes(x=condition,fill="99%PI",ymin=P0.5,
                    ymax=P99.5,y=Median),
                width = 0.4,fatten=0)+
  geom_crossbar(aes(x=condition,fill="95%PI",ymin=P2.5,
                    ymax=P97.5,y=P97.5),
                width = 0.3,fatten=0)+
  geom_crossbar(aes(x=condition,fill="67%PI",ymin=P16.5,
```

```
                    ymax=P83.5,y=P16.5),
                width = 0.2,fatten=0)+
geom_crossbar(aes(x=condition,fill="25%PI",ymin=P37.5,
                    ymax=P62.5,y=Median),
                width = 0.1,fatten=0)+
geom_pointrange(aes(x=condition,color="Min-Mean-Max",
                      ymin=Min,ymax=Max,y=Mean))+
scale_color_manual(values=c("black","blue"),name="")+
scale_fill_manual(values=c(colorsPal[[12]],colorsPal[[10]],
                           colorsPal[[8]],colorsPal[[6]]),name="")+
theme_dark()+
ylab("Proportion blue")+
xlab("Player type")
```

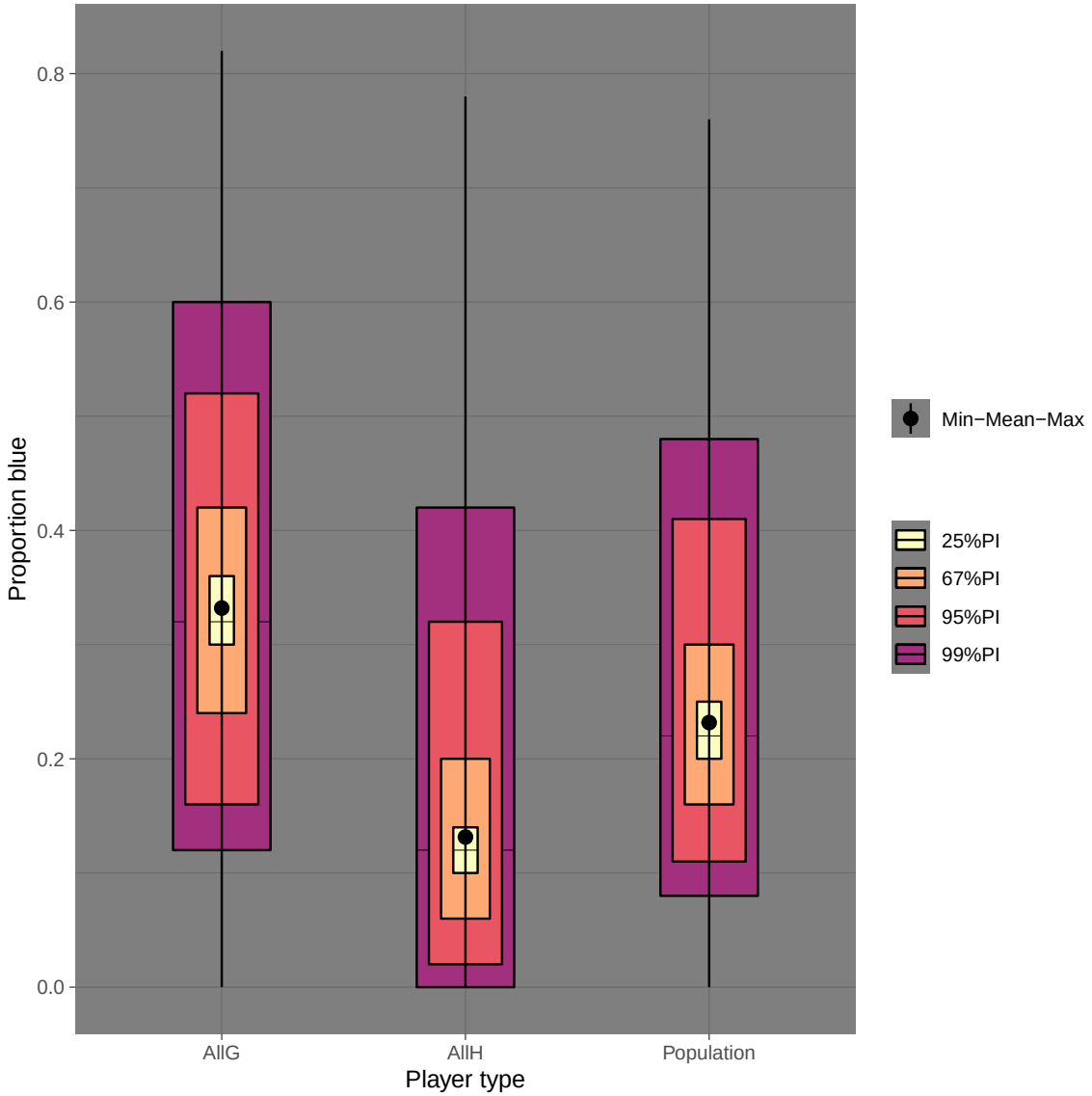

Figure SCR-4

Distribution of the proportion of blue playes at the end of the game ("survival rate" for both player types and the whole population.

```
dataTransformed<-dataCombined%>%
  select(c(expG,expH,expAll,statType))%>%
  rename(AllG=expG,
         AllH=expH,
         Population=expAll
  )%>%
gather(key="condition",value="Outcome",-statType) %>%
spread(key=statType,value="Outcome")


colorsPal2=viridis(option="inferno",12)

ggplot(data=dataTransformed)+
  geom_crossbar(aes(x=condition,fill="99%PI",ymin=P0.5,ymax=P99.5,y=Median),
                width = 0.4,fatten=0)+
  geom_crossbar(aes(x=condition,fill="95%PI",ymin=P2.5,ymax=P97.5,y=P97.5),
                width = 0.3,fatten=0)+
  geom_crossbar(aes(x=condition,fill="67%PI",ymin=P16.5,ymax=P83.5,y=P16.5),
                width = 0.2,fatten=0)+
  geom_crossbar(aes(x=condition,fill="25%PI",ymin=P37.5,ymax=P62.5,y=Median),
                width = 0.1,fatten=0)+
  geom_pointrange(aes(x=condition,color="Min-Mean-Max",ymin=Min,
                      ymax=Max,y=Mean))+
  scale_color_manual(values=c("black","blue"),name="")+
  scale_fill_manual(values=c(colorsPal2[[12]],colorsPal2[[9]],
                             colorsPal2[[6]],
                             colorsPal2[[4]]),name="")+
  theme_dark()+
  ylab("Expected outcome")+
  xlab("Player type")
```

SCR-3.2 Results for various population compositions

SCR-3.2.1 Infection rates

How do these results generalize to different mixtures of player types? We simulated 1,000,000 games each for 20 additional splits, starting from 0% All-H players going in 20 steps to 100% All-H players (with the corresponding percentage of All-G players going down from 100% to 0%). Given the population size, percentages are interchangeable with absolute numbers of players. The infection rates for all simulations are visualized in Figure SCR-6.

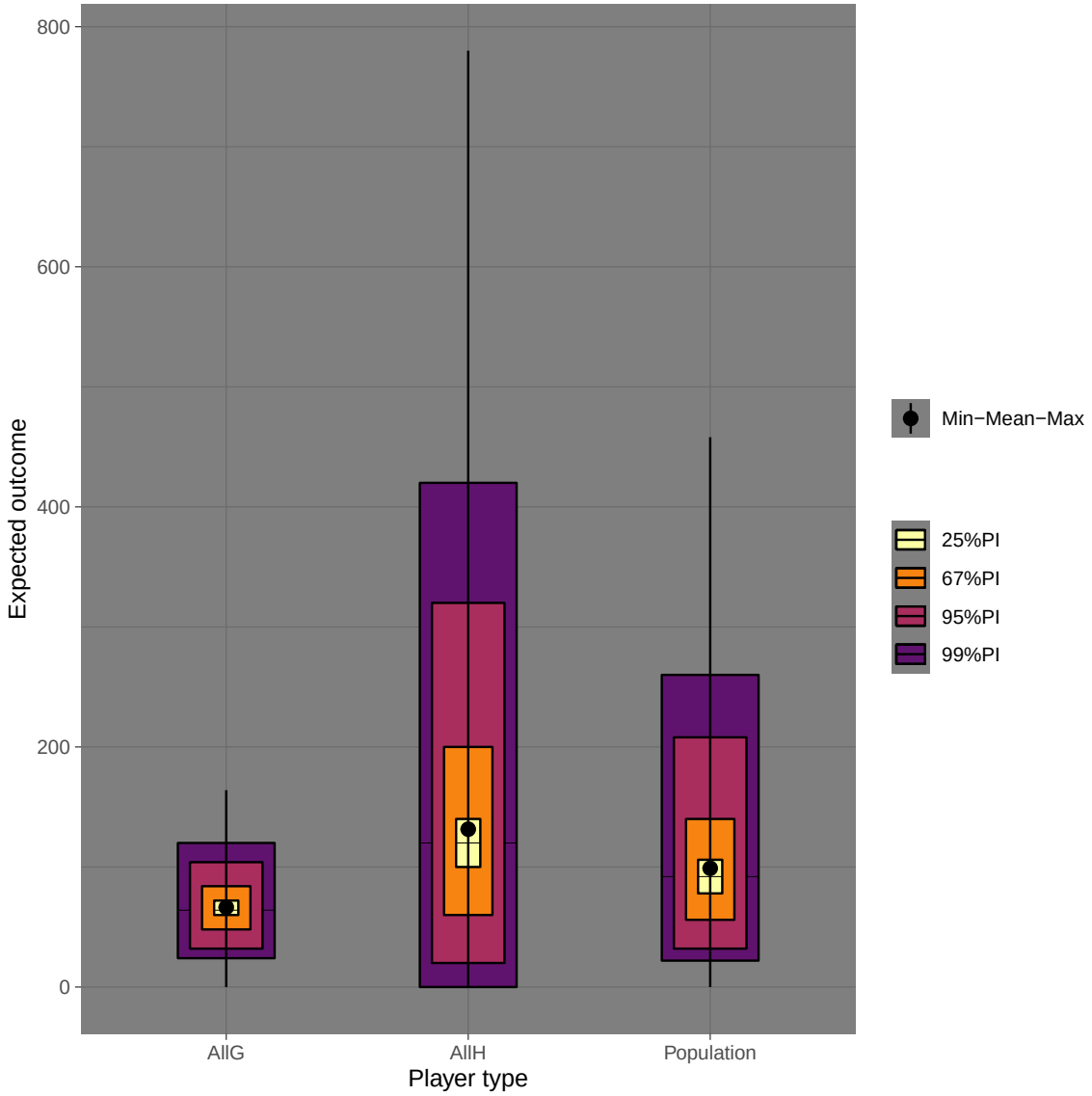

Figure SCR-5

Distribution of final scores for both player types and the whole population: These numbers reflect that purple players score zero points at the end of the game. Using the incentive structures in the studies, the average result translates into average payments in pence by dividing final scores by 2.

```
dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateStableProp.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$numH=0:20*5;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-numH)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

fixedProp<- dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=numH,group=numH))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="Number of\n H-players")

fixedProp
```

```
EndStateStable=dataRaw$R25
```

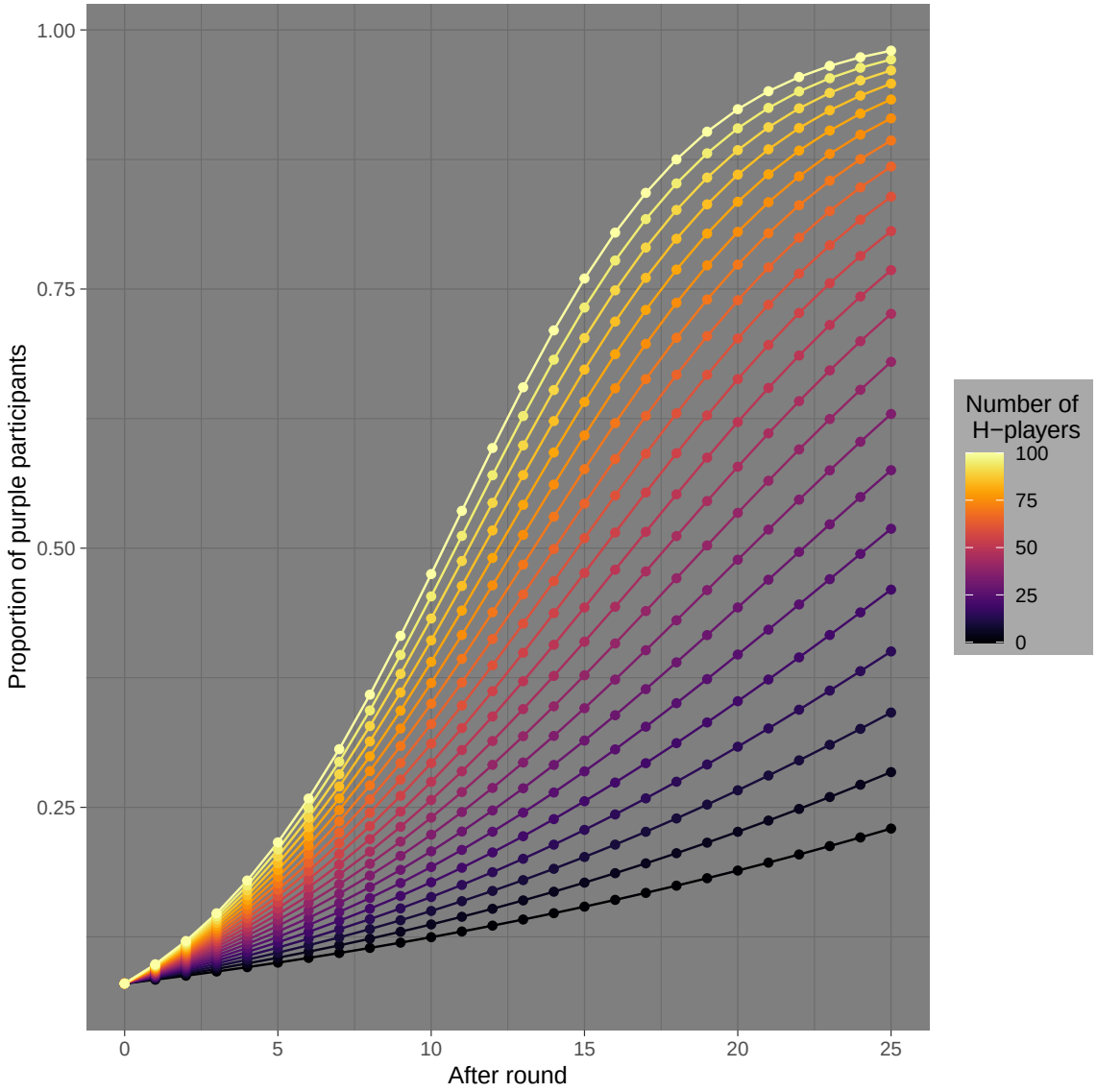

Figure SCR-6

Mean infection rates for each round conditional on the number of H-players (using the AllH-strategy) represented by color.

Differences between conditions emerge early in the game and increase over time. In conditions with a high number of All-H players the curves demonstrate several phases: From a slow rate of increase in the beginning, the slope increases (exponential growth phase), but this growth is limited by the finite population size, resulting in decreasing slopes (and a relative convergence of curves) in the final rounds of the game. Final outcomes vary dramatically with composition, ranging from below 25% for full cooperation to close to 100% for complete competition.

SCR-3.3 A social dilemma: group-specific outomes

Benefits and costs do not accrue evenly to both groups: Figure SCR-7 demonstrates, that irrespecitve of the distribution of players, AllH-players are at higher risk of turning purple than AllG-players. Risk for all players increases with the proportion of allH-players.

```
dataRaw=read.delim(
  file="figdata/SUMMARY--OutcomesconditionalStableProp.txt",
                    header=TRUE)
#dataRaw$numH=0:20*5;

dataLong<-dataRaw%>%
  select(c(nH,survH,survG,survAll)) %>%
  rename(
    AllH=survH,
    AllG=survG,
    Population=survAll
  )%>%
gather(key="playerType",value="ProportionBlue",-nH)

ggplot(data=dataLong,aes(x=nH,y=ProportionBlue,group=playerType,
                         color=playerType))+
  geom_line()+
  geom_point()+
  theme_dark()+
  scale_color_manual(values=c(colorsPal[[8]],colorsPal[[1]],
                              colorsPal[[12]]))+
  xlab("Number of AllH-players")+
  ylab("Proportion blue")

## Warning:  Removed 2 row(s) containing missing values (geom_path).
## Warning:  Removed 2 rows containing missing values (geom_point).
```

```
#Two values are NA: there are no All-G players with 100% All-H and vice versa.
```

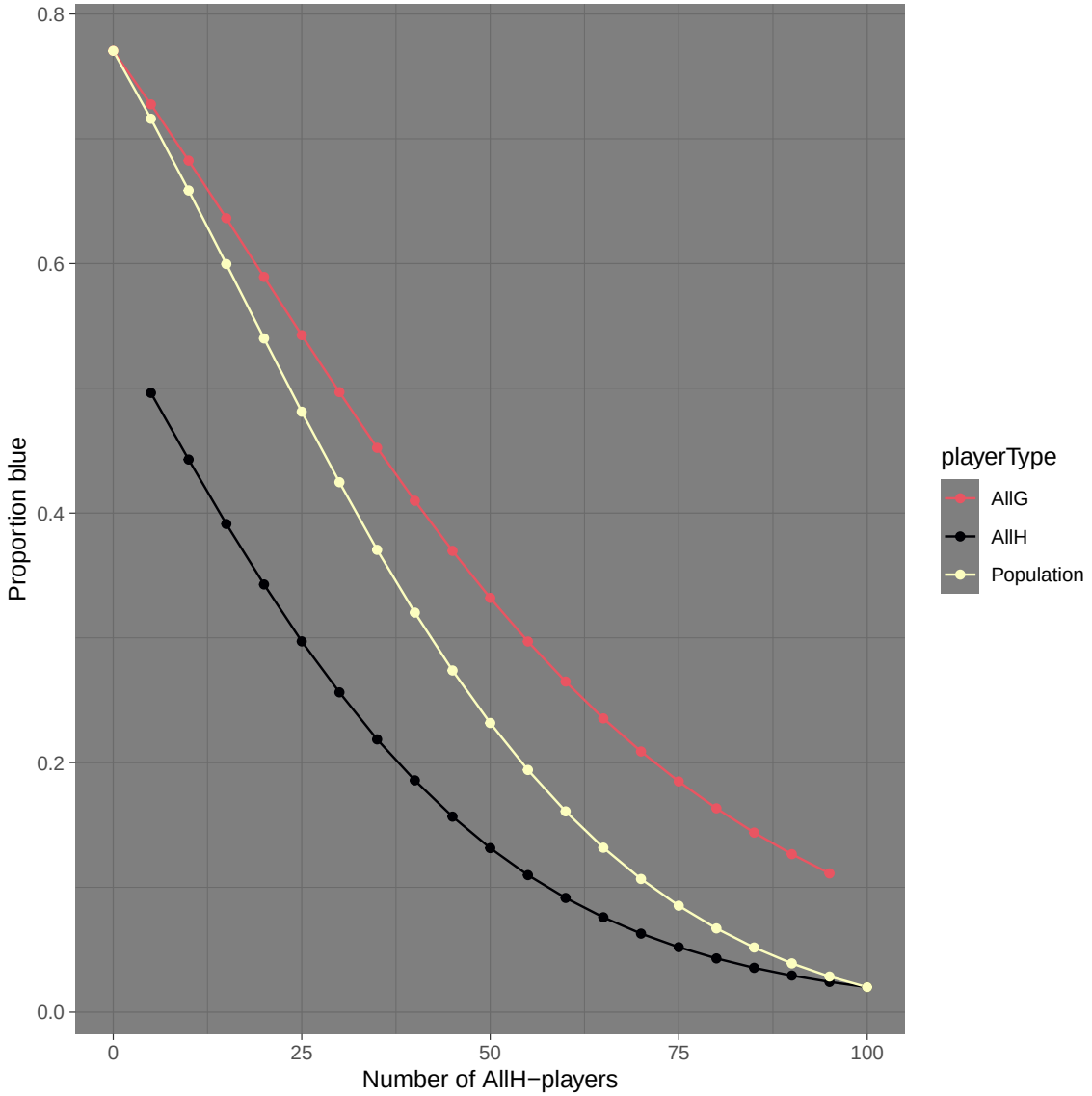

Figure SCR-7

Survival rate for different distributions of players: Points represent survival rates for AllG-players, All-H players and the entire population.

In spite of the elevated risk to turn purple, the expected final outcome is still higher for AllH-players, again irrespective of the distribution of players (see Fig. SCR-8). As seen in the example above, the relative increase in points is not outweighed by the lower survival rate. Crucially, while there is a relative advantage in playing an AllH-strategy, the absolute advantage of switching from AllG to AllH depends on the number of players making this switch. At 45 players playing AllH, their expected outcome is no longer higher than the outcome of AllG when all players choose it. For higher numbers of competitive players, all players perform worse than they could if no-one played competitively. At the same time, 100% cooperation does not guarantee the highest possible average payment: A small percentage of competitive players increases the average population outcome.

```
dataLong<-dataRaw%>%
  select(c(nH,expH,expG,expAll)) %>%
  rename(
    AllH=expH,
    AllG=expG,
    Population=expAll
  )%>%
gather(key="playerType",value="expOutcome",-nH)

ggplot(data=dataLong,aes(x=nH,y=expOutcome,group=playerType,
                         color=playerType))+
  geom_line()+
  geom_point(alpha=0.7)+
  theme_dark()+
  scale_color_manual(values=c(colorsPal[[8]],colorsPal[[1]],
                              colorsPal[[12]]))+
  xlab("Number of H-players")+
  ylab("Expected outcome")

## Warning:  Removed 2 row(s) containing missing values (geom_path).
## Warning:  Removed 2 rows containing missing values (geom_point).
```

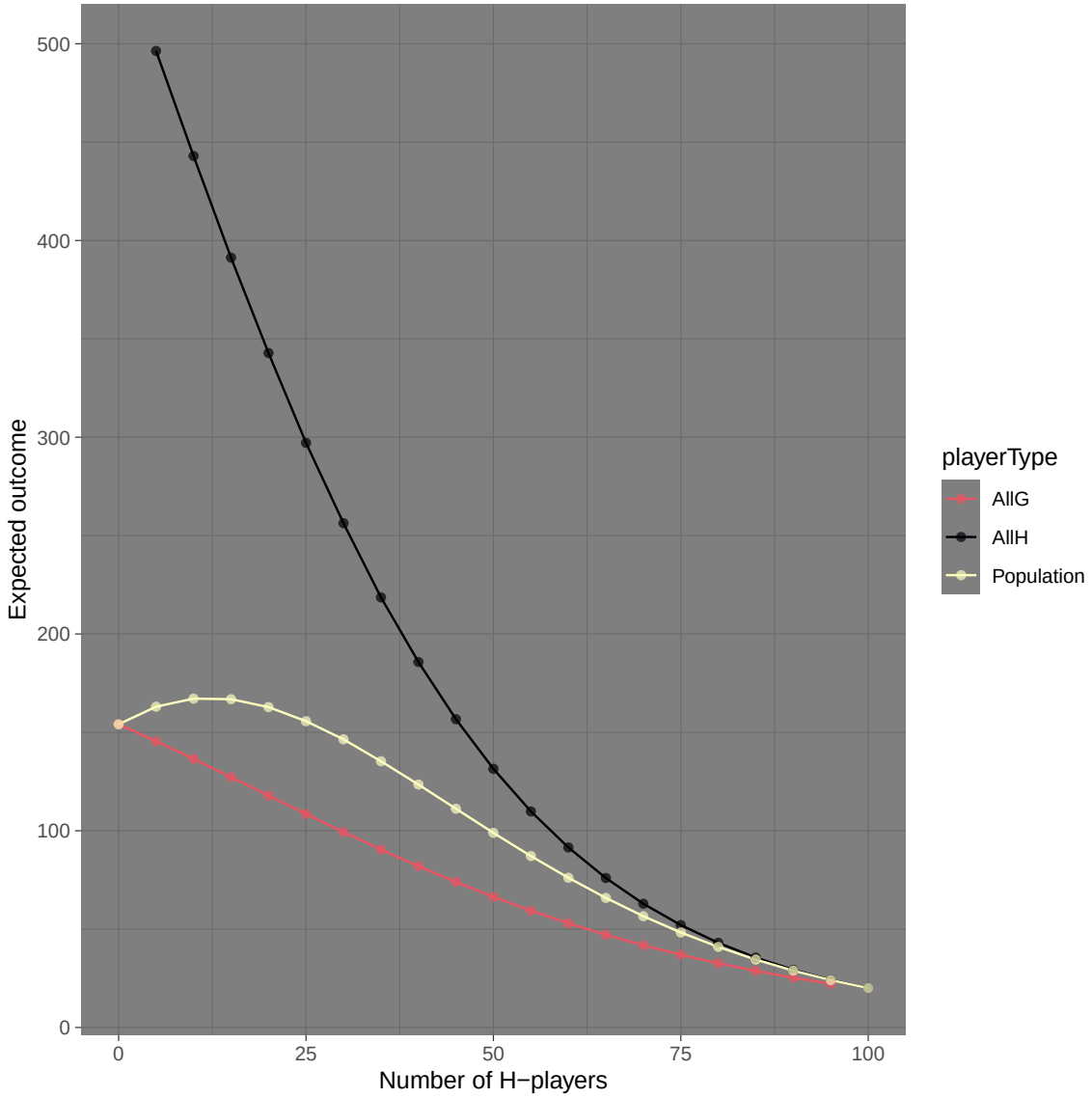

Figure SCR-8

Average expected outcome for each split of player types

The general structure nonetheless poses a social dilemma: There is a clear individual incentive to play competitively, but if too many player choose this strategy, all players end up in a worse place—both collectively and individually—than if no-one decided to compete. This structure mirrors the structure of n-person prisoner's dilemma games.

SCR-4 A search for the collusive optimum

SCR-4.1 A basic tradeoff

The previous figure seems to suggest that a small number of competitive players should be optimal. But optimality needs to be better defined. Different solutions vary in quality on two dimensions: the expected average outcome (which might be associated with total group welfare), and the proportion of players being paid (which might be associated both with risk and distributional fairness). Plotting both outcomes (on the level of the entire population) in a scatterplot, it is possible to see that some solutions are better than other solutions on both dimensions (see Fig. SCR-9).

```
dataLong<-dataRaw%>%
  select(c(nH,survAll,expAll)) %>%
  rename(
    propBlue=survAll,
    expV=expAll,
    numberH=nH
  )

shape=data.frame(
  shapex=c(0,0,0.6587,0.71604,0.77050,0.77050,0),
  shapey=c(0,167.15,167.15,163.060,154.100,0,0)
)


lineshape=data.frame(
  shapex=c(0,0.6587,0.71604,0.77050,0.77050),
  shapey=c(167.15,167.15,163.060,154.100,0)
)


ggplot(data=dataLong,aes(x=propBlue,y=expV,color=numberH))+
  geom_polygon(data=shape,aes(x=shapex,y=shapey),fill="gray",
               color="blue",alpha=0.2,linetype="blank")+
  geom_line(data=lineshape,aes(x=shapex,y=shapey),color="red",
            alpha=0.5)+
  geom_point()+
  scale_color_viridis(option="magma",name="Number of\n AllH-players")+
  xlab("Average proportion blue")+
  ylab("Average population outcome")+
```

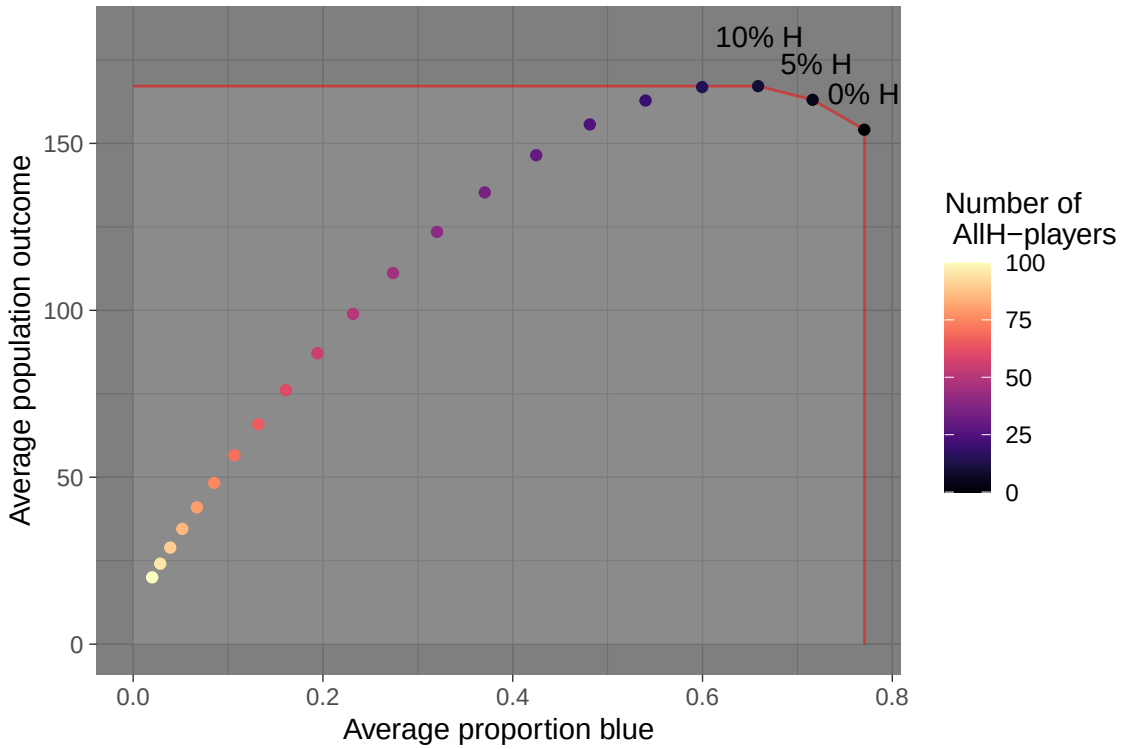

Figure SCR-9

Tradeoff between average survival rate and average outcome: Pareto-efficient outcomes and the Pareto frontier are marked are marked, dominated options are in the shaded area.

```
theme_dark()+
 annotate("text", x = 0.66, y = 182, label = "10% H")+
annotate("text", x = 0.72, y = 174, label = "5% H")+
annotate("text", x = 0.77, y = 165, label = "0% H")
```

There are only three non-dominated options, corresponding to 0%, 5%, and 10% of competitive players. Obviously, 0% AllH is the only symmetric strategy, which renders this analysis somewhat strange. The main point to consider here, though, is the ambiguity of defining optimal solution. While every player should care about increasing the average outcome, social preferences will determine the weighting of other players' outcomes. Likewise, while all players should value a high personal survival chance, the tradeoff with potentially higher outcomes will depend in part on the player's appetite for risk, that is, how much the increase in the probability of earning nothing detracts from the value of a higher expected outcome. Only when fixing social preferences and risk preference could a unique optimal strategy be determined. It is clear though, that no combination of preferences should prefer a dominated over a non-dominated option (this would require a high degree of risk-seeking or anti-social preferences). Antisocial preference were rare in the observed population and

some degree of risk-aversion is the most common assumption for the general population.

But it is clear that none of the solutions with split player types should qualify as an ideal solution when common preferences are assumed, unless all players are indifferent to who gains and loses given differential benefits. We will consider the question here, how players should play the game who seek to jointly realize the best possible outcome for each player simultaneously. As all players are playing together to achieve this outcome, we will call this the search for the collusive optimum.

SCR-4.2 Sharing risk and gains

As seen in the previous simulation, the universal strategy of AllH is dominated by the strategy of AllG. Yet, it is not a necessity that players stay with one action for the entirety of the game. Here we consider two strategies of collective switching. In one approach, players start out with H-actions and switch to G-actions. We call it "flattening the curve". In the other approach players start with G-actions and switch to H-actions, called "steepening the curve". In each simulation, all players choose the same strategy, thus the expected survival rate and the expected outcome for the population hold for each player, expected risks and gains are shared equally.

SCR-4.3 Flattening the curve: example

We call the strategy of switching from H to G "flattening the curve", as risky behavior is changed to safe behavior in the middle of the game. Figure SCR-10 shows the impact of this strategy on the infection rate, when players switch after ten rounds of risky actions.

```
dataRaw=read.delim(
  file="figdata/SwitchHG-11----HalfPercentileInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200


sintervals=c(0.1,0.25,0.67,0.95)
slabels=c("10%","25%","67%","95%")
```

```
ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position="left")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Switch from H to G after ten rounds")
```

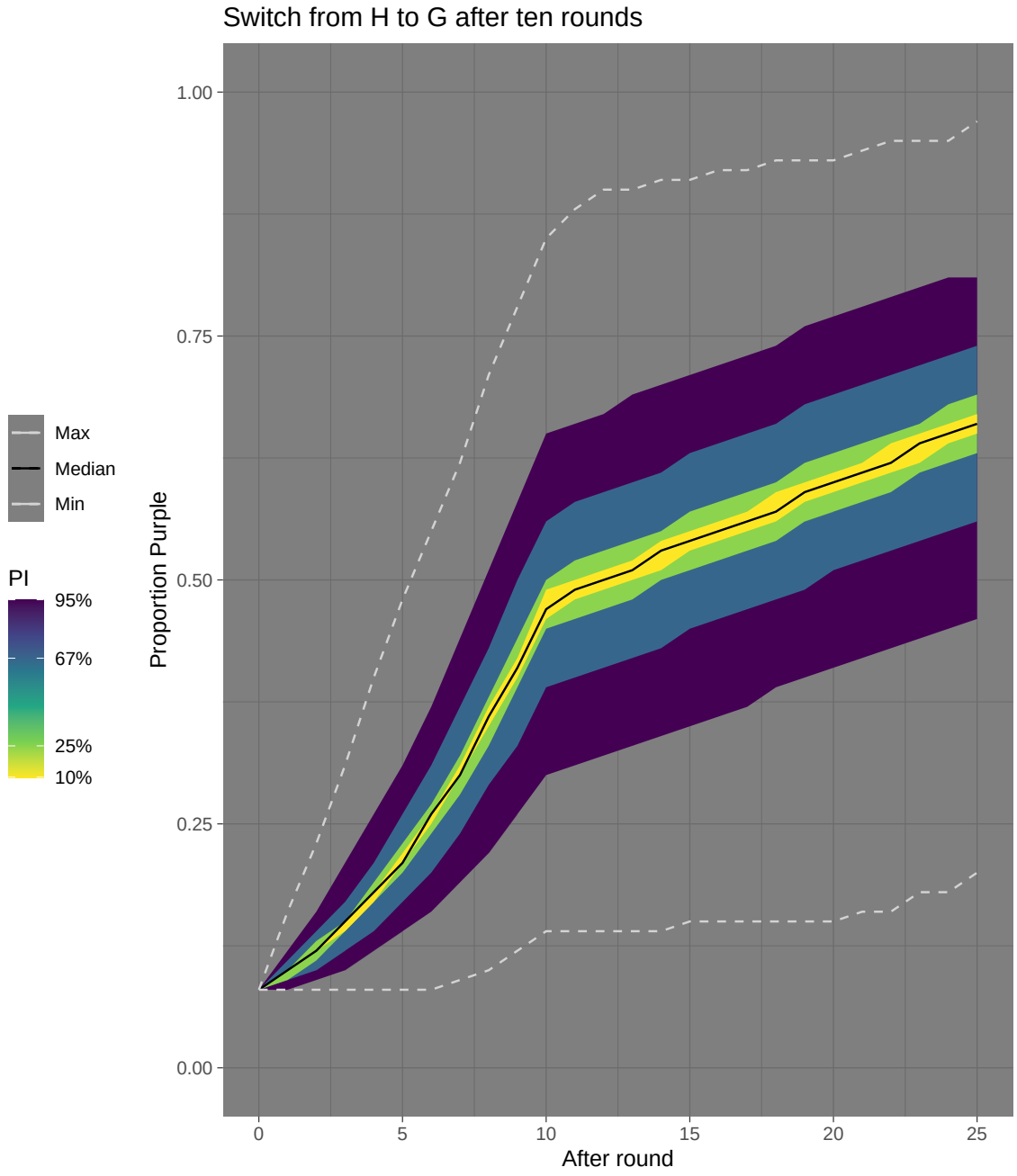

Figure SCR-10

Percentile plot for a population collectively switching from H to G after ten rounds

True to the name, the slope of the curve is much lower after the switch than before. A collective strategy exhibiting this pattern follows the intuition that foregoing any risky action might be suboptimal, but that risky actions in earlier rounds might be safer than risky actions in later rounds, with the number of purple players monotonously rising.

SCR-4.4 Flattening the curve: Comparison of infection rates

We conducted similar simulations for all possible splitting points. Again, we included the extreme strategies of switching before the first round (effectively AllG) and not switching before the end of the game (AllH). The impact of the switching point on the development of the infection rate is visualized in figure SCR-11.

```
dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateHG.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$switchAfter=0:25;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-switchAfter)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=switchAfter,
           group=switchAfter))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch to G after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="G after\n round")
```

```
saveEndpointsHG=dataRaw$R25
```

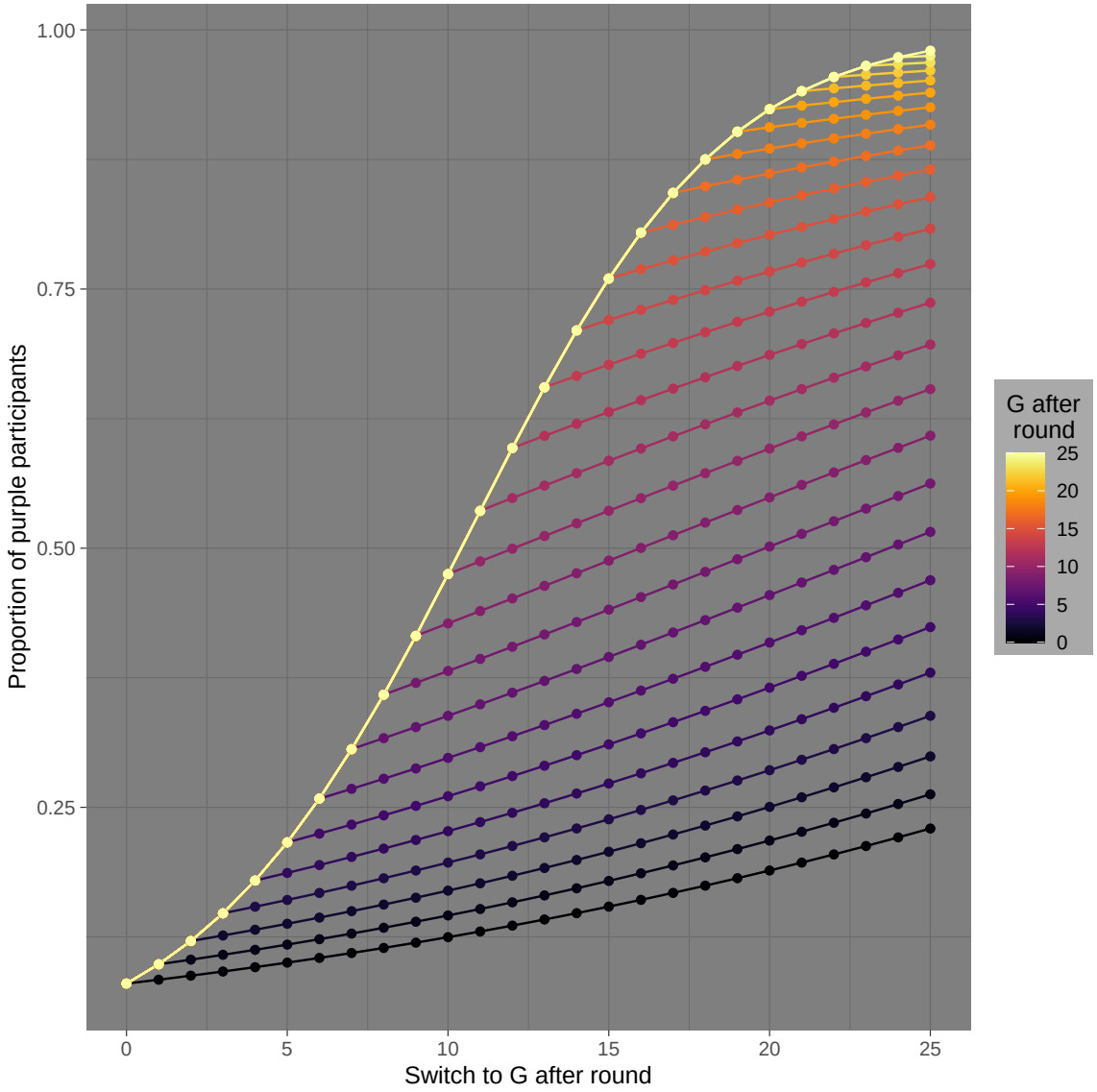

Figure SCR-11

Roundwise infection rate for different HG-switching points: All curves share points on the upper line up to the switching point.

SCR-4.5 Steepening the curve: Comparison of infection rates

The opposite strategy switches from G to H. It might follow the intuition that risky actions at the end of the game will have less time to affect larger parts of the population. Again, we ran simulations for all possible splitting points, resulting in infection rates illustrated in Figure SCR-12.

```
dataRaw=read.delim(
  file="figData/SUMMARY--MeanInfectionRateGH.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$switchAfter=0:25;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-switchAfter)

dataLong$AfterRound<-parse_number(dataLong$AfterRound);

dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=switchAfter,
           group=switchAfter))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch to H after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="H after\n round",
                      direction=-1)
```

```
saveEndpointsGH=dataRaw$R25
```

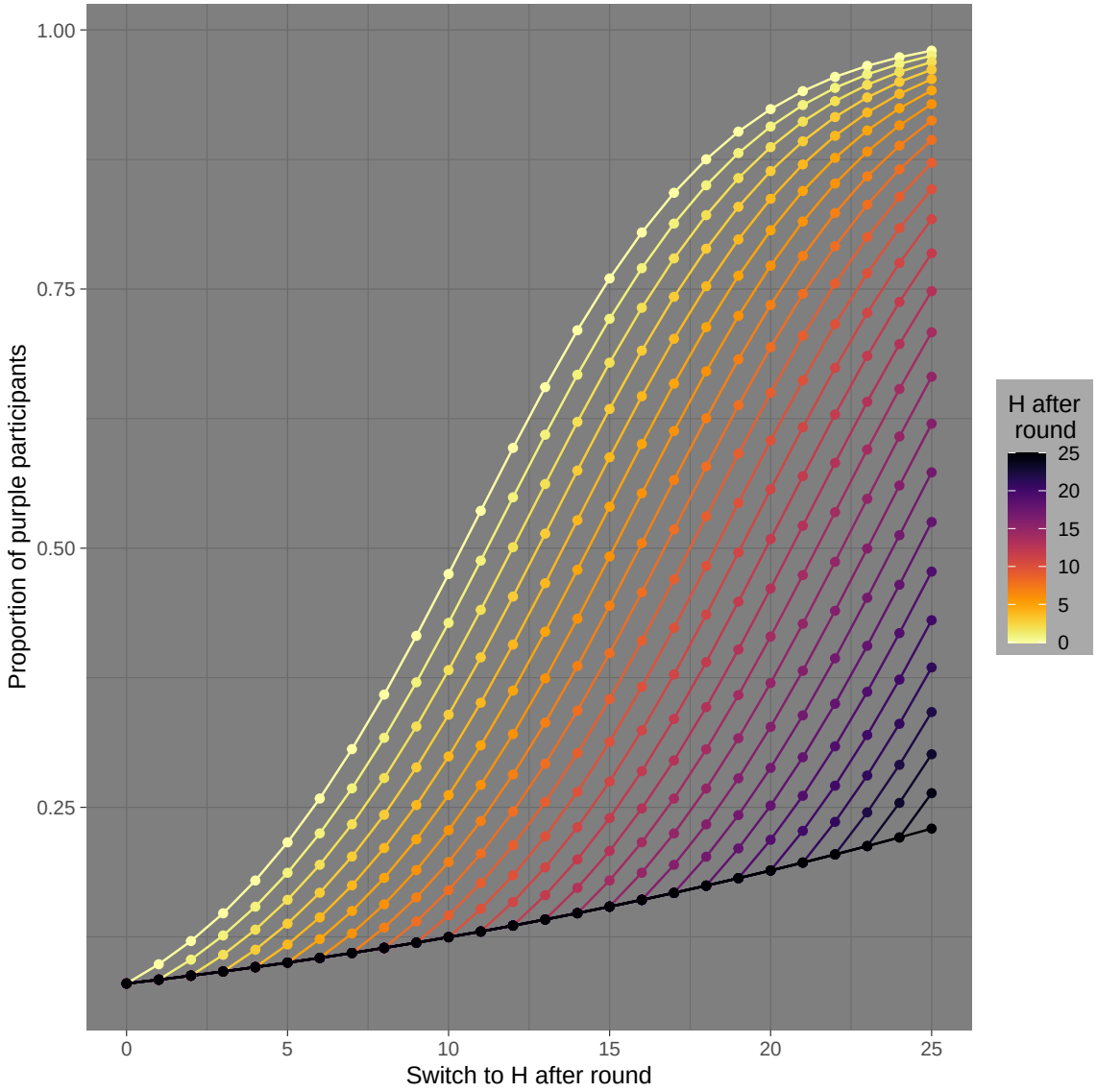

Figure SCR-12

Roundwise infection rate for different HG-switching points: All curves share points on the lower line up to the switching point.

Not surprisingly, the resulting curves show the reverse pattern of starting on the curve for AllG, then diverging with an increased slope for the remainder of the game.

SCR-4.6 Comparison of the two strategies

To compare the two switching strategies, it helps to align them by the total number of H-actions. The score after the last round is identical for players starting the game with ten H-actions and players ending the game with 10 H-action. Thus, the survival rate directly translates into expected outcome. Matching conditions with equal possible outcomes, a direct comparison reveals that—with the exception of pure strategies—HG-results are higher than GH-results, even if the differences are relatively small. Figure SCR-13 demonstrates both the consistency and relative size of differences.

```
dataRaw1=read.delim(file="figdata/SUMMARY--MeanSumOutcomesHG.txt",
                    header=FALSE,col.names="Outcome")

dataRaw2=read.delim(file="figdata/SUMMARY--MeanSumOutcomesGH.txt",
                     header=FALSE,col.names="Outcome")


HGcomp=data.frame(
  HG=dataRaw1$Outcome/100,
  GH=rev(dataRaw2$Outcome/100),
  advantageHfirst=dataRaw1$Outcome/100-rev(dataRaw2$Outcome/100),
  numH=0:25
)


HGbars<- HGcomp %>%
 gather(key="order",value="expOutcome",-advantageHfirst,-numH)


HGbars$order <- ordered(HGbars$order , levels = c("HG", "GH"))

ggplot(data=HGbars,aes(x=as.factor(numH),y=expOutcome,fill=order))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  scale_fill_manual(values=c(colorsPal[[9]],colorsPal[[4]]))+
  xlab("Number of H-actions")+
  ylab("Expected outcome")
```

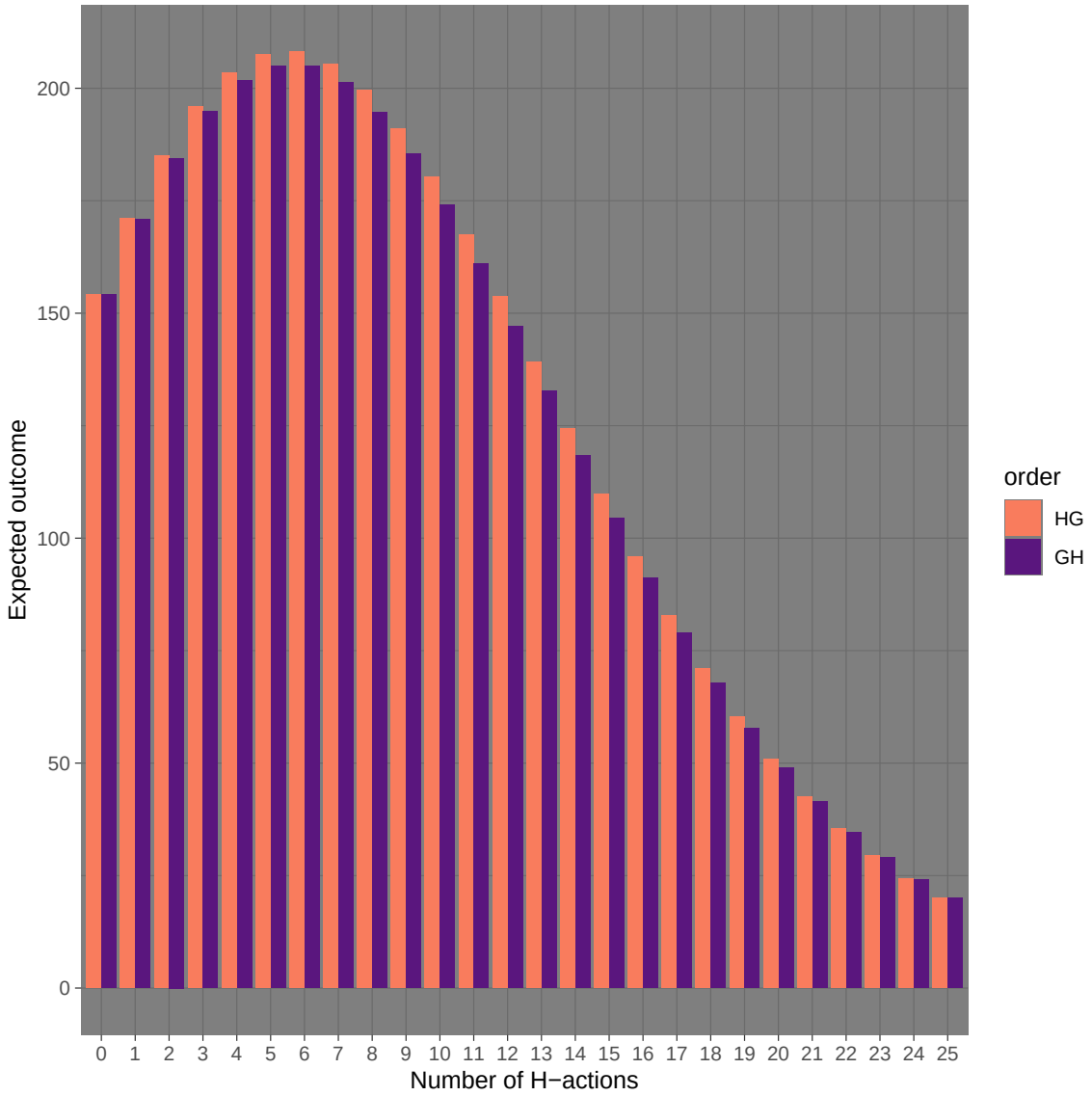

Figure SCR-13

Comparison of expected outcomes between populations switching from H to G, and from G to H, matched by the number of H-actions: each bar represents the expected outcome based on 1,000,000 simulations.

Figure SCR-14 zooms into the differences between the two strategies. The largest difference is observed when the shares of H-actions and G-actions are nearly equal. It is evident that GH-strategies need not be considered for determining the collusive optimum, as each variant is outperformed by the respective HG-variant.

```
ggplot(data=HGbars,aes(x=numH,y=advantageHfirst,color=numH))+
  geom_line()+
  geom_point()+
  xlab("Number of H-actions")+
  ylab("Advantage of HG vs. GH in expected outcome")
```

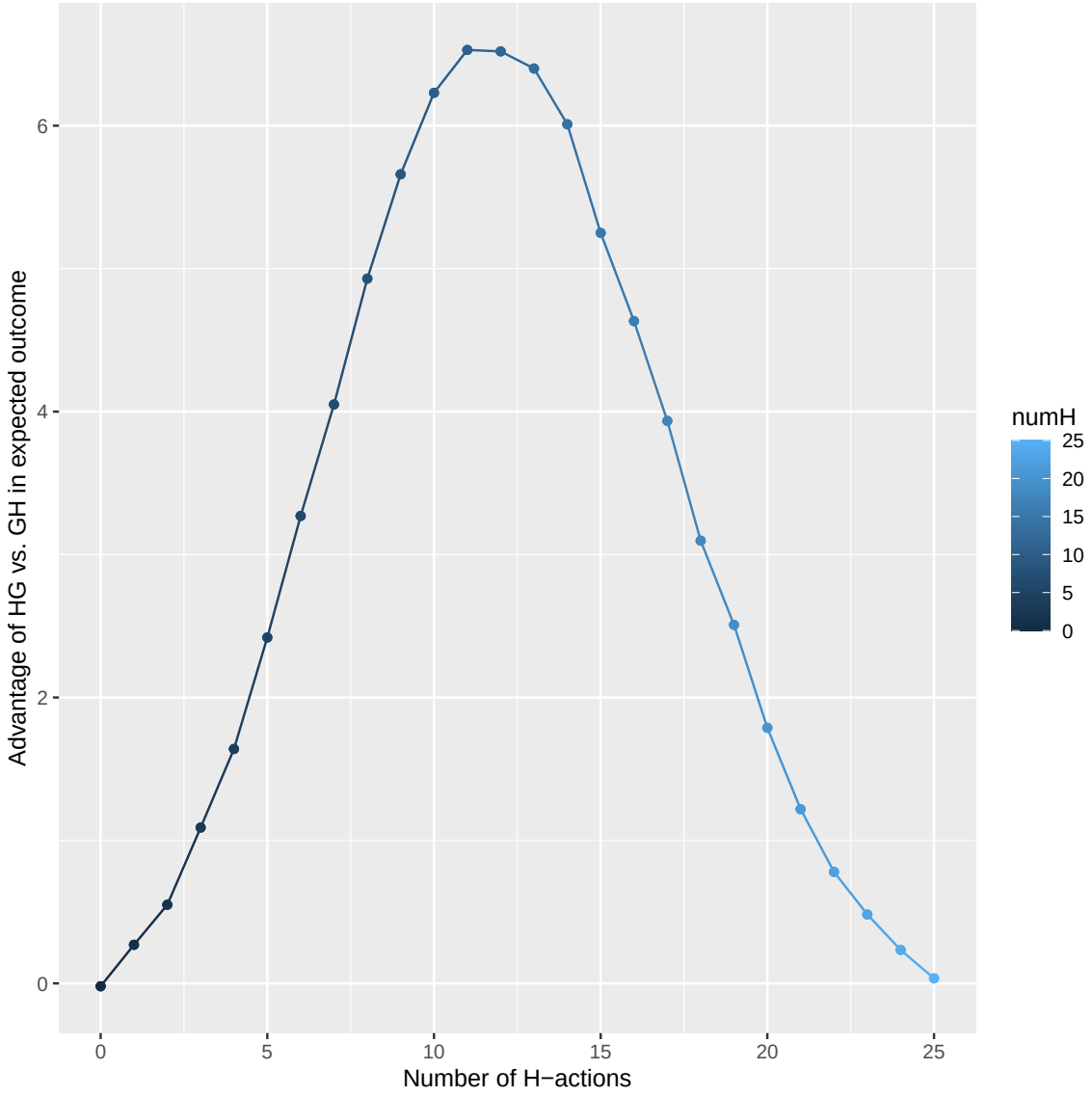

Figure SCR-14

Relative advantage in expected outcome for the HG-strategy compared to the GH-strategy.

Which of the HG-strategies should be considered? Again, a tradeoff analysis helps to organize the results. Figure SCR-15 places all variants in a two-dimensional plot, marking survival rates and expected outcomes: It is evident that strategies with more than 6 H-actions do not qualify as optimal (assuming risk-neutrality or risk-aversion), as expected outcomes fall for higher numbers of H-choices. Again, there is a tradeoff between survival rates and expected outcomes for the range of strategies between 0 and 6 H-actions. With the exception of the (identical) 0H/0%H-strategies, the HG-strategies outperform the fixed-proportion strategies discussed before.

```
dataOptimal=data.frame(
  probBlue=1-saveEndpointsHG,
  expOutc=HGcomp$HG,
  numH=HGcomp$numH
)


shape=data.frame(
  shapex=c(0,0,0.53092,0.57616,0.62007,0.66174,0.70088,
           0.73744,0.77046,0.77046,0),
 shapey=c(0,208.12,208.12,207.42,203.38,195.88,185.03,171.09,
          154.09,0,0)
)

lineshape=data.frame(
    shapex=c(0,0.53092,0.57616,0.62007,0.66174,0.70088,
             0.73744,0.77046,0.77046),
  shapey=c(208.12,208.12,207.42,203.38,195.88,185.03,
           171.09,154.09,0 )
  )


propOptimal=data.frame(
  shapex=c(0.6587,0.71604,0.77050),
  shapey=c(167.15,163.060,154.100)
)

ggplot(data=dataOptimal,aes(x=probBlue,y=expOutc,color=numH))+
  geom_point()+
  scale_color_viridis(option="magma")+
  xlab("Probability of staying blue")+
  ylab("Expected outcome")+
  theme_dark()+
  geom_point(data=propOptimal,aes(x=shapex,y=shapey),
             color="blue",alpha=0.8)+
  annotate("text", x = 0.54092, y = 220, label = "6H",color="white")+
```

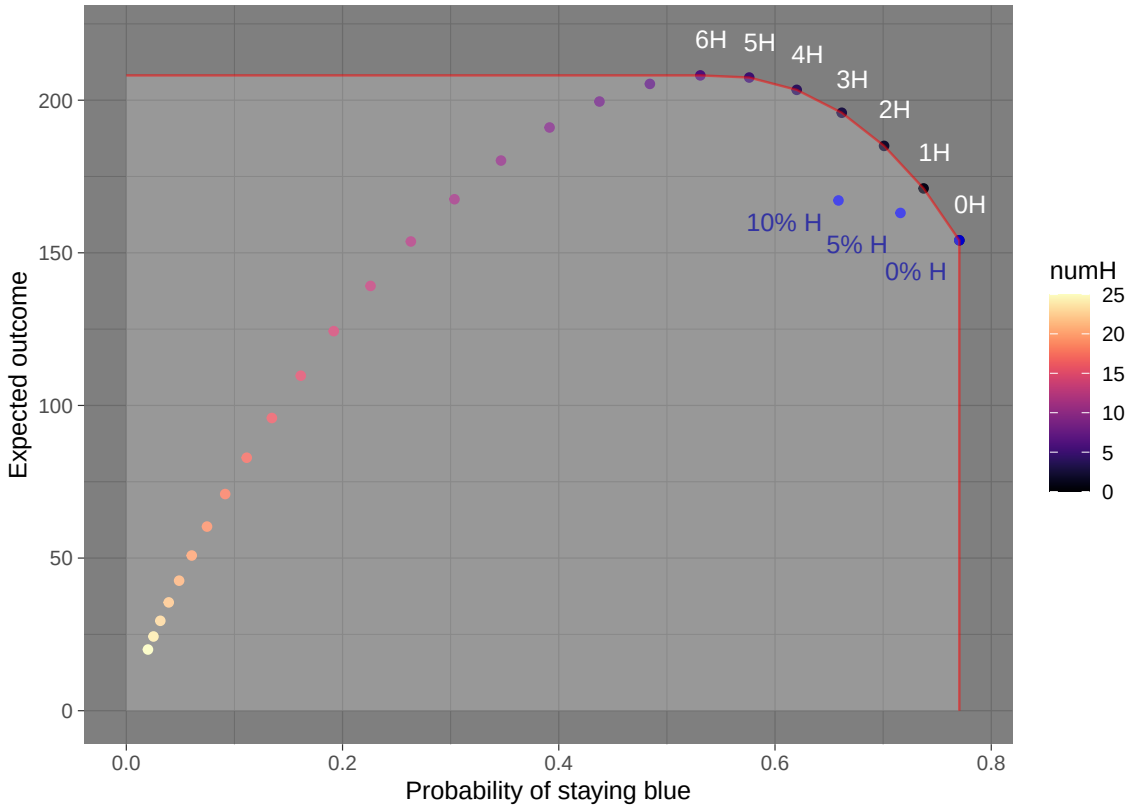

Figure SCR-15

Tradeoff between average survival rate and average outcomes for HG-strategies: Pareto-efficient outcomes and the Pareto frontier are marked are marked, dominated options are in the shaded area. Blue points mark he pareto-efficient subset of fixed-proportion strategies.

```
  annotate("text", x = 0.58616, y = 219, label = "5H",color="white")+
  annotate("text", x = 0.63007, y = 215, label = "4H",color="white")+
  annotate("text", x = 0.67174, y = 207, label = "3H",color="white")+
  annotate("text", x = 0.71088, y = 197, label = "2H",color="white")+
  annotate("text", x = 0.74744, y = 183, label = "1H",color="white")+
  annotate("text", x = 0.78046, y = 166, label = "0H",color="white")+
  annotate("text", x = 0.6087, y = 160, label = "10% H",color="darkblue")+
  annotate("text", x = 0.67604, y = 153, label = "5% H", color="darkblue")+
  annotate("text", x = 0.73050, y = 144, label = "0% H", color="darkblue")+
     geom_polygon(data=shape,aes(x=shapex,y=shapey),fill="white",
                  color="blue",
                  alpha=0.2,linetype="blank")+
  geom_line(data=lineshape,aes(x=shapex,y=shapey),color="red",alpha=0.5)
```

SCR-5 Challengers to the HG-strategy

SCR-5.1 Comparison of infection dynamic between point-equivalent collusive strategies

Here, we compare one of the non-dominated strategies with several competitors that are all characterized by having the same average number of H-actions by each individual in the population (specifically, a total of 500 H-choices across all rounds and individuals). We add two strategies that have an expected total of 505 H-choices, each. The strategies compared here are:

1. HG-5: Collective switch to G-actions after 5 H actions ($100 \cdot 5 = 500$).
2. GH-20: Collective switch to H-actions after 20 G actions ($100 \cdot 5 = 500$).
3. 20% H: a stable proportion of 20% H-players ($20 \cdot 25 = 500$).
4. 0.2pH: a probavbility of $p = 0.2$ to choose H in each round ($100 \cdot 25 \cdot 0.2 = 500$).
5. Stagg5: Five groups of participants make 5 H-choices taking turns, resulting in staggered distribution ($5 \cdot 100 = 500$).
6. Decr11: In round 1 all participants choose H, in each subsequent round 11 participants switch to G for the remainder of the game ($100+89+78+67+56+45+34+23+12+1 = 505$).
7. pDecr.11: In round 1, everyone chooses H with p=1, the probability decreases in each round by .11 (minimum 0; $[1 + 0.89 + 0.78 + 0.67 + 0.56 + 0.45 + 0.34 + 0.23 + 0.12 + 0.01] \cdot 100 = 505$)

All strategies lead to identical (or near-identical) total scores at the end of the game, thus their relative performance depends crucially on the infection rates, while differential survival additionally matters for asymmetric strategies (20%H, for example). Figure SCR-16 shows infection curves throughout the game for the seven strategies.

SCR-5.1.1 Impact on infection rates

```
dataRaw1=read.delim(file="figdata/SwitchHG-6--MeanInfectionRate.txt",
                    header=FALSE,col.names="Outcome")

dataRaw2=read.delim(file="figdata/SwitchGH-21--MeanInfectionRate.txt",
                    header=FALSE,col.names="Outcome")

dataRaw3=read.delim(file="figdata/PropStable-4--MeanInfectionRate.txt",
                    header=FALSE,col.names="Outcome")

dataRaw4=read.delim(file="figdata/PropVariable-4--MeanInfectionRate.txt",
                    header=FALSE,col.names="Outcome")
```

```
dataRaw5=read.delim(
  file="figdata/AllFiveHStaggered-1--MeanInfectionRate.txt",
                   header=FALSE,col.names="Outcome")

dataRaw6=read.delim(file="figdata/DecreaseStab-11--MeanInfectionRate.txt",
                   header=FALSE,col.names="Outcome")

dataRaw7=read.delim(file="figdata/VarDecrease-11--MeanInfectionRate.txt",
                   header=FALSE,col.names="Outcome")


compareData<- data.frame(
  HG5=dataRaw1$Outcome,
  GH20=dataRaw2$Outcome,
  H20perc=dataRaw3$Outcome,
  H02p=dataRaw4$Outcome,
  Stagg5=dataRaw5$Outcome,
  Decr11=dataRaw6$Outcome,
  VDecr11=dataRaw7$Outcome,
  round=c("R00","R01","R02","R03","R04","R05",
          "R06","R07","R08","R09","R10","R11",
          "R12","R13","R14","R15","R16","R17",
          "R18","R19","R20","R21","R22","R23",
          "R24","R25")
)

dataLong<-compareData%>%
gather(key="Condition",value="PercPurple",-round)

dataLong$round<-parse_number(dataLong$round);

dataLong$Condition <- ordered(dataLong$Condition  ,
        levels = c("HG5", "GH20","H20perc","H02p",
                   "Stagg5","Decr11","VDecr11"))

dataLong%>%
ggplot(aes(x=round, y=PercPurple, color=Condition,group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="Strategy",alpha=0.5)
```

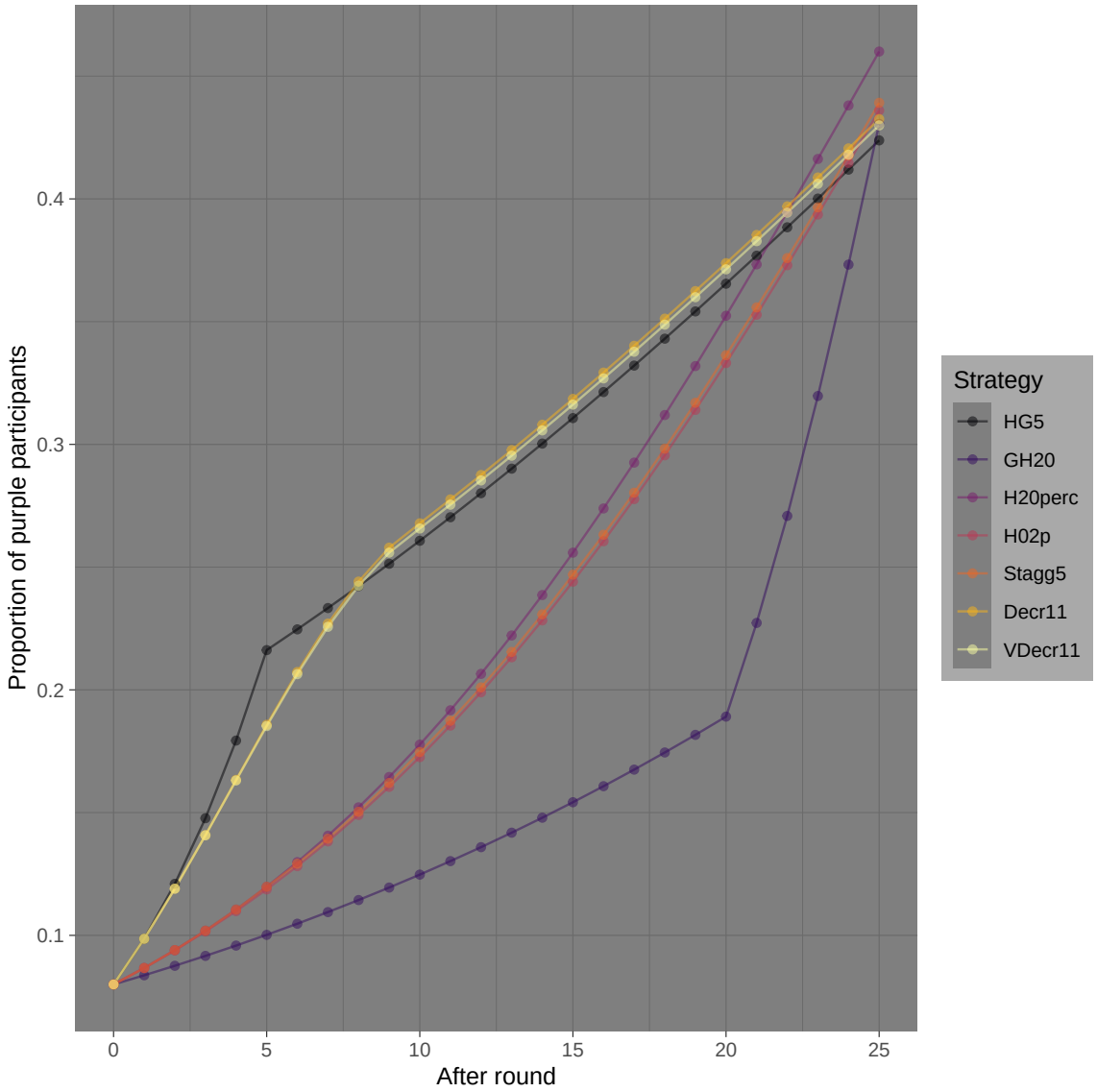

Figure SCR-16

Infection rates for seven strategies with an expected number of 500 (or 505) H-actions for theentire game and population: Points in different colors mark infection rates for different strategies.

By far, the highest infection rates are observed for the fixed proportion of AllH-players (H20perc). All other strategies have a similar final round rate, but reach this state on very different trajectories:

HG5, Decr11, and VDecr11 make H-choices early in the game. The infection rate increases in this phase, and the slope for the remainder of the game is higher than for the other strategies.

In contrast, GH5 does the opposite and waits for the final rounds. While the infection rates are much lower for the phase before, the sharp increase at the end more than outweighs the early advantage. Risky actions have a larger impact, when the number of purple players is higher, and even AllG-strategies see an increase over time.

The other three strategies, H02p, H20perc, and Stagg5, have the same expectation for the number of risky actions in each round. As remarked above, the clustering of H-actions in a subgroup of players leads to an elevated infection rate at the end, staggering or randomly distributing H-actions across participants leads to similar infection rates on average that are slightly higher than those of HG- or GH-populations.

SCR-5.1.2 Impact on expected outcomes

How do these differntial rates trnaslate into expected outcomes? Figure SCR-17 presents the average outcomes relative to the HG5-strategy.

```
dataRaw1=read.delim(file="figdata/SwitchHG-6--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw2=read.delim(file="figdata/SwitchGH-21--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw3=read.delim(file="figdata/PropStable-4--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw4=read.delim(file="figdata/PropVariable-4--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw5=read.delim(file="figdata/AllFiveHStaggered-1--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw6=read.delim(file="figdata/DecreaseStab-11--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")

dataRaw7=read.delim(file="figdata/VarDecrease-11--MeanSumOutcomes.txt",
                    header=FALSE,col.names="Outcome")


compareData<- data.frame(
  HG5=0,
  GH20=dataRaw2$Outcome/100-dataRaw1$Outcome/100,
```

```
  H2Operc=dataRaw3$Outcome/100-dataRaw1$Outcome/100,
  H02p=dataRaw4$Outcome/100-dataRaw1$Outcome/100,
  Stagg5=dataRaw5$Outcome/100-dataRaw1$Outcome/100,
  Decr11=dataRaw6$Outcome/100-dataRaw1$Outcome/100,
  VDecr11=dataRaw7$Outcome/100-dataRaw1$Outcome/100
)

dataLong<-compareData%>%
gather(key="Condition",value="ExpOutcome")

dataLong$Condition <- ordered(dataLong$Condition,
   levels = c("HG5", "GH2O","H2Operc","H02p","Stagg5",
              "Decr11","VDecr11"))
dataLong%>%
ggplot(aes( y=ExpOutcome, fill=Condition,x=Condition))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Strategy")+
  ylab("Expected outcome relative to HG5")+
  scale_fill_viridis_d(option="inferno",name="Strategy")
```

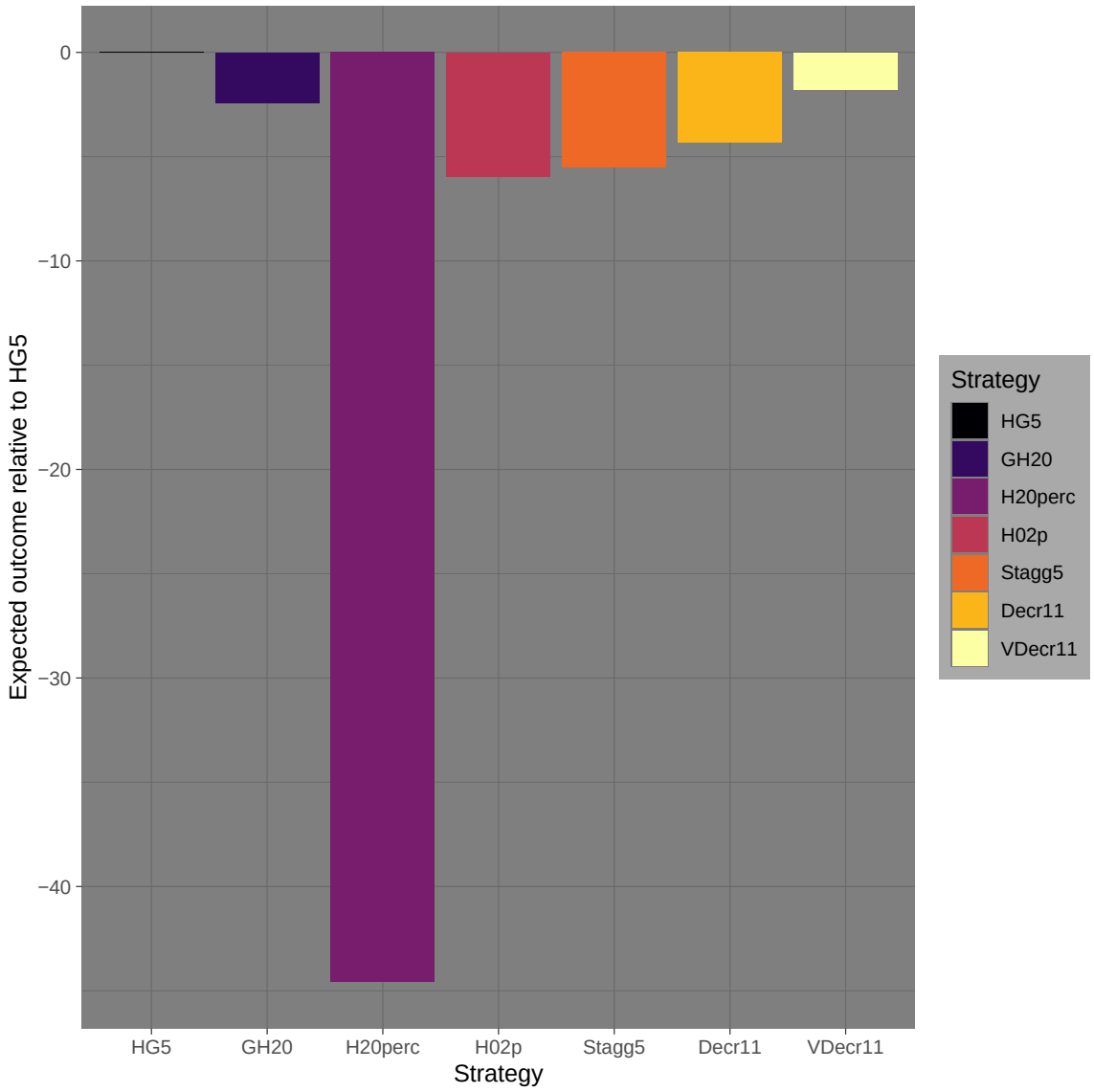

Figure SCR-17

Expected outcomes relative to the expected outcome for the HG5-strategy, based on 1,000,000 simulations for each population type.

No strategy outperforms the HG5-strategy. The HG5-strategy has the lowest infection rate (and therefore, highest survival rate) and the highest expected outcome, thus it dominates all other strategies in terms of the optimality criteria used before.

Strategies focusing risky actions on the early game or the late game perform slightly better than those with steady risky rates. Among those, the fixed proportion of All-H players is least successful.

We consider two results interesting enough for some further exploration: the stark contrast between fixed-percentage and stochastic proportion strategies, and the difference between HG- and GH-strategies.

SCR-5.2 Comparison of infection rates for fixed percentages of H-players and stochastic proportions

Figure SCR-18 shows the results for fixed proportions (already presented above) in direct comparison with those for simulations, where a percentage of H-actions for each individual in each round is systematically varied. At first glance, these two sets of curves look very similar.

```
dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRatePropVariable.txt",
           header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                    "R05","R06","R07","R08","R09",
                                    "R10","R11","R12","R13","R14",
                                    "R15","R16","R17","R18","R19",
                                    "R20","R21","R22","R23","R24",
                                    "R25"))

dataRaw$numH=0:20*5/100;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-numH)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

varProp<-dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=numH,group=numH))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",
                      name="Probability of\n H-actions")

EndStateDynamic=dataRaw$R25
```

```
fixedProp/varProp+
  plot_annotation(tag_levels = 'A')
```

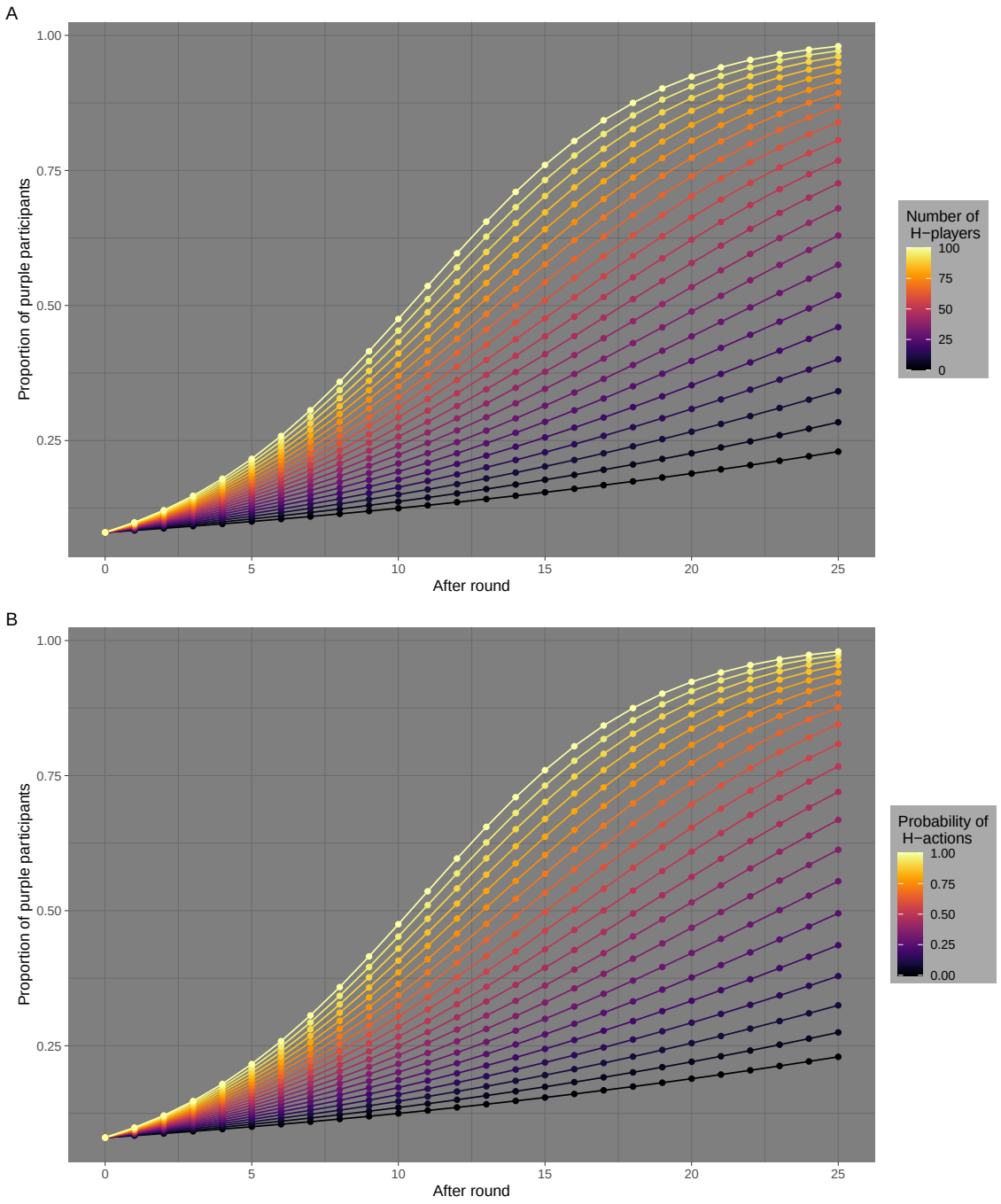

Figure SCR-18

Infection rates for simulations with A) a fixed proportion of AllH-players, and B) a fixed probability of playing H for each player.

Figure SCR-19 plots survival rates (the complement of infection rates after the final round) for both set sof simulations. Results are aligned by the expected number of H-choices.

```
dataRaw1=read.delim(
  file="figdata/SUMMARY--OutcomesconditionalStableProp.txt",
                    header=TRUE)

dataRaw2=read.delim(
  file="figdata/SUMMARY--MeanSumOutcomesPropVariable.txt",
                    header=FALSE,col.names="Outcome")


dataComp=data.frame(
  stableSurv=1-EndStateStable,
  dynSurv=1-EndStateDynamic,
  stableOutc=dataRaw1$AvOut,
  dynOutc=dataRaw2$Outcome/100,
  prop=0:20*0.05
)

dataLong<-dataComp%>%
  select(c(stableSurv,dynSurv,prop))%>%
  rename(
    stable=stableSurv,
    stochastic=dynSurv
  )%>%
gather(key="Condition",value="percPurple",-prop)

dataLong%>%
ggplot(aes(x=prop, y=percPurple, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Proportion/Probability of H-actions")+
  ylab("Proportion of blue participants")+
  scale_color_viridis_d(option="inferno",
                        name="Strategy",alpha=0.5)
```

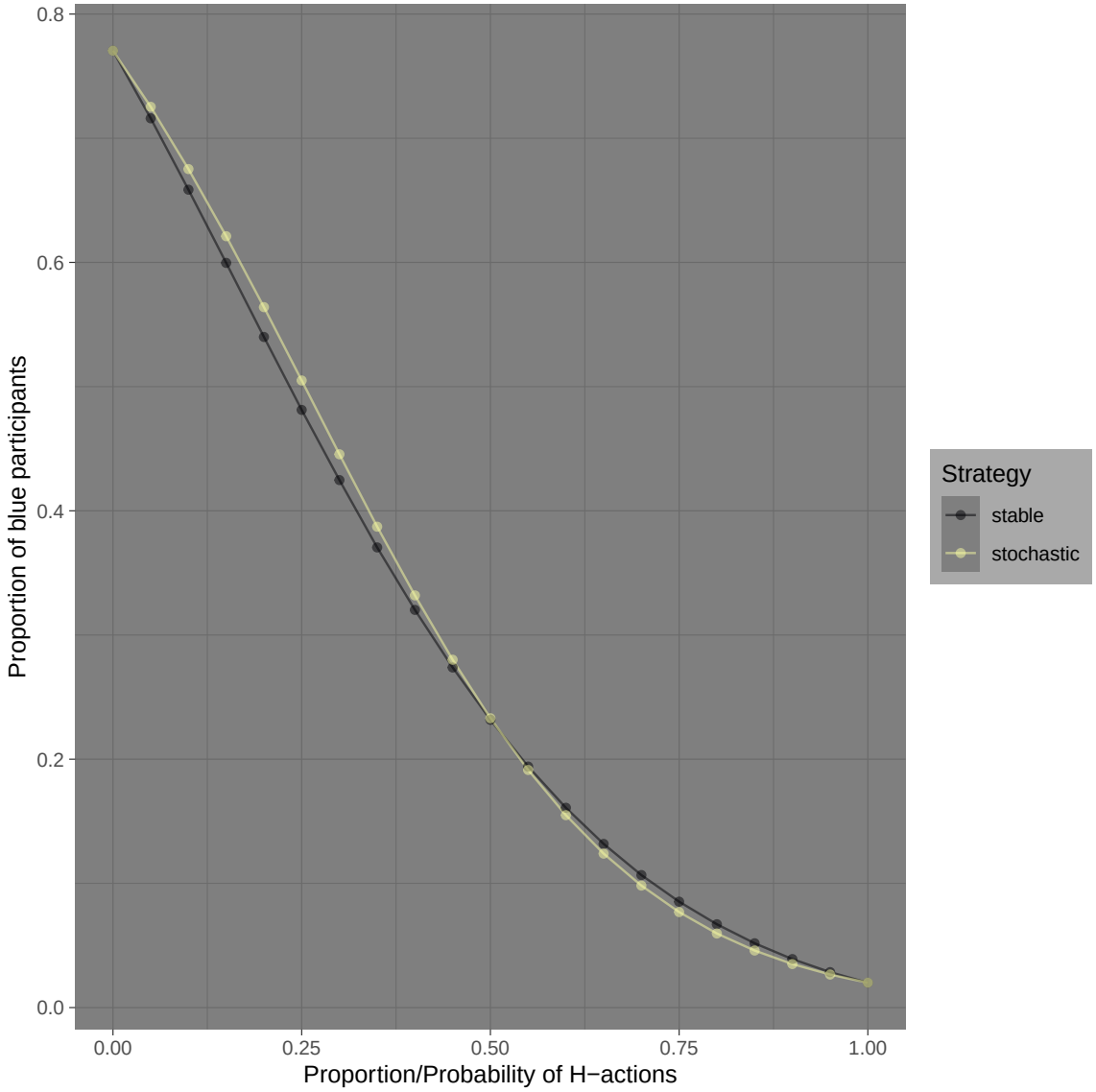

Figure SCR-19

Comparison of survival rates as a function of the relative frequency of H-chocices.

This corroborates the impression that infection rates are very similar in both strategies. Stable percentages show slighly higher rates when the majority of actions are H-choices, and slightly lower rates when the majority of chocies are G-choices. Survival rates alone cannot explain the difference outcomes observed int eh example. Figure SCR-20 presents an extended comparison of outcomes.

```
dataLong<-dataComp%>%
  select(c(stableOutc,dynOutc,prop))%>%
  rename(
    stable=stableOutc,
    stochastic=dynOutc
  )%>%
gather(key="Condition",value="expOutcome",-prop)

dataLong%>%
ggplot(aes(x=prop, y=expOutcome, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Proportion/Probability of H-actions")+
  ylab("Expected outcome")+
  scale_color_viridis_d(option="inferno",name="Strategy",
                        alpha=0.5)
```

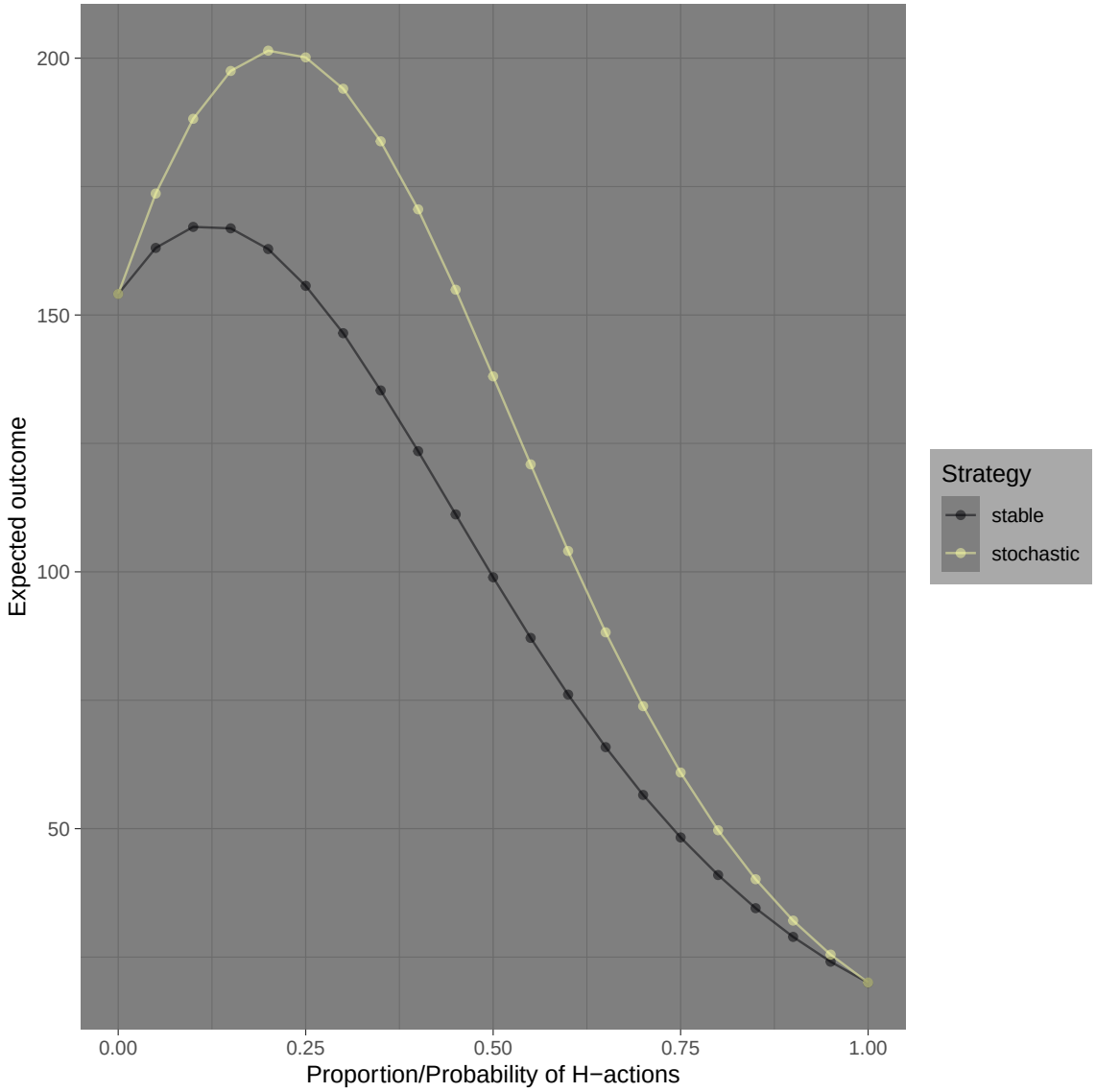

Figure SCR-20

Comparison of expected outcomes as a function of the relative frequency of H-chocices.

Indeed, the stochastic strategy systemtically outperforms the stable strategy. The solution to this puzzlehas already been presented in Figure SCR-7. The infection risk asymmetrically affects risky players. Thus, more AllH-players than AllG-players end the game with a final outcome of 0. The score-benefits of H-actions are likewise stacked towards AllH-players. Thus, even with similar overall infection rates, more points are voided in the fixed-percentage simulations than in the variable-probability simulations.

SCR-6 A robustness check for differences between HG and GH strategies

SCR-6.1 Rationale for comparison

We have observed a distinct advantage for HG-strategies against GH-strategies, but the differences were relatively small. Here, we try to illuminate some factors that might impact the relative performance. The previous simulations assumed perfect collaboration between all participants. Here, we investigate what happens, when part of the population does not collude, but insists on different behavior. We consider two scenarios:

1. 5 participants play AllH-strategies, while the other 95 participants try to find the collusive optimum
2. 5 participants play AllG-strategies, while the other 95 participants try to find the collusive optimum

As a second type of variation, we introduce exogenous risk increase into the simulation: HG-strategies and GH-strategies share the total number of H-choices. Here, we introduce a roundwise-risk that is independent from actions. After each round, there is a chance of $p = 0.01$ that a healthy individual becomes infected.

SCR-6.2 Results for HG-strategies

First, we simulated sets of games for populations following the HG-strategy, In two of these sets, five players were replaced by AllH- or AllG-players for all switching points, in the third set, the exogenous risk was introduced. Roundwise results for all conditions are shown in Figure SCR-21.

```
dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateHGBut5H.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))

dataRaw$switchAfter=0:25;

dataLong<-dataRaw%>%
```

```
gather(key="AfterRound",value="PercPurple",-switchAfter)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

plotSwitch5H <-dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=switchAfter,
           group=switchAfter))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch to G after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="G after\n round")+
 ggtitle("5 AllH-players")



saveEndpointsHGbut5H=dataRaw$R25

dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateHGBut5G.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataRaw$switchAfter=0:25;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-switchAfter)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

plotSwitch5G <-dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=switchAfter,
           group=switchAfter))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch to G after round")+
```

```
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="G after\n round")+
  ggtitle("5 AllG-players")


saveEndpointsHGbut5G=dataRaw$R25

dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateHGOnePerc.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$switchAfter=0:25;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-switchAfter)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

plotSwitchOnePerc <-dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=switchAfter,
           group=switchAfter))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch to G after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis(option="inferno",name="G after\n round")+
  ggtitle("1\\% roundwise risk")


saveEndpointsHGonePerc=dataRaw$R25


plotSwitch5H /
plotSwitch5G /
plotSwitchOnePerc+
  plot_annotation(tag_levels = 'A')
```

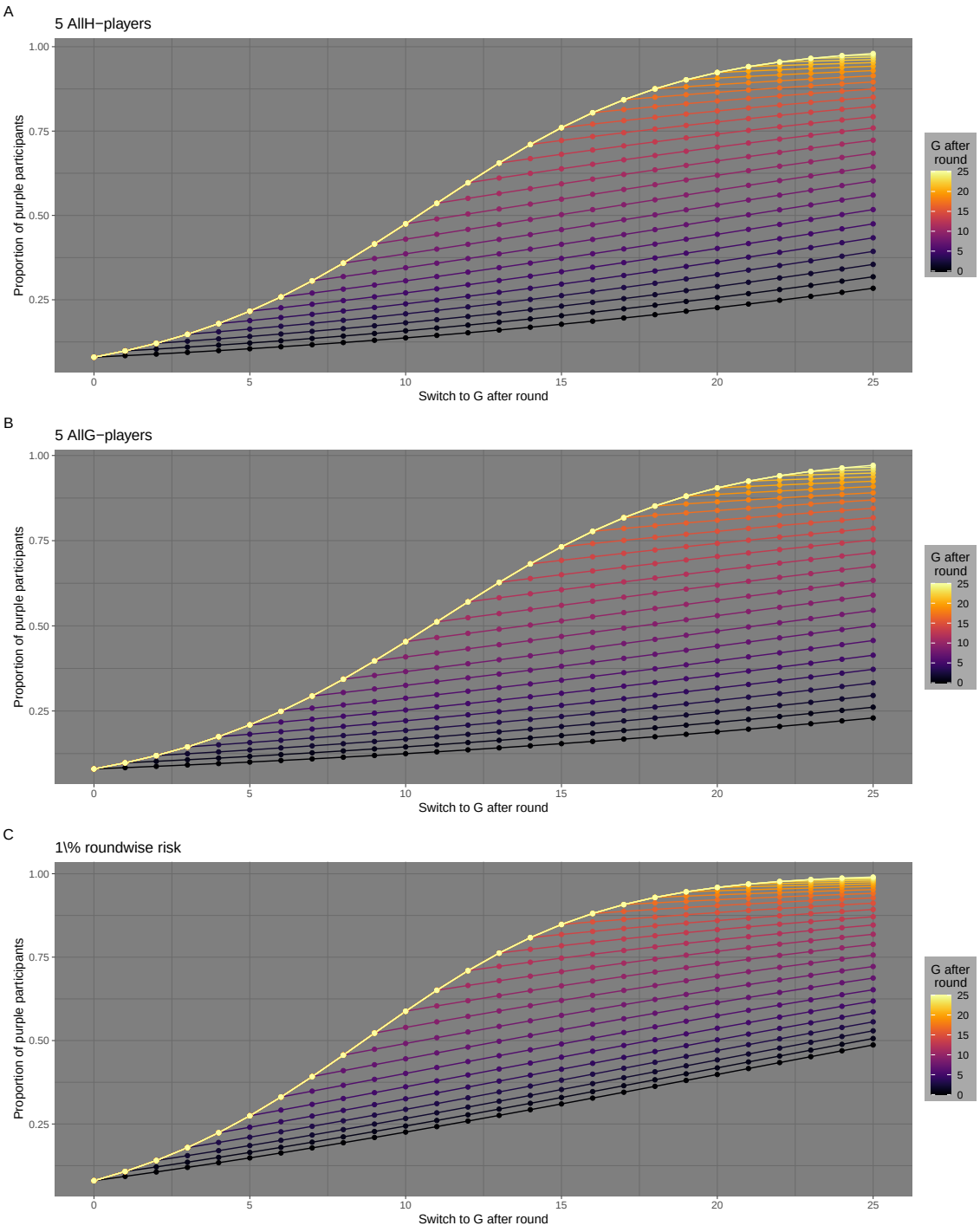

Figure SCR-21

Roundwise infection rates for three variations of the HG-strategies with all possible siwtching points: Infection rates are shown for A) games with five AllH-players, B) games with five AllG-players, C) games with an additional 1% chance of switching to purple after each round.

To compare these results with each other and the original variant with 100 players following the HG-strategy, the resulting final infection rates (depending on the switching point from H to G) are plotted in one diagram in Figure SCR-22.

```
compareHG=data.frame(
  HG=saveEndpointsHG,
  HGfiveH=saveEndpointsHGbut5H,
  HGfiveG=saveEndpointsHGbut5G,
  HGonePerc=saveEndpointsHGonePerc,
  switchAfter=0:25
)

dataLong<-compareHG%>%
gather(key="Condition",value="PercPurple",-switchAfter)


dataLong$Condition <- ordered(dataLong$Condition,
                              levels = c("HG", "HGfiveH",
                                         "HGfiveG","HGonePerc"))

dataLong%>%
ggplot(aes(x=switchAfter, y=PercPurple, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="Strategy",alpha=0.5)
```

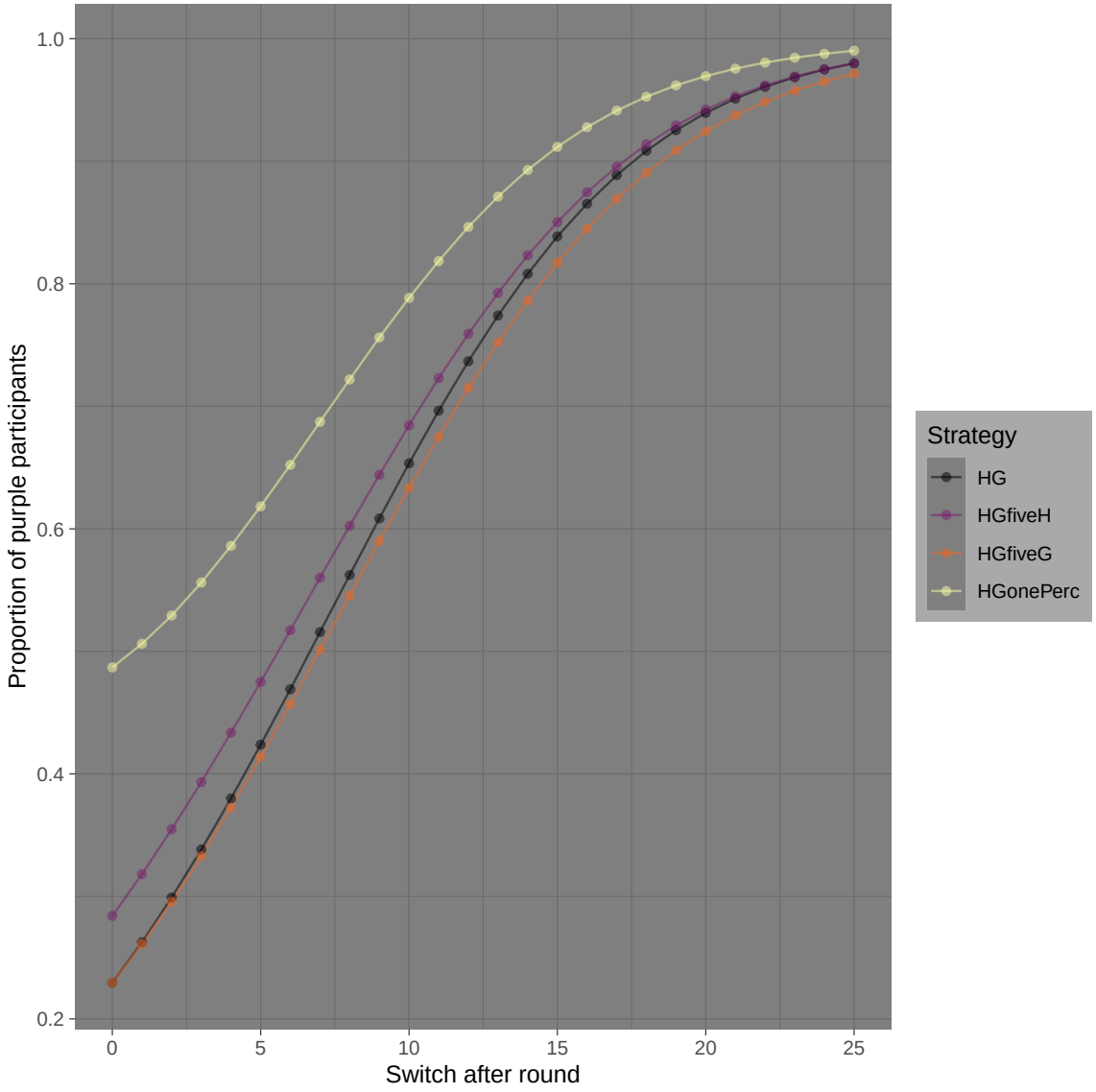

Figure SCR-22

Infection rates for each possible switching points for populations following the HG-strategy.

It is evident, that the introduction of the exogenous risk leads to increased infection rates. The difference is naturally larger, when the number of risky actions is low (i.e., for early switching points). The introduction of AllG-players does not matter for a swithcing point at 0, and the introduction of AllH-players is without consequence for a switching point at 25. In between, the original scenario falls in between the FiveG and FiveH variants. One concern might be that the latter two condition contain players that do not participate in the collusive strategy. Thus, we show the infection rates restricted to players following the HG-strategy in Figure SCR-23.

```
dataRaw1=read.delim(
  file="figdata/SUMMARY--MeanConditionalHGBut5H.txt",
                    header=FALSE,col.names=c("countH","countS","countF",
                                             "countG","survH","survS",
                                             "survF","survG","expH",
                                             "expS","expF","expG"))


dataRaw2=read.delim(
  file="figdata/SUMMARY--MeanConditionalHGBut5G.txt",
                    header=FALSE,col.names=c("countH","countS","countF",
                                             "countG","survH","survS",
                                             "survF","survG","expH",
                                             "expS","expF","expG"))


saveEndpointsHGbut5H <- c(1-dataRaw1$survG[1],1-dataRaw1$survF[2:25],
                          1-dataRaw1$survH[26])
saveEndpointsHGbut5G <- c(1-dataRaw2$survG[1],1-dataRaw2$survF[2:25],
                          1-dataRaw2$survH[26])

saveOutcomeHGbut5H <- c(dataRaw1$expG[1],dataRaw1$expF[2:25],
                        dataRaw1$expH[26])
saveOutcomeHGbut5G <- c(dataRaw2$expG[1],dataRaw2$expF[2:25],
                        dataRaw2$expH[26])

compareHG=data.frame(
  HG=saveEndpointsHG,
  HGfiveH=saveEndpointsHGbut5H,
  HGfiveG=saveEndpointsHGbut5G,
  HGonePerc=saveEndpointsHGonePerc,
  switchAfter=0:25
)

dataLong<-compareHG%>%
gather(key="Condition",value="PercPurple",-switchAfter)
```

```
dataLong$Condition <- ordered(dataLong$Condition  ,
                             levels = c("HG", "HGfiveH",
                                        "HGfiveG","HGonePerc"))

dataLong%>%
ggplot(aes(x=switchAfter, y=PercPurple, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Switch after round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="Strategy",
                        alpha=0.5)
```

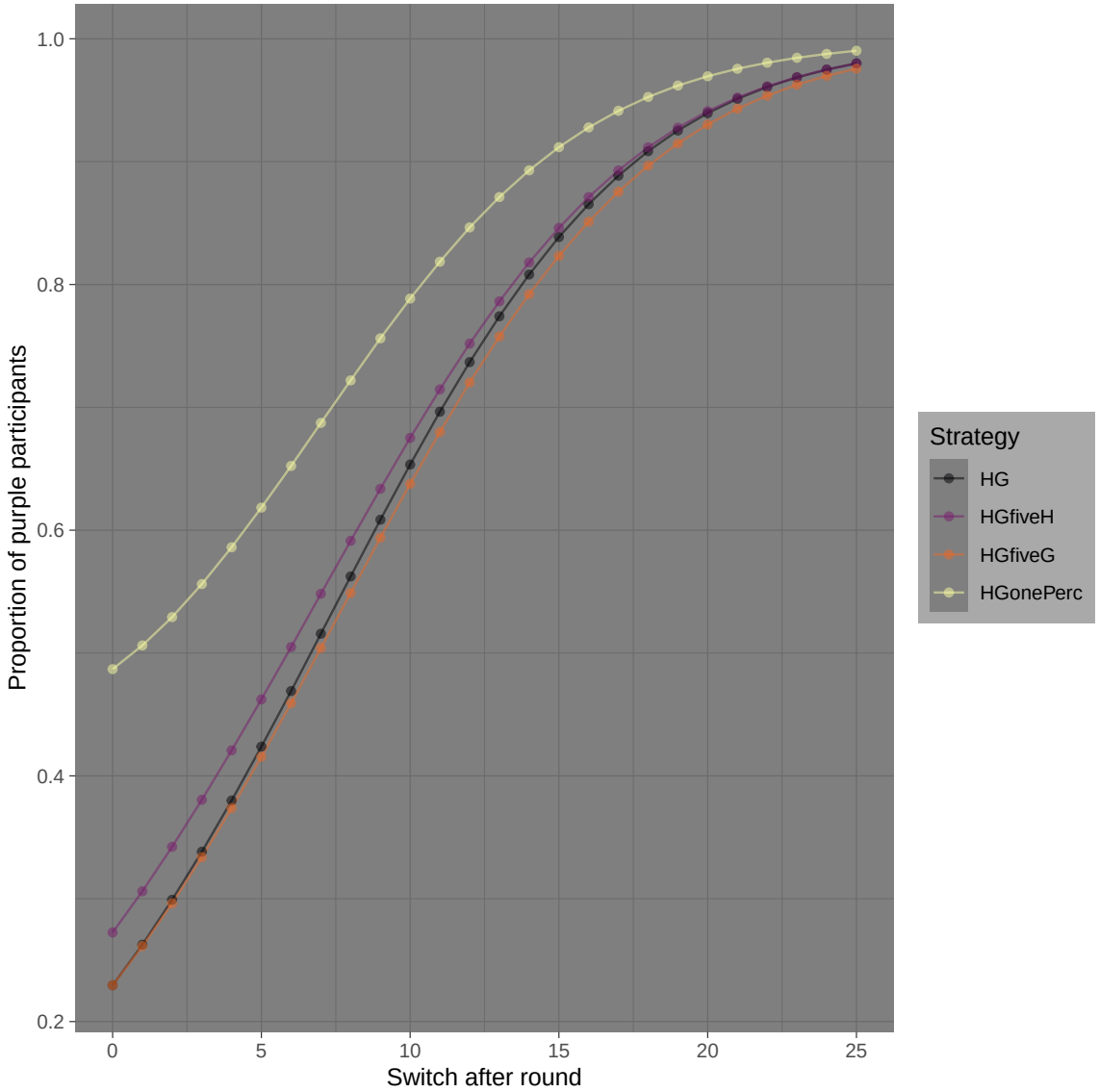

Figure SCR-23

Infection rates for each possible switching points for populations following the HG-strategy, not considering the introduced AllG-players or AllH-players.

Results are hard to distinguish from the previous version, end points for HGfiveH and HGfiveG are somewhat closer together.

Here, an increase in switching points corresponds to a decrease in total H-actions, thus curves are downward-sloping. Otherwise, the general pattern corresponds to the previously found one for HG-strategies. Due to the increase in accumulated points, there is no linear relations between infection rates and outcomes, the expected outcomes are shown in Figure SCR-24.

```
dataRaw1=read.delim(
  file="figdata/SUMMARY--MeanSumOutcomesHG.txt",
                    header=FALSE,col.names=c("expOutcome"))

dataRaw2=read.delim(
  file="figdata/SUMMARY--MeanSumOutcomesHGOnePerc.txt",
                    header=FALSE,col.names=c("expOutcome"))


compareHGOut=data.frame(
  HG=dataRaw1$expOutcome/100,
  HGfiveH=saveOutcomeHGbut5H,
  HGfiveG=saveOutcomeHGbut5G,
  HGonePerc=dataRaw2$expOutcome/100,
  switchAfter=0:25
)

dataLong<-compareHGOut%>%
gather(key="Condition",value="expOutcome",-switchAfter)


dataLong$Condition <- ordered(dataLong$Condition  ,
                              levels = c("HG", "HGfiveH",
                                         "HGfiveG","HGonePerc"))

dataLong%>%
ggplot(aes(x=switchAfter, y=expOutcome, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Expected Outcome")+
  scale_color_viridis_d(option="inferno",name="Strategy",
                        alpha=0.5)
```

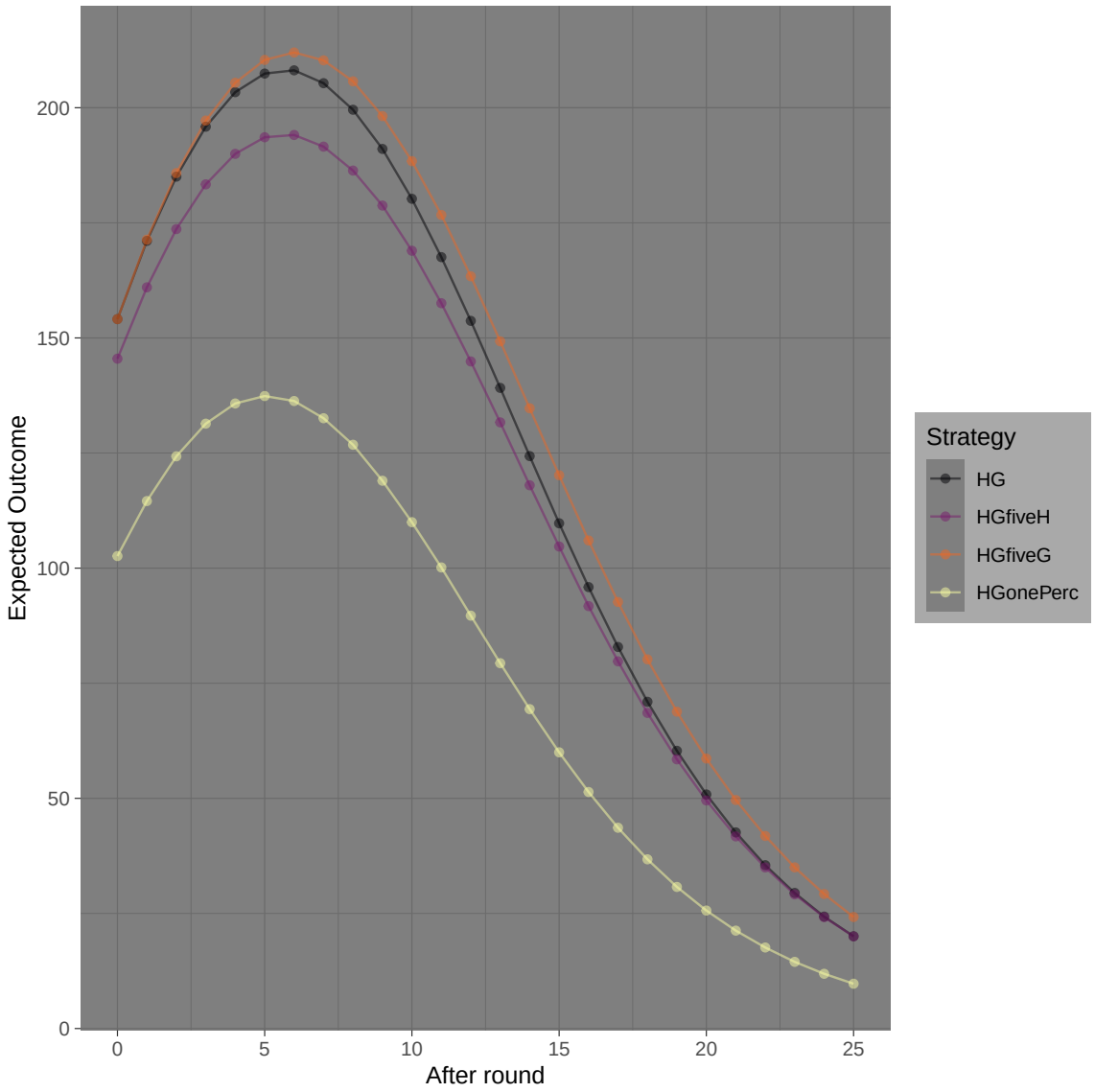

Figure SCR-24

Expected outcomes for each possible switching points for populations following the HG-strategy, not considering the introduced AllG-players or AllH-players.

The maximum expected outcome is reached at five or six H-actions, the increased risk in the OnePercent environment reduced the maximum to 5. Otherwise, the curves follow a similar pattern.

The same analysis can be done for populations following the GH-strategy. Here, we only show the results corresponding those in Figure SCR-23. These are presented in Figure SCR-24.

```
dataRaw1=read.delim(
  file="figdata/SUMMARY--MeanConditionalGHBut5H.txt",
                   header=FALSE,col.names=c("countH","countS","countF",
                                            "countG","survH","survS",
                                            "survF","survG","expH",
                                            "expS","expF","expG"))


dataRaw2=read.delim(
  file="figdata/SUMMARY--MeanConditionalGHBut5G.txt",
                   header=FALSE,col.names=c("countH","countS","countF",
                                            "countG","survH","survS",
                                            "survF","survG","expH",
                                            "expS","expF","expG"))

saveEndpointsGHbut5H <- c(1-dataRaw1$survH[1],1-dataRaw1$survS[2:25],
                          1-dataRaw1$survG[26])
saveEndpointsGHbut5G <- c(1-dataRaw2$survH[1],1-dataRaw2$survS[2:25],
                          1-dataRaw2$survG[26])

saveOutcomeGHbut5H <- c(dataRaw1$expH[1],dataRaw1$expS[2:25],
                        dataRaw1$expG[26])
saveOutcomeGHbut5G <- c(dataRaw2$expH[1],dataRaw2$expS[2:25],
                        dataRaw2$expG[26])



dataRaw=read.delim(
  file="figdata/SUMMARY--MeanInfectionRateGHOnePerc.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

saveEndpointsHGonePerc=dataRaw$R25
```

```
compareGH=data.frame(
  GH=saveEndpointsGH,
  GHfiveH=saveEndpointsGHbut5H,
  GHfiveG=saveEndpointsGHbut5G,
  GHonePerc=saveEndpointsHGonePerc,
  switchAfter=0:25
)

dataLong<-compareGH%>%
gather(key="Condition",value="PercPurple",-switchAfter)


dataLong$Condition <- ordered(dataLong$Condition  ,
                              levels = c("GH", "GHfiveH",
                                         "GHfiveG","GHonePerc"))

dataLong%>%
ggplot(aes(x=switchAfter, y=PercPurple, color=Condition,
           group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="Strategy",
                        alpha=0.5)
```

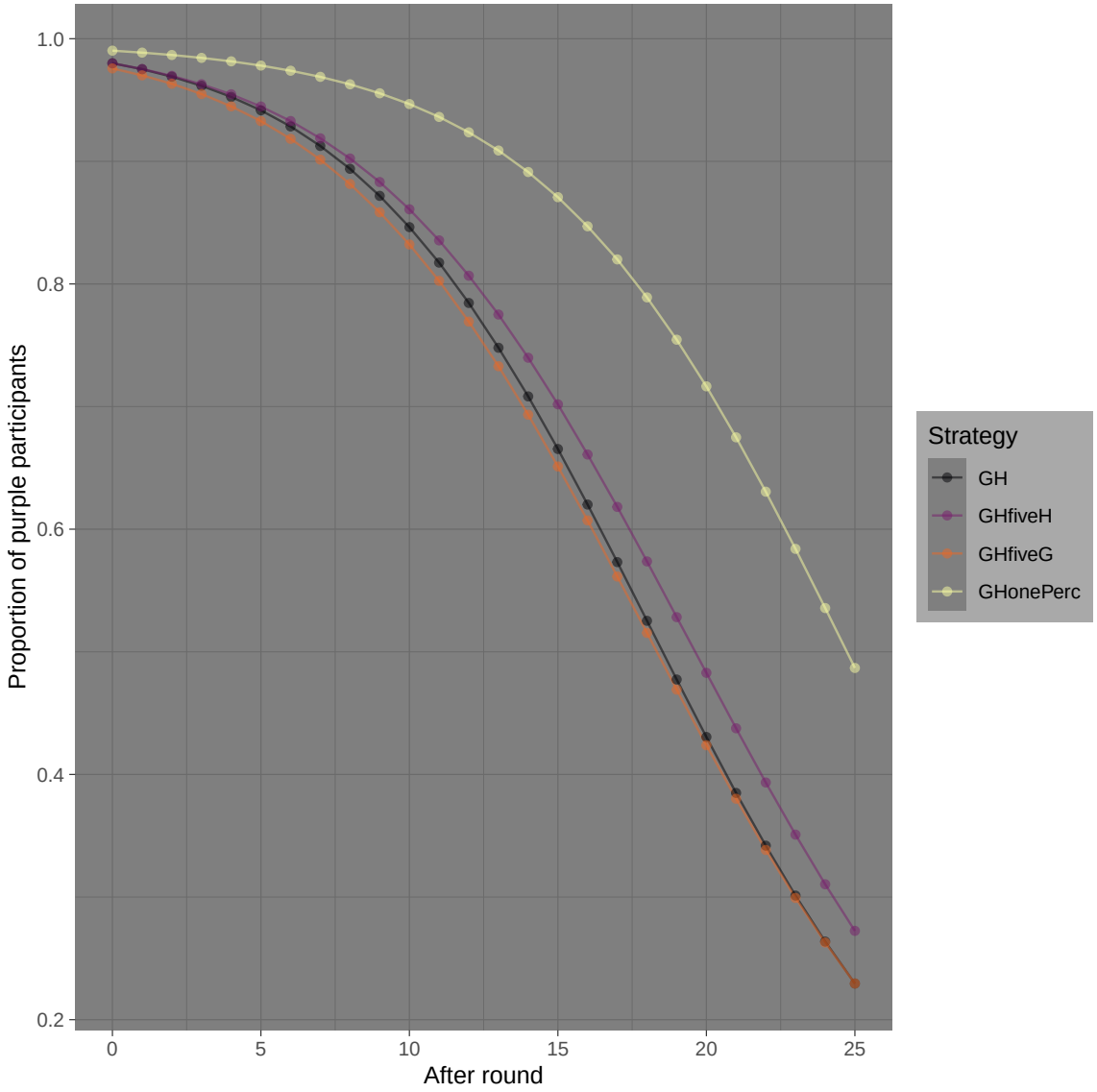

Figure SCR-25

Infection rates for each possible switching points for populations following the GH-strategy, not considering the introduced AllG-players or AllH-players.

Inverting the x-axis allows for a direct comparison between the two strategies, as this maps populations with the same number of H-actions. Again, we plot a comparison of outcome between populations fpollowign the HG-switching pattern and populations following the GH-switchign pattern in Figure SCR-26.

```
dataRaw1=read.delim(file="figdata/SUMMARY--MeanSumOutcomesGH.txt",
                    header=FALSE,col.names=c("expOutcome"))

dataRaw2=read.delim(file="figdata/SUMMARY--MeanSumOutcomesGHOnePerc.txt",
                    header=FALSE,col.names=c("expOutcome"))


compareGHout=data.frame(
  GH=dataRaw1$expOutcome/100,
  GHfiveH=saveOutcomeGHbut5H,
  GHfiveG=saveOutcomeGHbut5G,
  GHonePerc=dataRaw2$expOutcome/100,
  switchAfter=0:25
)


compareAdvantageOut=data.frame(
  standard=-rev(compareGHout$GH)+compareHGOut$HG,
  FiveH=-rev(compareGHout$GHfiveH)+compareHGOut$HGfiveH,
  FiveG=-rev(compareGHout$GHfiveG)+compareHGOut$HGfiveG,
  OnePerc=-rev(compareGHout$GHonePerc)+compareHGOut$HGonePerc,
  numH=0:25

)


dataLong<-compareAdvantageOut%>%
gather(key="Condition",value="PercPurple",-numH)


dataLong$Condition <- ordered(dataLong$Condition  ,
                              levels = c("standard", "FiveH","FiveG","OnePerc"))

plotOutc <- dataLong%>%
ggplot(aes(x=numH, y=PercPurple, color=Condition,group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Number of H choices")+
```

```
  ylab(expression(paste(Delta," expected outcome (HG-GH)")))+
  scale_color_viridis_d(option="inferno",name="Strategy",alpha=0.5)+
  ggtitle("Outcomes")


#Note: the difference in purple is also the difference in blue participants
# Results are reported in terms of additional blue partcipant proportion for HG
compareAdvantage=data.frame(
  standard=rev(compareGH$GH)-compareHG$HG,
  FiveH=rev(compareGH$GHfiveH)-compareHG$HGfiveH,
  FiveG=rev(compareGH$GHfiveG)-compareHG$HGfiveG,
  OnePerc=rev(compareGH$GHonePerc)-compareHG$HGonePerc,
  numH=0:25

)


dataLong<-compareAdvantage%>%
gather(key="Condition",value="PercPurple",-numH)


dataLong$Condition <- ordered(dataLong$Condition  ,
                              levels = c("standard", "FiveH","FiveG",
                                         "OnePerc"))

plotPerc<- dataLong%>%
ggplot(aes(x=numH, y=PercPurple, color=Condition,group=Condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Number of H choices")+
  ylab(expression(paste(Delta,
                        " proportion of blue participants (HG-GH)")))+
  scale_color_viridis_d(option="inferno",name="Strategy",alpha=0.5)+
  ggtitle("Survival rate")

plotPerc/plotOutc+
  plot_annotation(tag_levels = 'A')
```

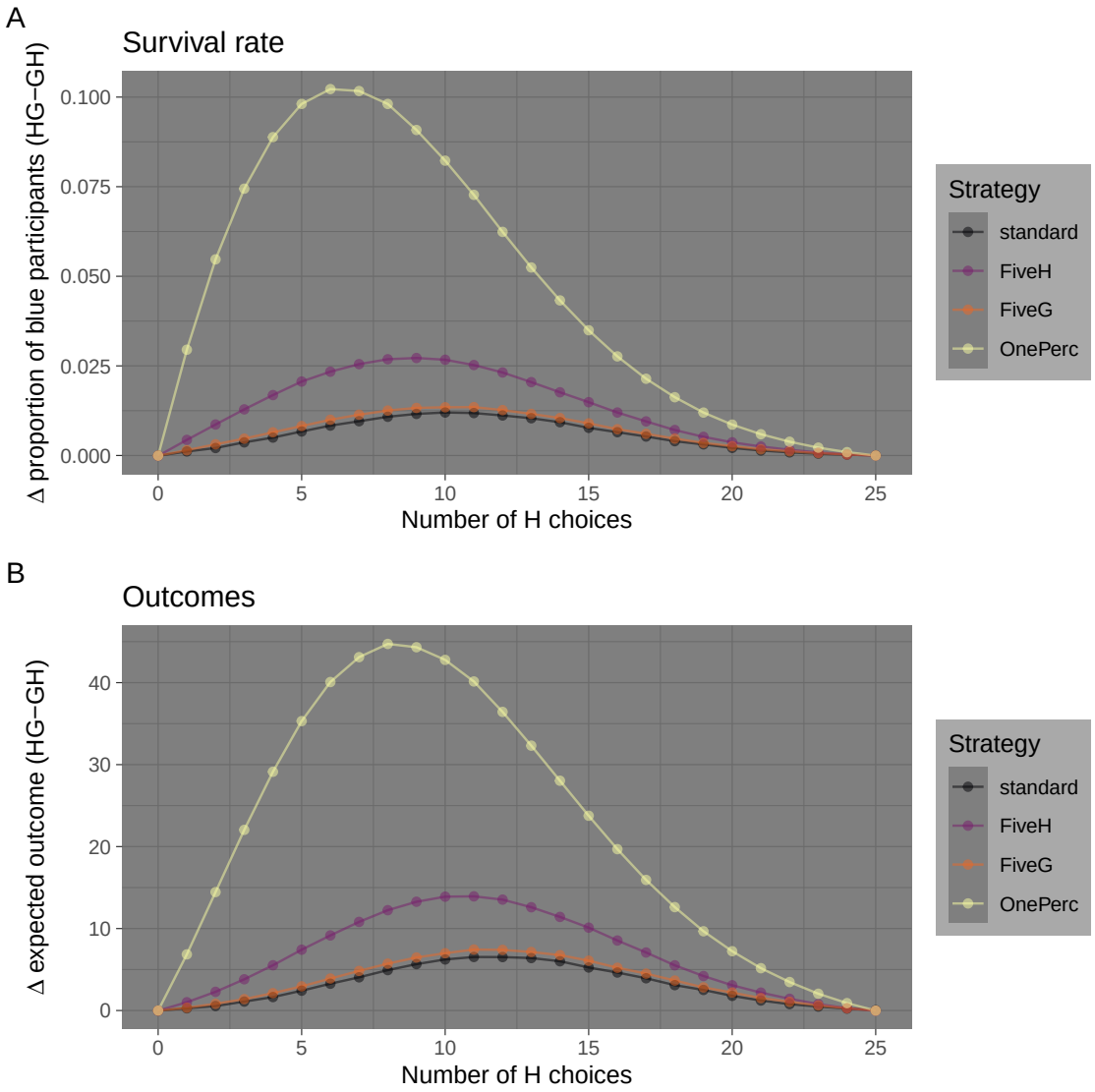

Figure SCR-26

Difference in A) Survival rates and B) expected outcomes between HG-populations and GH-populations: Each point corresponds to the difference between simulation results for the equivalent number of H-chocies in both populations. All results ignore additional participants not following the switchign strategy.

It is apparent at first glance, that the shape of the lines are identical between the two figures. This is not surprising, as all population members score the same number of points in the game and survival translates into expected outcomes. Ccomparing the conditions, it can be observed that in every variant the differences between HG and GH are more pronounced than in the situation of universal rule-following without external risk. Thus, the superiority of HG-switching compared to GH-switching becomes even more pronounced under these conditions. Additional risk has a larger effect on this difference than the addition of cooperative population members. Adding risky behaviuor creates a sharper differential between earlier and later game stages in terms of potential transmission of color changes.

This concludes the theoretical analysis of game results and it can serve as a frame for evaluating actual game behavior and projected results.

SCR-7 Simulations based on empirical data

In Study 2, We observed six groups of 100 participants each, who made 25 choices throughout their games. Based on the 2500 responses for each group, we simulated 1,000,000 games to explore the possible consequences of their actions. Note that this was independent of the simulations run to determine monetary payments: We ran each simulation only once– in accordance with the procedure explained to participants and the incentives described in the instructions.

The following chunk contains multiple calculations to construct a figure panel (see Fig.SCR-27 including the distribution of observed roundwise infection rates, mean infection rates, and expected outcomes by condition. Note that mean results can be measured quite precisely with a million games and visible differences can be interpreted as significant differences (based on repeated simulations of the game with the given responses).

```
sintervals=c(0.1,0.25,0.67,0.95)
slabels=c("10%","25%","67%","95%")
measures=c(2.5,50,97.5)
#study 2

dataRaw=read.delim(
  file="figdata/Study2-1----HalfPercentileInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)
```

```
dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_1 <- dataRaw$R25[1+measures/0.5]

study2_1 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Chain reaction (CHN)")


dataRaw=read.delim(
  file="figdata/Study2-2----HalfPercentileInfectionRate.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_2 <- dataRaw$R25[1+measures/0.5]
```

```
study2_2 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position="left")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Control (CON)")



dataRaw=read.delim(
  file="figdata/Study2-3----HalfPercentileInfectionRate.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_3 <- dataRaw$R25[1+measures/0.5]


study2_3 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
```

```
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Descriptive norms (DES)")


dataRaw=read.delim(
  file="figdata/Study2-4----HalfPercentileInfectionRate.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_4 <- dataRaw$R25[1+measures/0.5]


study2_4 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
```

```
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Injunctive norms (INJ)")

dataRaw=read.delim(
  file="figdata/Study2-5----HalfPercentileInfectionRate.txt",
                  header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                           "R05","R06","R07","R08","R09",
                                           "R10","R11","R12","R13","R14",
                                           "R15","R16","R17","R18","R19",
                                           "R20","R21","R22","R23","R24",
                                           "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_5 <- dataRaw$R25[1+measures/0.5]


study2_5 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
```

```
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Simulator (SIM)")

dataRaw=read.delim(
  file="figdata/Study2-6----HalfPercentileInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalState2_6 <- dataRaw$R25[1+measures/0.5]

study2_6 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                     quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
```

```
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Vicarious learning (VIC)")

dataRaw1=read.delim(
  file="figdata/Study2-1--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))
dataRaw2=read.delim(file="figdata/Study2-2--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))
dataRaw3=read.delim(file="figdata/Study2-3--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))
dataRaw4=read.delim(file="figdata/Study2-4--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))
dataRaw5=read.delim(file="figdata/Study2-5--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))
dataRaw6=read.delim(file="figdata/Study2-6--MeanInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
```

```
                                                "R10","R11","R12", "R13","R14",
                                                "R15","R16","R17","R18","R19",
                                                "R20","R21","R22","R23","R24",
                                                "R25"))


allData=rbind(dataRaw1,dataRaw2,dataRaw3,dataRaw4,dataRaw5,dataRaw6)

allData$condition=c("CHN","CON","DES","INJ","SIM","VIC")

allData$condition<-factor(allData$condition,levels=c("CON","DES","VIC",
                                                     "SIM","CHN","INJ"))

dataLong<-allData%>%
gather(key="AfterRound",value="PercPurple",-condition)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

compPlot1 <- dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=condition,
           group=condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="condition")+
  ggtitle("Study 2: all conditions")


dataRaw1=read.delim(file="figdata/Study2-1--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw2=read.delim(file="figdata/Study2-2--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw3=read.delim(file="figdata/Study2-3--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw4=read.delim(file="figdata/Study2-4--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw5=read.delim(file="figdata/Study2-5--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw6=read.delim(file="figdata/Study2-6--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
```

```
allData=rbind(dataRaw1,dataRaw2,dataRaw3,dataRaw4,dataRaw5,dataRaw6)
allData$Outcome<-(allData$Outcome-replicate(6,dataRaw2$Outcome))/100

allData$condition=c("CHN","CON","DES","INJ","SIM","VIC")

allData$condition<-factor(allData$condition,levels=c("CON","DES","VIC",
                                                     "SIM","CHN","INJ"))



compPlot2 <- allData%>%
ggplot(aes(x=condition, y=Outcome,fill=condition))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Condition")+
  ylab("Average expected outcome relative to CON")+
  scale_fill_viridis_d(option="inferno")+
   annotate("segment",x=0.6,xend=1.4,y=0,yend=0)+
  ggtitle("Study 2: all conditions")



(compPlot1|compPlot2) /
(study2_2 | study2_3 | study2_6) /
 (study2_1 | study2_5 | study2_4) +
   plot_annotation(tag_levels = 'A')
```

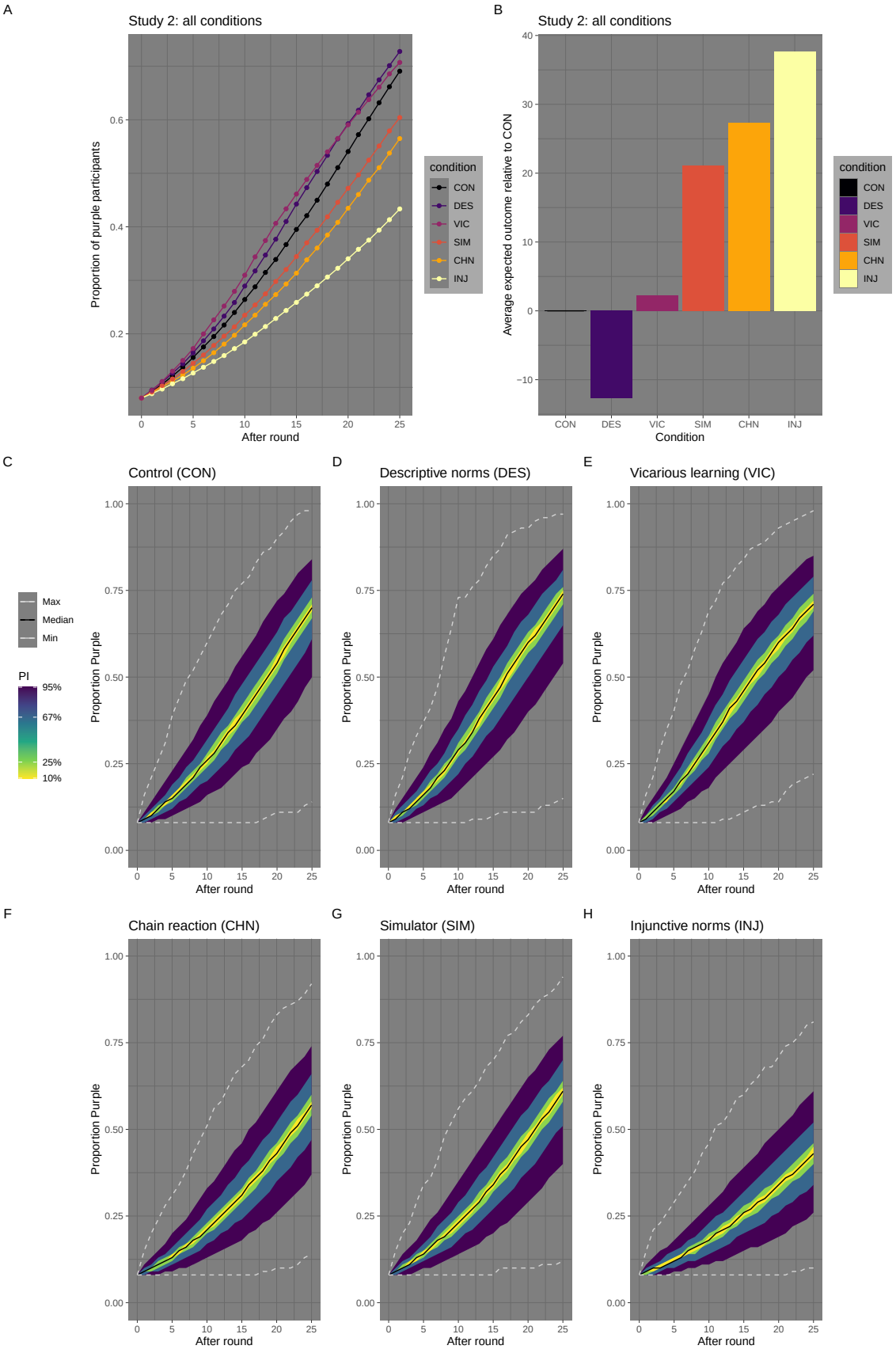
A
Study 2: all conditions
Proportion of purple participants
After round
condition
CON
DES
VIC
SIM
CHN
INJ
B
Study 2: all conditions
Average expected outcome relative to CON
Condition
C
Control (CON)
D
Descriptive norms (DES)
E
Vicarious learning (VIC)
F
Chain reaction (CHN)
G
Simulator (SIM)
H
Injunctive norms (INJ)
Proportion Purple
Max
Median
Min
PI
95%
67%
25%
10%

Figure SCR-27

Results of simulated games (n=1,000,000) based on the empirically observed responses: Subfigure A shows the mean infection rates for the six conditions, subfigure B the average expected outcomes relative to the outcome in the control condition. The remaining subfigure show percentile plots for the roundwise evolution of infection rates in each of the six conditions, the C) control condition (CON), the D) descriptive norms condition (DES), the E) vicarious learning condition (VIC), the F) chain reaction condition (CHN), the G) simulator condition (SIM), and the H) injunctive norms condition (INJ).

Relative to the control condition, two conditions show higher infection rates (DES and VIC), and three show lower infection rates (SIM, CHN, and INJ). Only DES results in a worse average outcome than the control condition. The reason, why VIC leads to better outcomes than CON is the distribution of H-choices: while there is a larger number of H-choices in the early rounds than in any other condition, there is a smaller number of H-choices in the final round. Thus, the same pattern can be observed as for the HG-simulations based on theoretical data.
The most plausible causal explanation is a reaction to the exponentially growing data progressively shown to participants. In the beginning, infection rates in the previous group were low, leading participants to potentially underestimate the future risk. As previous case numbers grew, the growing risk became apparent to participants and more and more participants lowered their amount of risk-taking, saving them from the expected loss in the Descriptive norms condition. For participants in the DES condition, previous behavior did not lead participants to shy away from H-actions. Those wanting to take risks seem to have taken previous behavior as validation of their actions rather than a correction of assumed consensus.
The three effective interventions differ in the degree of gains. In all three conditions, infection rates stay lower throughout the game. The most extreme group is the INJ condition that exhibits the lowest infection rates and the largest gain in expected outcomes.

SCR-8 Strategy-specific results based on the empirical data

As seen in the theoretical simulations, the game rules imply both a social dilemma and a risk-reward tradeoff. Usign the classification of strategies introduced at the beginning, we can conditionalize general results on the strategies chosen. Fugre SCR-28 shows the distribution of specific strategy users across conditions.

```
dataRaw1=read.delim(
  file="figdata/Study2-1--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw2=read.delim(
  file="figdata/Study2-2--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw3=read.delim(
  file="figdata/Study2-3--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw4=read.delim(
  file="figdata/Study2-4--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw5=read.delim(
  file="figdata/Study2-5--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw6=read.delim(
  file="figdata/Study2-6--MeanConditionalOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
```

```
allData=data.frame(
var=rbind(t(dataRaw1),t(dataRaw2),t(dataRaw3),t(dataRaw4),
          t(dataRaw5),t(dataRaw6))

)

colnames(allData)<-c("nH","nS","nF","nG","survH","survS",
                     "survF","survG","outH","outS","outF",
                     "outG")
allData$condition=c("CHN","CON","DES","INJ","SIM","VIC")
allData$condition<-factor(allData$condition,
                          levels=c("CON","DES","VIC",
                                   "SIM","CHN","INJ"))


nData<- allData %>%
  select(c("nH","nS","nF","nG","condition"))

survData<- allData %>%
  select(c("survH","survS","survF","survG","condition"))

outcData<- allData %>%
  select(c("outH","outS","outF","outG","condition"))


dataLongn<-nData%>%
gather(key="group",value="number",-condition)

dataLongSurv<-survData%>%
gather(key="group",value="survival",-condition)


dataLongOutc<-outcData%>%
gather(key="group",value="outcome",-condition)


dataLongn$group<-factor(dataLongn$group,
                        levels=c("nG","nF","nS","nH"))
dataLongSurv$group<-factor(dataLongSurv$group,
                           levels=c("survG","survF","survS",
                                    "survH"))
dataLongOutc$group<-factor(dataLongOutc$group,
                           levels=c("outG","outF","outS",
                                    "outH"))
```

```
levels(dataLongn$group) <- list(AllG="nG", HG="nF",
                                Switch="nS", AllH="nH")
levels(dataLongSurv$group) <- list(AllG="survG",
                                   HG="survF", Switch="survS",
                                   AllH="survH")
levels(dataLongOutc$group) <- list(AllG="outG", HG="outF",
                                   Switch="outS", AllH="outH")

dataLongAll=data.frame(
  number=dataLongn$number,
  survival=dataLongSurv$survival,
  outcome=dataLongOutc$outcome,
  strategy=dataLongSurv$group,
  condition=dataLongSurv$condition
)

dataLongn%>%
ggplot(aes( y=number, fill=condition,x=group))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Strategy")+
  ylab("Number of players")+
  scale_fill_viridis_d(option="inferno",name="Strategy")
```

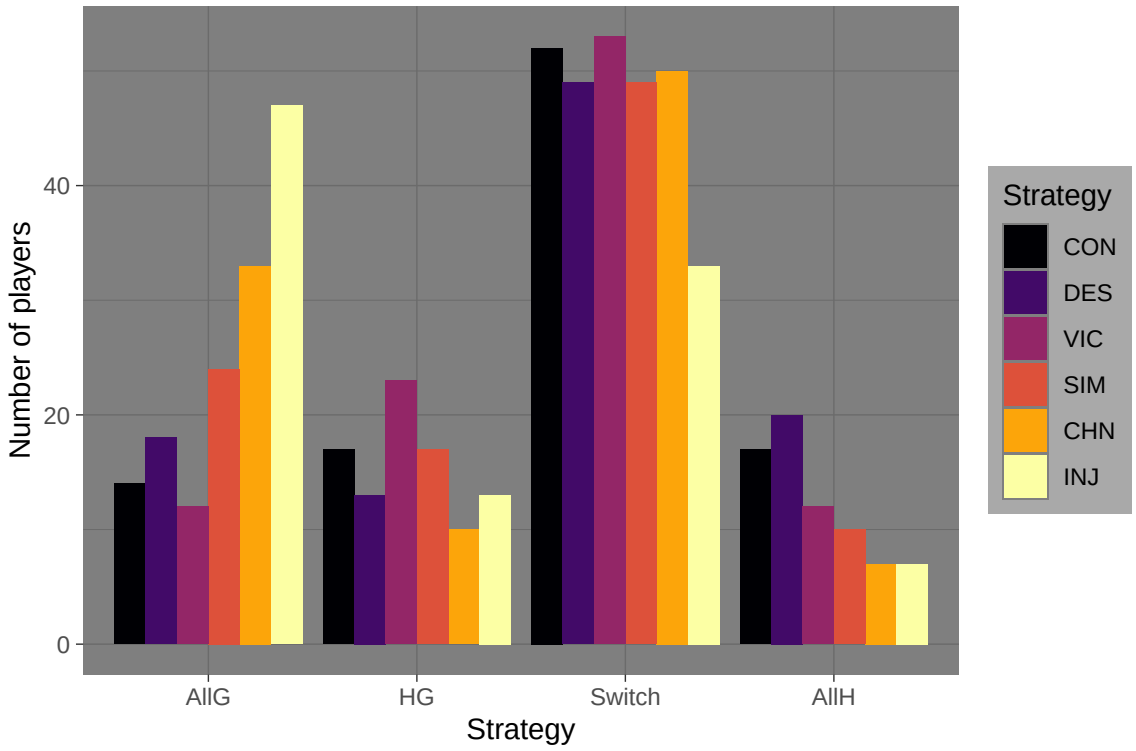

Figure SCR-28

Number of strategy users (classified based on choice pattern) across conditions: Numbers and percentages are equivalent ($n=100$ per group).

This distribution fleshes out the explanation for differential infection rates observed before: AllG-players are most numerous in the INJ-condition, switching players least numerous in the INJ-condition. The control condition shows a similar pattern to the DES-condition, the VIC condition has more players following the HG-strategy. This is consistent with the idea of initial under-estimation of the evolution of infection rates that could be corrected by later data. Figure SCR-29 presents strategy- and condition-specific surival rates.

```
dataLongSurv%>%
ggplot(aes( y=survival, fill=condition,x=group))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Strategy")+
  ylab("Proportion blue")+
  scale_fill_viridis_d(option="inferno",name="Strategy")
```

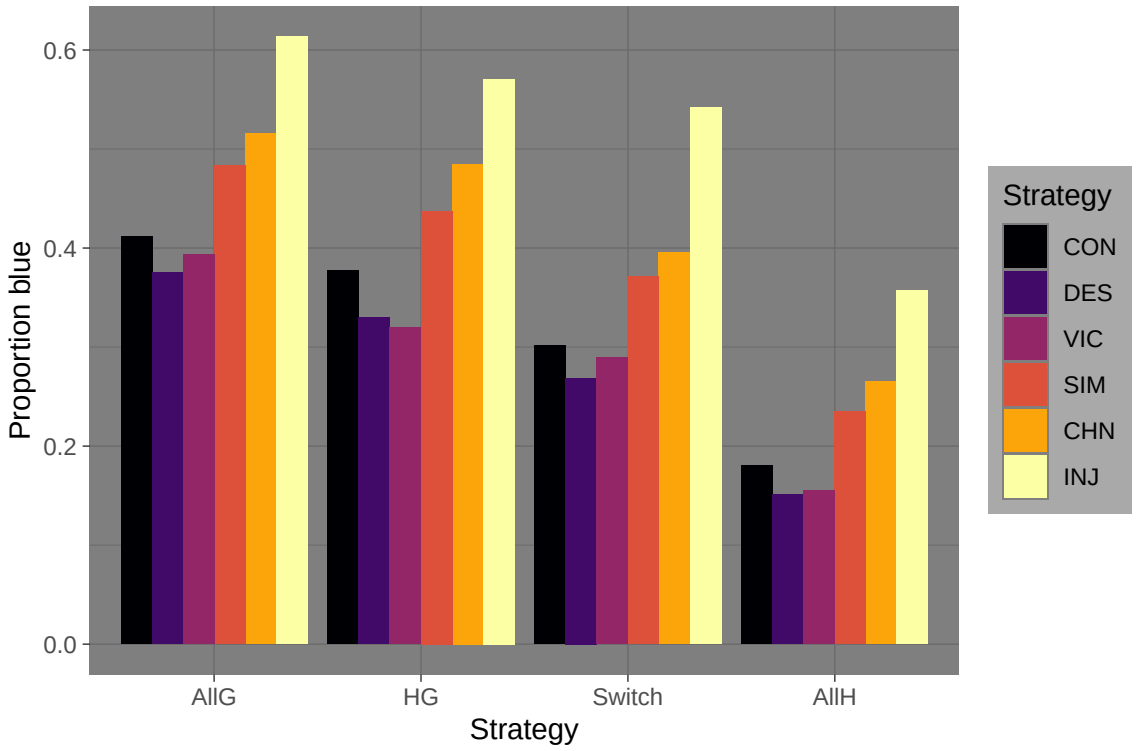

Figure SCR-29

Survival rates of strategy users (classified based on choice pattern) across conditions.

Survival rate differencs between conditions equally impact all strategy groups, but the level of survival clearly differs between groups irrespective of condition, descending in the order of AllG-HG-Switch-AllH. Regarding outcome, the pattern is summarized in Figure **??**.

```
dataLongOutc%>%
ggplot(aes( y=outcome, fill=condition,x=group))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
  xlab("Strategy")+
  ylab("Average outcome")+
  scale_fill_viridis_d(option="inferno",name="Strategy")
```

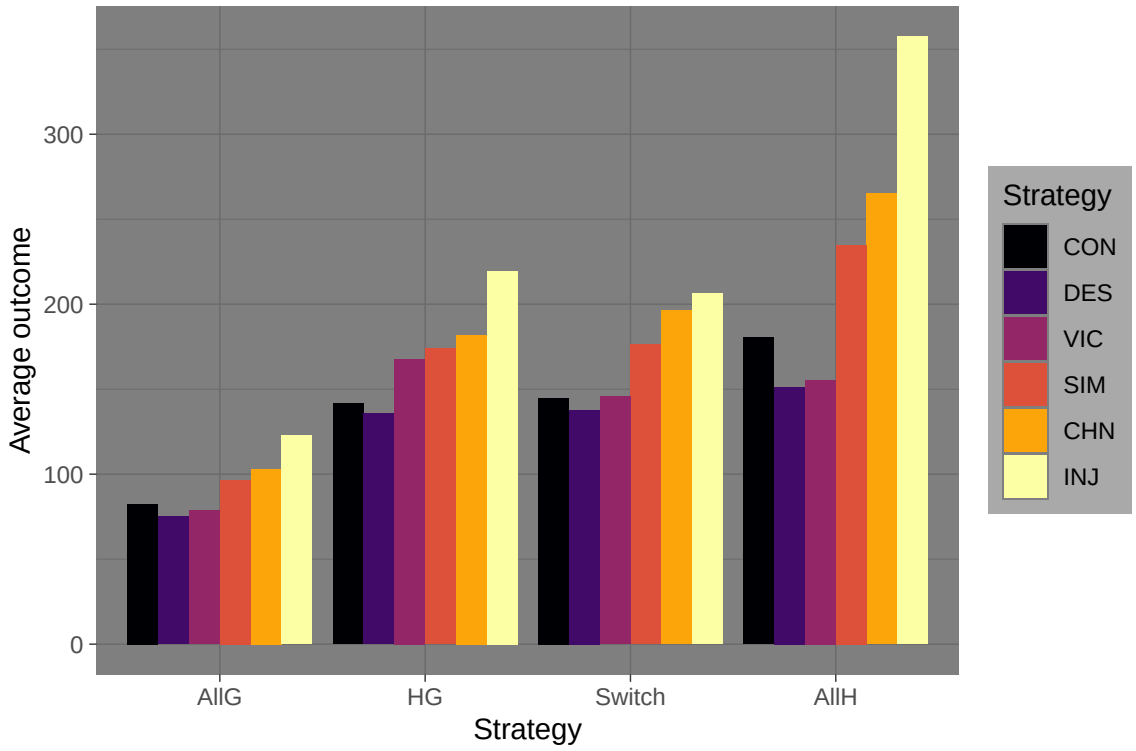

Figure SCR-30

Expected outcomes of strategy users (classified based on choice pattern) across conditions.

Outcomes follow the inverse pattern of survival rates with one notable exception: In some conditions, outcomes are lower in the Switch-condition than in the HG-condition. The social dilemma is more pronounced in the groups showing riskier behavior. This is due to the higher stakes generated by accumulated points throughout the game. In other words, those exhibiting riskier behavior profit more from other people's choice of exhibiting safer behavior.
To explore how survival rate and expected outcomes are jointly distributed across groups and conditions, Figure SCR-31 places them in a joint scatterplot.

```
colPal = viridis(option="inferno",6)
shapeVector <-  c(16,15,17,18)

dataLongAll%>%
ggplot(aes( y=outcome, x=survival,shape=strategy,cex=number,
            fill=condition, color=condition))+
  geom_point()+
  theme_dark()+
  theme(legend.background = element_rect(fill = "darkgray"))+
```

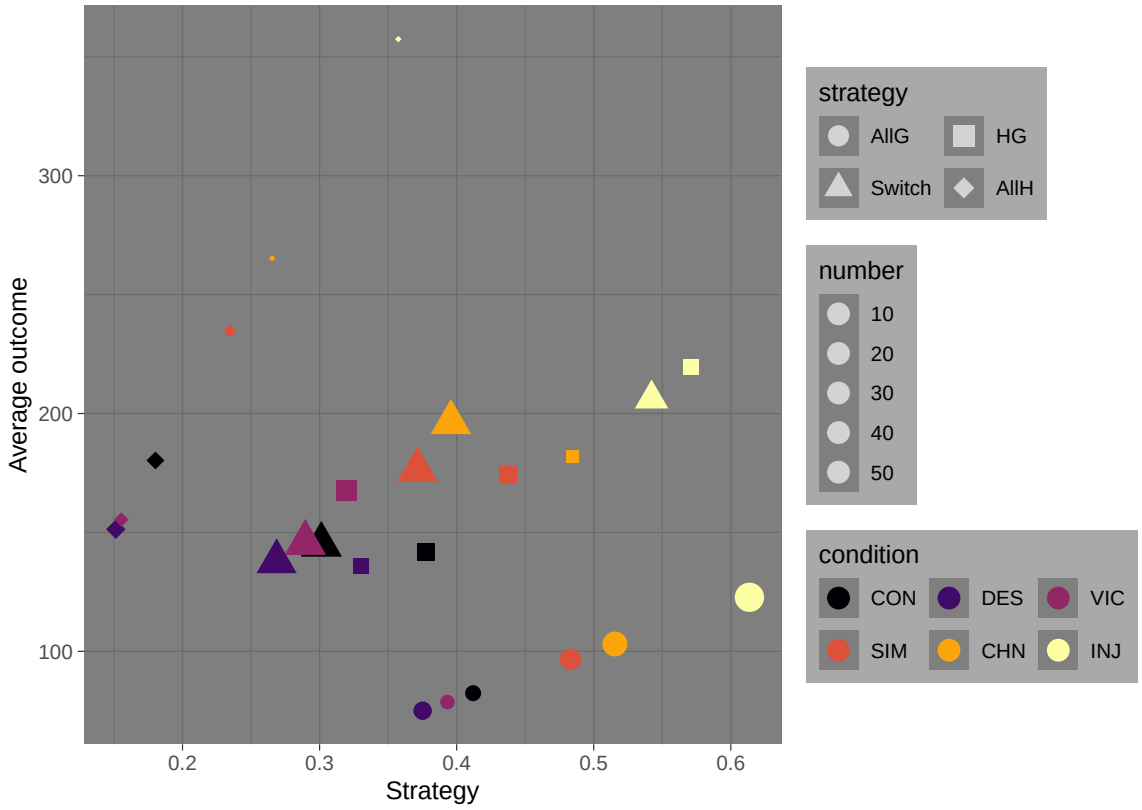

Figure SCR-31

Scatter plot of survival rates and expected outcomes of strategy users (classified based on choice pattern) across conditions. Symbols signify strategy user groups, sizes correspond to group sizes and colors signify conditions.

```
  xlab("Strategy")+
  ylab("Average outcome")+
   scale_color_manual(values = c("CON" = colPal[1],
                                 "DES" = colPal[2], "VIC" = colPal[3],
                               "SIM" = colPal[4],
                               "CHN" = colPal[5], "INJ" = colPal[6] ))+
   guides(color = guide_legend(nrow = 2, byrow = T,
                               override.aes=list(size=4))) +
   guides(shape = guide_legend(nrow = 2, byrow = T,
                               override.aes=list(size=4,color="lightgray"))) +
   guides(cex = guide_legend(override.aes=list(size=4,color="lightgray"))) +
   scale_shape_manual(values = shapeVector)
```

Results for AllG- users and AllH users show a clear pattern across conditions. In the order DES-VIC-CON-SIM-CHN-INJ both expected outcomes and survival rates increase. This is imperfectly mirrored by the results for HG-users: VIC does not conform to the pattern and

shown higher surival rates than DES, but lower survival rates than DES. Similary switching results for VIC show higher expected outcomes than for CON. With these exceptions, the general impression can be confirmed that benefits of cooperation accrue to different degrees at different rates. For some groups, HG results dominate Switch-resultsby showing higher values in both survival rates and outcomes.

SCR-8.1 Comparing theoretical and empirical results

The theoretical results showed a non-linear relationship between competitive choices and average expected outcomes. For all groups observed the observed competition was higher than the collusive optimum and within the domain, where additional competition leads to decreases in both average survival rates and average expected outcomes.
Thus, even in the INJ condition there is no reduction in risk-taking that reduces social welfare. Nonetheless, as other successful intervention against universal excessive risk-taking, a wide-spread reduction of risk-taking makes risk-taking more profitable for those who are not willing to conform. Competitive strategies performed better than the collusive average optimum only if there enough players reducing their risk-taking even below the viable universal strategy.This did not happen in CON, DES, and VIC: Participants in these conditions were universally worse off than theoretical participants aiming at the collusive strategy. At the same time, it cannot be excluded that a large appetite for risk might drive some participants to choose risky strategies even if all implications were transparent.

SCR-9 Robustness check: Resampled results

Finally, we would like to do one analysis to explore the stability of results. All empirical simulations took the six group samples as fixed populations. To approximate a sampling process, we did another set of analyses using resampling. We repeatedly (again, n=1,000,000 for each condition and variant) generated groups of n=100 by randomly drawing samples from the original groups with equal probability for each original participant and replacement.
First, we juxtapose the distribution of results for the original CON condition and the resampled CON condition (note that the resampling is repeated for each trial; see Fig. SCR-32).

```
dataRaw=read.delim(
  file="figdata/Study2Resample-2----HalfPercentileInfectionRate.txt",
                    header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                             "R05","R06","R07","R08","R09",
                                             "R10","R11","R12","R13","R14",
                                             "R15","R16","R17","R18","R19",
                                             "R20","R21","R22","R23","R24",
                                             "R25"))

dataRaw$percentile=0:200;

dataLong<-dataRaw%>%
```

```
gather(key="AfterRound",value="PercPurple",-percentile)


dataLong$AfterRound<-parse_number(dataLong$AfterRound);
dataLong$percentile<-dataLong$percentile/200

finalStateR2_2 <- dataRaw$R25[1+measures/0.5]

studyRES2R_2 <-ggplot(data=dataLong, aes(x=AfterRound,y=PercPurple,
                                         quantile=percentile))+
  geom_fan(intervals=sintervals)+
  theme_dark()+
   scale_fill_viridis_c(option="viridis",direction=-1,breaks=sintervals,
                        labels=slabels,
                        name = "PI")+
  stat_summary(fun=median,geom="line",lwd=0.5,aes(color="Median"))+
  scale_color_manual(values=c("lightgray","black","lightgray"),name="")+
  stat_summary(fun=max,geom="line",lwd=0.5,aes(color="Min"),
               linetype="dashed")+
  stat_summary(fun=min,geom="line",lwd=0.5,aes(color="Max"),
               linetype="dashed")+
  ylim(0,1)+
  theme(legend.position = "none")+
  ylab("Proportion Purple")+
  xlab("After round")+
  ggtitle("Control (Resampled)")


study2_2 + studyRES2R_2
```

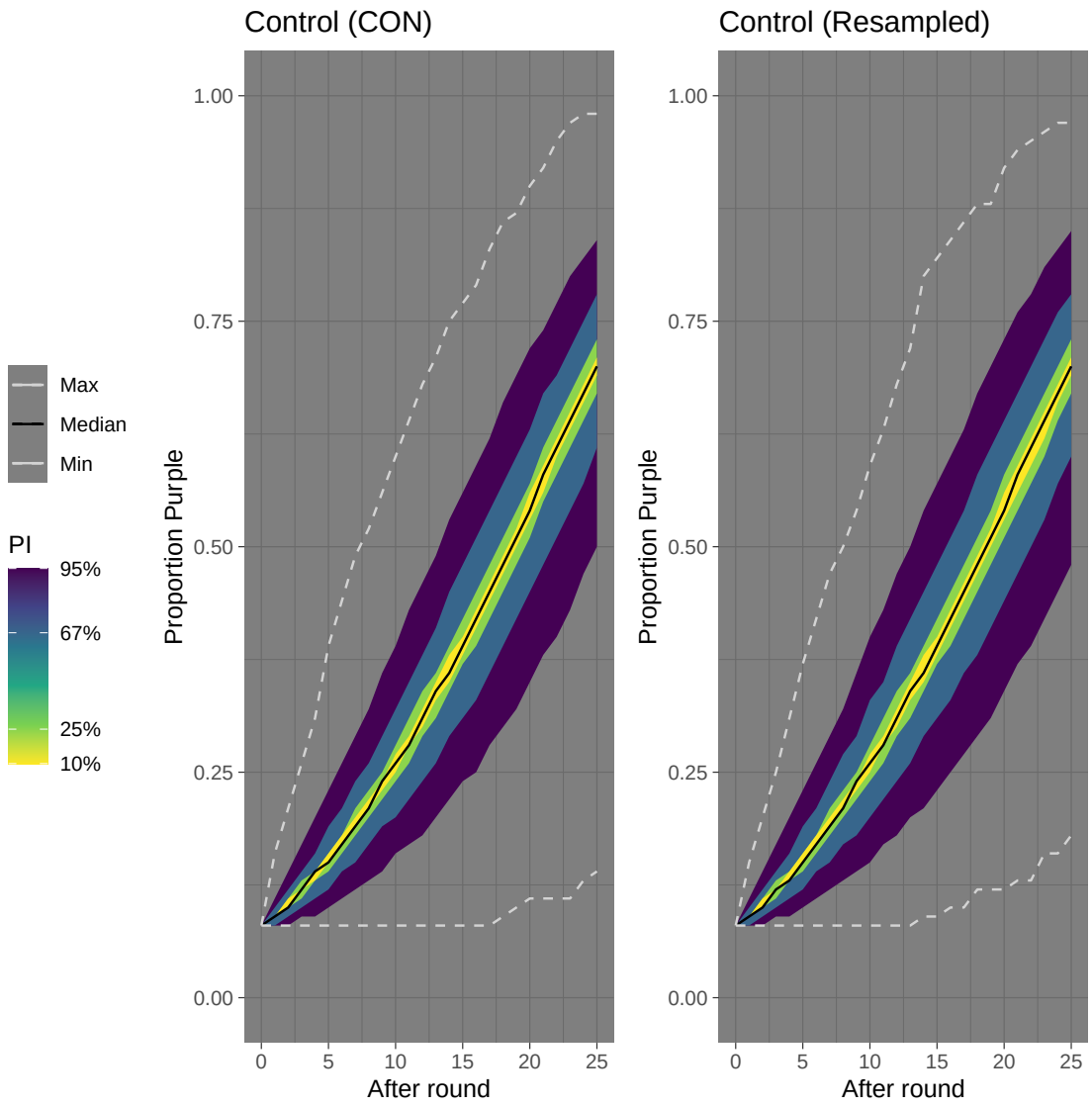

Figure SCR-32

Percentile plot of results A) in the control condition (Study 2), and B) in the repeatedly resampled control condition.

There are no stark differences between the two distributions, investigating the outer borders of the 95% PI, one can detect a slightly wider dispersion in the resampled condition, but differences shrink when moving to inner PIs. In termss of average final outcomes, the juxtaposition shows a very similar picture (see Fig. SCR-33).

```
dataRaw1=read.delim(
  file="figdata/Study2Resample-1--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
dataRaw2=read.delim(
  file="figdata/Study2Resample-2--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
dataRaw3=read.delim(
  file="figdata/Study2Resample-3--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
dataRaw4=read.delim(
  file="figdata/Study2Resample-4--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
dataRaw5=read.delim(
  file="figdata/Study2Resample-5--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))
```

```
dataRaw6=read.delim(
  file="figdata/Study2Resample-6--MeanInfectionRate.txt",
                   header=FALSE,col.names=c("R00","R01","R02","R03","R04",
                                            "R05","R06","R07","R08","R09",
                                            "R10","R11","R12","R13","R14",
                                            "R15","R16","R17","R18","R19",
                                            "R20","R21","R22","R23","R24",
                                            "R25"))

allData=rbind(dataRaw1,dataRaw2,dataRaw3,dataRaw4,dataRaw5,dataRaw6)

allData$condition=c("CHN","CON","DES","INJ","SIM","VIC")

allData$condition<-factor(allData$condition,levels=c("CON","DES","VIC",
                                                     "SIM","CHN","INJ"))

dataLong<-allData%>%
gather(key="AfterRound",value="PercPurple",-condition)

dataLong$AfterRound<-parse_number(dataLong$AfterRound)

compPlot1Res <- dataLong%>%
ggplot(aes(x=AfterRound, y=PercPurple, color=condition,
           group=condition))+
  geom_line()+
  geom_point()+
  theme_dark()+
   theme(legend.position = "none")+
  xlab("After round")+
  ylab("Proportion of purple participants")+
  scale_color_viridis_d(option="inferno",name="condition")+
  ggtitle("Resampling with replacement")


dataRaw1=read.delim(
  file="figdata/Study2Resample-1--MeanSumOutcomes.txt",
                   header=FALSE,col.names=c("Outcome"))
dataRaw2=read.delim(
  file="figdata/Study2Resample-2--MeanSumOutcomes.txt",
                   header=FALSE,col.names=c("Outcome"))
dataRaw3=read.delim(
  file="figdata/Study2Resample-3--MeanSumOutcomes.txt",
                   header=FALSE,col.names=c("Outcome"))
dataRaw4=read.delim(
```

```
  file="figdata/Study2Resample-4--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw5=read.delim(
  file="figdata/Study2Resample-5--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))
dataRaw6=read.delim(
  file="figdata/Study2Resample-6--MeanSumOutcomes.txt",
                    header=FALSE,col.names=c("Outcome"))

allData=rbind(dataRaw1,dataRaw2,dataRaw3,dataRaw4,dataRaw5,dataRaw6)
allData$Outcome<-(allData$Outcome-replicate(6,dataRaw2$Outcome))/100

allData$condition=c("CHN","CON","DES","INJ","SIM","VIC")

allData$condition<-factor(allData$condition,levels=c("CON","DES","VIC",
                                                     "SIM","CHN","INJ"))


compPlot2Res <- allData%>%
ggplot(aes(x=condition, y=Outcome,fill=condition))+
  geom_bar(position = 'dodge', stat = 'identity')+
  theme_dark()+
   theme(legend.position = "none")+
  xlab("Condition")+
  ylab("Average expected outcome relative to CON")+
  scale_fill_viridis_d(option="inferno")+
   annotate("segment",x=0.6,xend=1.4,y=0,yend=0)+
  ggtitle("Resampling with replacement")


(compPlot1|compPlot1Res)/
  (compPlot2|compPlot2Res) +
  plot_annotation(tag_levels = 'A')
```

Results are remarkably consistent between original and resampled simulations (the maximum absolute outcome difference is 0.6 in the INJ condition). Based on this re-analysis, there is no reason to suspect that any of the analysis is produced by a very specific configuration of actions.

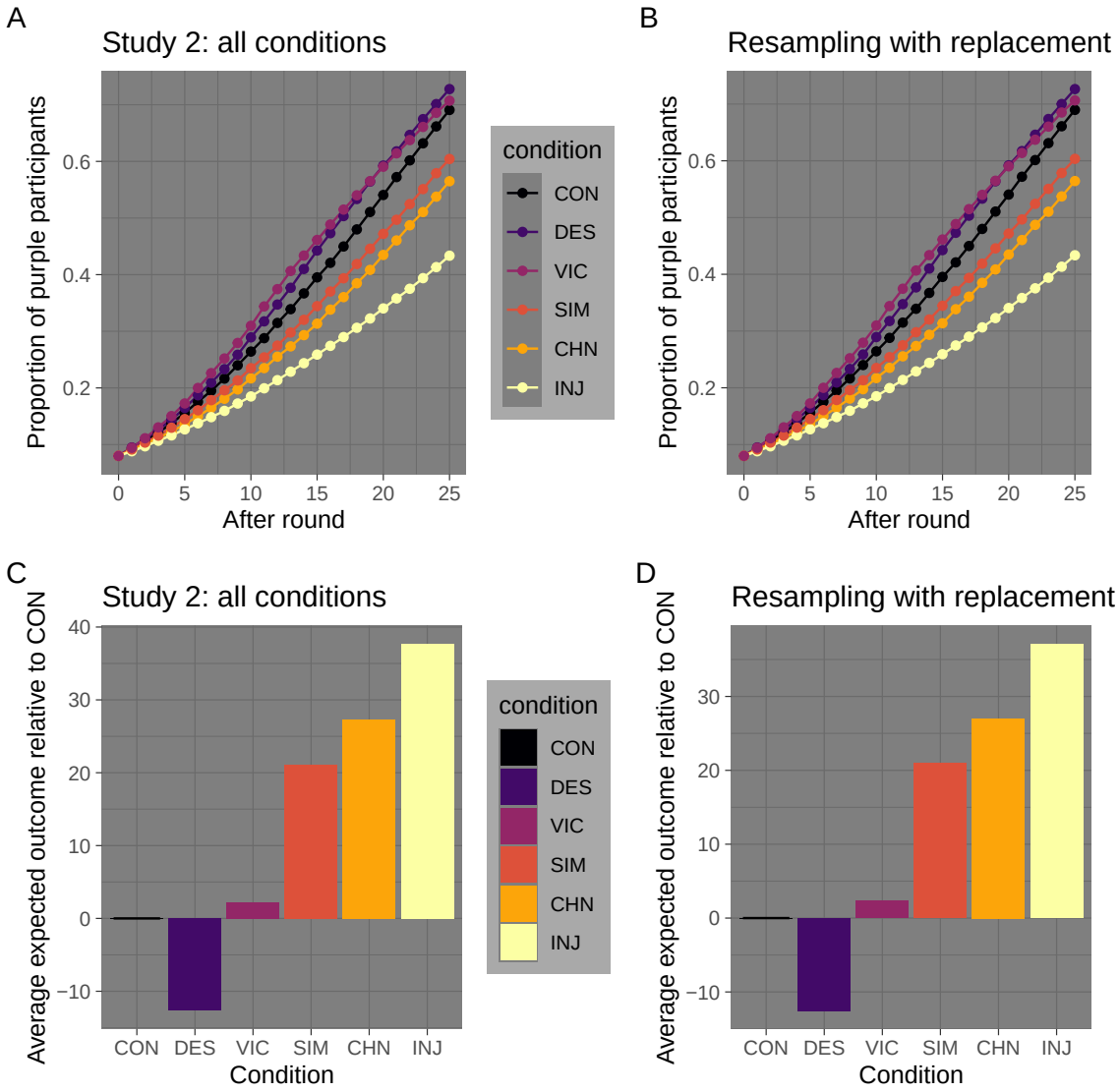

Figure SCR-33

Comnparison of results between the original and the resampled simulations: Evolution of infection rates across conditions A) in the original condition, and B) in the resampled condition, and groupwise expected outcomed c) in the original condition and D) in the resampled condition.

SCR-10 Simulation code (Matlab)

SCR-10.1 Simulation code (Matlab): shared functions

All simulations are run on the top level with access to several shared functions. This section presents the shared functions. Loading functions are presented in abridged form, as they mainly consist of copied data columns. The simulation are initialized by running the code presented last in the section, but all of them use the functions shown here.

SCR-10.1.1 Basic simulation loop

```
function [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,savePatternOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
      ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,
      bconditionalOutcomes)

%CONVENTIONS
%for individual states: 0 signifies blue and 1 signifies purple
% for actions: 0 signifies G and 1 signifies H

%----------------------------
% INITIALIZE SAVE ARRAYS
%----------------------------
 savePopState=zeros(popSize,numTrials);
 saveOutcomeState=zeros(popSize,numTrials);
 saveSumOutcomes=zeros(numTrials,1);
 saveInfectionRate=zeros(numberRounds+1,numTrials);
 saveActionRate=zeros(numberRounds,numTrials);
 savePatternOutcomes=zeros(12,numTrials);
%----------------------------------------

stable=0;

 for trials=1:numTrials

    % at the beginning (or for each trial):
    % determine all player choices for the game
    % based on chosen simulation type (see function)
    if (trials==1 || ~stable)
      [popChoices,popTypes]=determineChoices_v1(simType,
         simParameter,...
    popSize,numberRounds,bconditionalOutcomes);
```

```
32        potentialOutcome=(bonusG*numberRounds+sum(popChoices*(
              bonusH-bonusG),2));
33    end
34
35    %set all players to blue
36    population=zeros(popSize,1);
37
38    %initialize trial-based save arrays
39    saveTrialInfectionRate=zeros(numberRounds+1,1);
40    saveTrialActionRate=zeros(numberRounds,1);
41    saveTrialInfectionRate(1,1)=mean(population,1);
42
43    if (bfixedPerc)
44        %fixed percentage switched to purple
45        infectionRand=randperm(popSize);
46        population(infectionRand(1,1:initialPerc),1)=1;
47    else
48        %each player switched with same probability
49        infectionRand = rand(popSize,1)*100 < initialPerc;
50        population(infectionRand)=1;
51    end
52
53
54    % repeat transmission rounds and save relevant statistics
55    for ri=1:numberRounds
56        saveTrialInfectionRate(ri,1)=mean(population,1);
57        saveTrialActionRate(ri,1)=mean(popChoices(1:popSize,ri)
              ,1);
58
59        [population]= transmissionRound_v01(...
60            population,popChoices(1:popSize,ri),...
61            interactionRisks,passiveRisk);
62    end
63
64    saveTrialInfectionRate(numberRounds+1,1)=mean(population,1);
65
66
67    %save statistics for the trial in output variables
68    savePopState(1:popSize, trials)=  (1-population(1:popSize,1))
          ;
69    saveOutcomeState(1:popSize, trials)= ...
70                    (1- population(1:popSize,1)).*potentialOutcome
                        ;
71    saveSumOutcomes(trials,1)=sum(saveOutcomeState(1:popSize,
          trials));
```

```
72      saveInfectionRate(1:numberRounds+1,trials)= ...
73                              saveTrialInfectionRate(1:numberRounds
                                    +1,1);
74      saveActionRate(1:numberRounds,trials)= ...
75                              saveTrialActionRate(1:numberRounds,1);
76      if (bconditionalOutcomes)
77       % save number count, proportion blue (survival rate), and
78       % average outcome
79       savePatternOutcomes(1,trials)= sum(popTypes==1);
80       savePatternOutcomes(2,trials)= sum(popTypes==2);
81       savePatternOutcomes(3,trials)= sum(popTypes==3);
82       savePatternOutcomes(4,trials)= sum(popTypes==4);
83       savePatternOutcomes(5,trials)=sum(savePopState(popTypes
             ==1,...
84                  trials)) /savePatternOutcomes(1,trials);
85       savePatternOutcomes(6,trials)=sum(savePopState(popTypes
             ==2,...
86                  trials)) /savePatternOutcomes(2,trials);
87       savePatternOutcomes(7,trials)=sum(savePopState(popTypes
             ==3,...
88                  trials)) /savePatternOutcomes(3,trials);
89       savePatternOutcomes(8,trials)=sum(savePopState(popTypes
             ==4,...
90                  trials)) /savePatternOutcomes(4,trials);
91       savePatternOutcomes(9,trials)=sum(saveOutcomeState(popTypes
             ==1,...
92                  trials)) /savePatternOutcomes(1,trials);
93       savePatternOutcomes(10,trials)=sum(saveOutcomeState(popTypes
             ==2,...
94                  trials)) /savePatternOutcomes(2,trials);
95       savePatternOutcomes(11,trials)=sum(saveOutcomeState(popTypes
             ==3,...
96                  trials)) /savePatternOutcomes(3,trials);
97       savePatternOutcomes(12,trials)=sum(saveOutcomeState(popTypes
             ==4,...
98                  trials)) /savePatternOutcomes(4,trials);
99
100     end
101  end % end trials
102 end
```

SCR-10.1.2 Choice determination function

```
1  function [ popChoices,popTypes,stable ] = determineChoices_v1(
       simType,simParameter,...
```

```
2       popSize,numberRounds,bconditionalOutcomes)
3   %SUMMARY determine the behavior of all players throughout the
        game
4   % simType determines the type of behavior generated
5   %
6   %Study1: behavior is the empriical data from Study 1 (unchanged)
7   %Study2: behavior is the empriical data from Study 1 (unchanged);
8   %        Parameter determines condition:
9   %        1: CHN, 2: CON, 3: DES, 4: INJ, 5:SIM, 6:VIC
10  %Study1Resample: behavior is the empriical data from Study 1, but
11  %                 population is determined by resampling
12  %Study2Resample: behavior is the empriical data from Study 2, but
13  %                 population is determined by resampling (same
        parameter
14  %                 settings as for Study2 above
15  %PropStable: A fixed proportion (simParamter) of indivduals
        choose
16  %                   always H, the remainder chooses G
17  %RandomPropIndividual: Each individual chooses H with a
        porbability of
18  %                     simParamter, each round is independent
19  %SwitchGHAll:   All individuals start with G an switch to H in
        round
20  %               simParameter (not a typical behavior)
21  %SwitchHGAll:   All individuals start with H an switch to G in
        round
22  %               simParameter (observable behavior)
23  %ConstantDecreaseStable: All individuals start with 100% H and in
         each
24  %               round a proportion of simParameter individuals
        switches
25  %               to G for the remainder of the game
26  %ConstantDecreaseIndividual: All individuals start with 100% H
        and in each
27  %               round the probability of choosing H is reduced by
28  %               simParameter; each round is independent
29  %SwitchHGallButFiveH: Same rules as for SwitchHGAll, but 5
        players play H in
30  %               every round
31  %SwitchHallButFiveH: Same rules as for SwitchHGAll, but 5 players
         play H in
32  %               every round
33  %SwitchHGallButFiveG: Same rules as for SwitchHGAll, but 5
        players play G in
34  %               every round
```

```
35 %SwitchHallButFiveGH: Same rules as for SwitchHGAll, but 5
       players play G in
36 %                every round
37 %AllFiveHStaggered: All individuals play 5 rounds of H, 20 rounds
       of G, but
38 %                    rounds of H are staggered in five groups (no
       parameter
39 %                    here)
40
41
42 if simType=="Study1"
43   popChoices = loadStudy1();
44   stable=1;
45 elseif simType=="Study2"
46   popChoices  = loadStudy2(simParameter);
47   stable=1;
48 elseif simType=="Study1Resample"
49   popChoices = loadStudy1();
50   sizePop=size(popChoices,1);
51   resamplePop=randsample(sizePop,sizePop,true);
52   popChoices=popChoices(resamplePop,:);
53   stable=0;
54 elseif simType=="Study2Resample"
55   popChoices = loadStudy2(simParameter);
56   sizePop=size(popChoices,1);
57   resamplePop=randsample(sizePop,sizePop,true);
58   popChoices=popChoices(resamplePop,:);
59   stable=0;
60 elseif simType=="PropStable"
61   popChoices = zeros(popSize,numberRounds);
62   popChoices(1:round(sizePop*simParameter),1:numberRounds)=1;
63   stable=1;
64
65 elseif simType=="RandomPropIndividual"
66   popChoices = zeros(popSize,numberRounds);
67   determineH=rand(popSize,numberRounds)<simParameter;
68   popChoices(determineH)=1;
69   stable=0;
70
71 elseif simType=="SwitchGHall"
72   popChoices = zeros(popSize,numberRounds);
73   popChoices(1:popSize,simParameter:numberRounds)=1;
74   stable=1;
75
76 elseif simType=="SwitchHGall"
```

```
77    popChoices = ones(popSize,numberRounds);
78    popChoices(1:popSize,simParameter:numberRounds)=0;
79    stable=1;
80
81  elseif simType=="ConstantDecreaseStable"
82    popChoices = ones(popSize,numberRounds);
83    for ci=2:numberRounds
84       popChoices(1:min( round( (ci-1) * simParameter * popSize),
             popSize)...
85            ,ci)=0;
86    end
87    stable=1;
88  elseif simType=="ConstantDecreaseIndividual"
89    popChoices = ones(popSize,numberRounds);
90    for ci=2:numberRounds
91       determineG=rand(popSize,1) < simParameter*(ci-1);
92       popChoices(determineG,ci)=0;
93    end
94    stable=0;
95  elseif simType=="SwitchHGallButFiveH"
96    popChoices = ones(popSize,numberRounds);
97    popChoices(1:popSize-5,simParameter:numberRounds)=0;
98    stable=1;
99   elseif simType=="SwitchHGallButFiveG"
100   popChoices = ones(popSize,numberRounds);
101   popChoices(1:popSize-5,simParameter:numberRounds)=0;
102   popChoices(popSize-4:popSize,1:numberRounds)=0;
103   stable=1;
104    elseif simType=="SwitchGHallButFiveH"
105   popChoices = zeros(popSize,numberRounds);
106   popChoices(1:popSize-5,simParameter:numberRounds)=1;
107   popChoices(popSize-4:popSize,1:numberRounds)=1;
108   stable=1;
109    elseif simType=="SwitchGHallButFiveG"
110   popChoices = zeros(popSize,numberRounds);
111   popChoices(1:popSize-5,simParameter:numberRounds)=1;
112   stable=1;
113  elseif simType=="AllFiveHStaggered"
114   popChoices = zeros(popSize,numberRounds);
115   popChoices(1:round(popSize/5),1:5)=1;
116   popChoices(round(popSize/5)+1:2*round(popSize/5),6:10)=1;
117   popChoices(2*round(popSize/5)+1:3*round(popSize/5),11:15)=1;
118   popChoices(3*round(popSize/5)+1:4*round(popSize/5),16:20)=1;
119   popChoices(4*round(popSize/5)+1:popSize,21:25)=1;
120   stable=1;
```

```
 else
  assert (1==-1)
end

 if (bconditionalOutcomes)
 %if boolean variable is 1:
 %determine behavioral pattern for each player:
 %All H: every single action is H, coded as 1
 %Switch: alternates between H and G (more than once or starts with G),
 %    coded as 2
 %H then G: starts with only H actions, then switch to only G actions,
 %    coded as 3
 %All G: every single action is G, coded as 4


   sumActions=sum(popChoices,2);
   allHChoices=sumActions==25;
   allGChoices=sumActions==0;
   allMixedChoices=(sumActions>0)&(sumActions<25);
   HthenG=allMixedChoices;
   for ci=2:numberRounds
     HthenG = HthenG &(popChoices(:,ci-1)>= popChoices(:,ci));
   end
   Switch=allMixedChoices&(~HthenG);
   popTypes=zeros(popSize,1);
   popTypes(allHChoices)=1;
   popTypes(Switch)=2;
   popTypes(HthenG)=3;
   popTypes(allGChoices)=4;


 else
   popTypes=0;
 end
end
```

SCR-10.2 Game trial function

```
function [ population] = transmissionRound_v01( population, actionTypes,interactionRisks,passiveRisk)
%REQUIREMENTS
%population size has to be even
%action Types must have the same size as population
```

```
%interactioRisks is an array of three numbers
%passiveRisk is a single number (default: set to0)


  %determine population size
  numPop=size(population,1);

  %initialize individual risk
  indivRisk=zeros(numPop,1);

  %create random permutation to determine the random pairing
  %   (the random sequence is considered as n/2 pairs in sequence
     )
  pairings=randperm(numPop)';


  %the same procedure is applied to each pair
  for pairi=1:numPop/2
    %treat each pair depending on action type combination
    %the first step does not take color into account

    if actionTypes(pairings( (pairi-1)*2+1,1))==0 &&...
          actionTypes(pairings( pairi*2,1),1)==0

       %G-G pair: both individuals are ssigned the lowes risk
       indivRisk(pairings( (pairi-1)*2+1,1),1)=interactionRisks
          (1,1)...
           .*population(pairings( pairi*2,1),1);
       indivRisk(pairings( pairi*2,1),1)=interactionRisks(1,1)...
           .*population(pairings( (pairi-1)*2+1,1),1);


    elseif   actionTypes(pairings( (pairi-1)*2+1,1))==1 &&...
          actionTypes(pairings( pairi*2,1),1)==0

        %G-H pair: both individuals are ssigned the intermeidate
           risk
        indivRisk(pairings( (pairi-1)*2+1,1),1)=interactionRisks
          (1,2)...
           .*population(pairings( pairi*2,1),1);
       indivRisk(pairings( pairi*2,1),1)=interactionRisks(1,2)...
           .*population(pairings( (pairi-1)*2+1,1),1);

    elseif actionTypes(pairings( (pairi-1)*2+1,1))==0 &&...
           actionTypes(pairings( pairi*2,1),1)==1
```

```
46          %H-G pair: both individuals are ssigned the intermediate
                risk
47          indivRisk(pairings( (pairi-1)*2+1,1),1)=interactionRisks
                (1,2)...
48              .*population(pairings( pairi*2,1),1);
49          indivRisk(pairings( pairi*2,1),1)=interactionRisks(1,2)...
50              .*population(pairings( (pairi-1)*2+1,1),1);
51
52      elseif actionTypes(pairings( (pairi-1)*2+1,1))==1 &&...
53              actionTypes(pairings( pairi*2,1),1)==1
54          %H-H pair: both individuals are ssigned the highest risk
55          indivRisk(pairings( (pairi-1)*2+1,1),1)=interactionRisks
                (1,3)...
56              .*population(pairings( pairi*2,1),1);
57          indivRisk(pairings( pairi*2,1),1)=interactionRisks(1,3)...
58              .*population(pairings( (pairi-1)*2+1,1),1);
59
60      else
61          assert(1==-1);
62          %program will stop, as this point will be only reached
                given a data
63          %problem
64      end
65
66
67  end
68
69  %A purple individual has a 100% chance of staying purple
70  indivRisk=max(population,indivRisk);
71  passiveRand=zeros(numPop,1);
72
73
74  %This is an optional rule not used in the paper: Each blue
        individual has
75  % a chance to switch to purple of 100*passiveRisk % in each
        round
76  for pi=1:numPop
77      passiveRand(pi,1)=rand(1,1)<=passiveRisk;
78  end
79  indivRisk=max(indivRisk,passiveRand);
80
81  %determine new colors for each individual by comparing random
        number from
82  %U(0,1) with the risk factor (1 for individuals who were
        already purple)
```

```
  %the new population array is the fucntion output
  randNumbers=rand(numPop,1);
  population=randNumbers<=indivRisk;
end
```

SCR-10.2.1 Save function

```
function [ complete ] = saveSimulationResults_v02(...
    saveFolder,saveName,numberRounds,...
    savePopState,saveOutcomeState,saveSumOutcomes,
        saveInfectionRate,...
    saveActionRate,saveConditionalOutcomes,...
    bconditionalOutcomes,bSingleSave,bMeanSave,
        bStandardDeviationSave,...
    bPercentileSave,bDecileSave,bAreaSave)

%save simulation results to saveFolder
%each filename starts with saveName
%Boolean variables determine whether:
%
%bconditionalOutcomes: saves outcomes for four behaviroal types:
%AllH, Switch,H-G, AllG: 1-4: counts
%                        5-8: survival rate
%                       9-12: average outcome
%
%bSingleSave: save trial-wise information, bMeanSave: save
    averages,
%bStandardDeviationSave: save standard deviation
%bPercentileSaves: save percentiles, bDecileSae: save deciles

bPercentileOldSave=0;

if bSingleSave
    %save information on every trial
    %creates large results files
    fn=strcat(saveFolder,saveName,"-PopState.txt");
    dlmwrite(fn,savePopState','delimiter','\t');
    fn=strcat(saveFolder,saveName,"-IndivOutcomes.txt");
    dlmwrite(fn,saveOutcomeState','delimiter','\t');
    fn=strcat(saveFolder,saveName,"-SumOutcomes.txt");
    dlmwrite(fn,saveSumOutcomes,'delimiter','\t');
    fn=strcat(saveFolder,saveName,"-InfectionRate.txt");
    dlmwrite(fn,saveInfectionRate','delimiter','\t');
    fn=strcat(saveFolder,saveName,"-ActionRate.txt");
    dlmwrite(fn,saveActionRate','delimiter','\t');
```

```
36      if (bconditionalOutcomes)
37          fn=strcat(saveFolder,saveName,"-ConditionalOutcomes.txt")
                ;
38          dlmwrite(fn,saveConditionalOutcomes','delimiter','\t');
39      end
40
41  end
42
43
44  if bMeanSave
45      %save average results
46
47      fn=strcat(saveFolder,saveName,"--MeanPopState.txt");
48      dlmwrite(fn,mean(savePopState',1),'delimiter','\t');
49      fn=strcat(saveFolder,saveName,"--MeanIndivOutcomes.txt");
50      dlmwrite(fn,mean(saveOutcomeState',1),'delimiter','\t');
51      fn=strcat(saveFolder,saveName,"--MeanSumOutcomes.txt");
52      dlmwrite(fn,mean(saveSumOutcomes,1),'delimiter','\t');
53      fn=strcat(saveFolder,saveName,"--MeanInfectionRate.txt");
54      dlmwrite(fn,mean(saveInfectionRate',1),'delimiter','\t');
55      fn=strcat(saveFolder,saveName,"--MeanActionRate.txt");
56      dlmwrite(fn,mean(saveActionRate',1),'delimiter','\t');
57      if (bconditionalOutcomes)
58          fn=strcat(saveFolder,saveName,"--MeanConditionalOutcomes.
                txt");
59          dlmwrite(fn,mean(saveConditionalOutcomes',1),'delimiter',
                '\t');
60      end
61  end
62
63
64  if bStandardDeviationSave
65      %save standard deviations
66
67      fn=strcat(saveFolder,saveName,"---SDPopState.txt");
68      dlmwrite(fn,std(savePopState'),'delimiter','\t');
69      fn=strcat(saveFolder,saveName,"---SDIndivOutcomes.txt");
70      dlmwrite(fn,std(saveOutcomeState'),'delimiter','\t');
71      fn=strcat(saveFolder,saveName,"---SDSumOutcomes.txt");
72      dlmwrite(fn,std(saveSumOutcomes),'delimiter','\t');
73      fn=strcat(saveFolder,saveName,"---SDInfectionRate.txt");
74      dlmwrite(fn,std(saveInfectionRate'),'delimiter','\t');
75      fn=strcat(saveFolder,saveName,"---SDActionRate.txt");
76      dlmwrite(fn,std(saveActionRate'),'delimiter','\t');
77      if (bconditionalOutcomes)
```

```
78          fn=strcat(saveFolder,saveName,"---SDConditionalOutcomes.
                txt");
79          dlmwrite(fn,std(saveConditionalOutcomes'),'delimiter','\t
                ');
80      end
81  end
82
83
84  if bPercentileOldSave
85      %save selected percentiles (including Min and Max)
86
87      percInfection=zeros(101,numberRounds);
88      percSumOutcomes=zeros(101,1);
89      percCondOutcomes=zeros(101,12);
90
91      for ci=0:100
92
93        percInfection(ci+1,1:numberRounds+1)=...
94              prctile(saveInfectionRate',ci);
95
96        percSumOutcomes(ci+1,1)=...
97              prctile(saveSumOutcomes,ci);
98
99
100       if (bconditionalOutcomes)
101          percCondOutcomes(ci+1,1:12)=...
102                prctile(saveConditionalOutcomes',ci);
103       end
104     end
105     fn=strcat(saveFolder,saveName,"----PercentileInfectionRate.
            txt");
106     dlmwrite(fn,percInfection,'delimiter','\t');
107
108     fn=strcat(saveFolder,saveName,"----PercentileSumOutcome.txt")
            ;
109     dlmwrite(fn,percSumOutcomes,'delimiter','\t');
110
111     if (bconditionalOutcomes)
112         fn=strcat(saveFolder,saveName,"----
                PercentileConditionalOutcomes.txt");
113         dlmwrite(fn,percCondOutcomes,'delimiter','\t');
114     end
115 end
116
117
```

```
118
119
120 if bDecileSave
121     %save selected deciles (including Min and Max)
122
123     decInfection=zeros(11,numberRounds);
124     decSumOutcomes=zeros(11,1);
125     decCondOutcomes=zeros(11,12);
126     for ci=0:10
127
128       decInfection(ci+1,1:numberRounds+1)=...
129             prctile(saveInfectionRate',ci*10);
130
131       decSumOutcomes(ci+1,1)=...
132             prctile(saveSumOutcomes,ci*10);
133
134
135       if (bconditionalOutcomes)
136          decCondOutcomes(ci+1,1:12)=...
137                prctile(saveConditionalOutcomes',ci*10);
138       end
139     end
140     fn=strcat(saveFolder,saveName,"----DecileInfectionRate.txt");
141     dlmwrite(fn,decInfection,'delimiter','\t');
142
143     fn=strcat(saveFolder,saveName,"----DecileSumOutcome.txt");
144     dlmwrite(fn,decSumOutcomes,'delimiter','\t');
145
146     if (bconditionalOutcomes)
147         fn=strcat(saveFolder,saveName,"----
              DecileConditionalOutcomes.txt");
148         dlmwrite(fn,decCondOutcomes,'delimiter','\t');
149     end
150
151 end
152 complete=1;
153
154
155
156 if bPercentileSave
157     %save selected half-percentiles (including Min and Max)
158
159     percInfection=zeros(201,numberRounds);
160     percSumOutcomes=zeros(201,1);
161     percCondOutcomes=zeros(201,12);
```

```
162
163     for ci=0:200
164
165       percInfection(ci+1,1:numberRounds+1)=...
166             prctile(saveInfectionRate',ci/2);
167
168       percSumOutcomes(ci+1,1)=...
169             prctile(saveSumOutcomes,ci/2);
170
171
172       if (bconditionalOutcomes)
173          percCondOutcomes(ci+1,1:12)=...
174                prctile(saveConditionalOutcomes',ci/2);
175       end
176     end
177     fn=strcat(saveFolder,saveName,"----
          HalfPercentileInfectionRate.txt");
178     dlmwrite(fn,percInfection,'delimiter','\t');
179
180     fn=strcat(saveFolder,saveName,"----HalfPercentileSumOutcome.
          txt");
181     dlmwrite(fn,percSumOutcomes,'delimiter','\t');
182
183     if (bconditionalOutcomes)
184        fn=strcat(saveFolder,saveName,"----
             HalfPercentileConditionalOutcomes.txt");
185        dlmwrite(fn,percCondOutcomes,'delimiter','\t');
186     end
187 end
188
189 end
```

SCR-10.2.2 Minimal save function

```
1  function [ complete ] = saveReducedSimulationResults_v02(...
2       saveFolder,saveName,numberRounds,...
3       saveSumOutcomes,saveInfectionRate,...
4       saveConditionalOutcomes,...
5       bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
6       bPercentileSave)
7
8  %save simulation results to saveFolder
9  %each filename starts with saveName
10 %Boolean variables determine whether:
11 %
```

```
12 %bconditionalOutcomes: saves outcomes for four behaviroal types:
13 %AllH, Switch,H-G, AllG: 1-4: counts
14 %                        5-8: survival rate
15 %                       9-12: average outcome
16 %
17 %bSingleSave: save trial-wise information, bMeanSave: save
       averages,
18 %bStandardDeviationSave: save standard deviation
19
20
21 if bMeanSave
22     %save average results
23
24
25     fn=strcat(saveFolder,saveName,"--MeanSumOutcomes.txt");
26     dlmwrite(fn,mean(saveSumOutcomes,1),'delimiter','\t');
27     fn=strcat(saveFolder,saveName,"--MeanInfectionRate.txt");
28     dlmwrite(fn,mean(saveInfectionRate',1),'delimiter','\t');
29
30     if (bconditionalOutcomes)
31         fn=strcat(saveFolder,saveName,"--MeanConditionalOutcomes.
               txt");
32         dlmwrite(fn,mean(saveConditionalOutcomes',1),'delimiter',
               '\t');
33     end
34 end
35
36
37 if bStandardDeviationSave
38     %save standard deviations
39
40
41     fn=strcat(saveFolder,saveName,"---SDSumOutcomes.txt");
42     dlmwrite(fn,std(saveSumOutcomes),'delimiter','\t');
43     fn=strcat(saveFolder,saveName,"---SDInfectionRate.txt");
44     dlmwrite(fn,std(saveInfectionRate'),'delimiter','\t');
45     if (bconditionalOutcomes)
46         fn=strcat(saveFolder,saveName,"---SDConditionalOutcomes.
               txt");
47         dlmwrite(fn,std(saveConditionalOutcomes'),'delimiter','\t
               ');
48     end
49 end
50
51
```

```
52 if bPercentileSave
53     %save selected half-percentiles (including Min and Max)
54
55     percInfection=zeros(201,numberRounds);
56     percSumOutcomes=zeros(201,1);
57     percCondOutcomes=zeros(201,12);
58
59     for ci=0:200
60
61       percInfection(ci+1,1:numberRounds+1)=...
62             prctile(saveInfectionRate',ci/2);
63
64       percSumOutcomes(ci+1,1)=...
65             prctile(saveSumOutcomes,ci/2);
66
67
68       if (bconditionalOutcomes)
69          percCondOutcomes(ci+1,1:12)=...
70                prctile(saveConditionalOutcomes',ci/2);
71       end
72     end
73     fn=strcat(saveFolder,saveName,"----
          HalfPercentileInfectionRate.txt");
74     dlmwrite(fn,percInfection,'delimiter','\t');
75
76     fn=strcat(saveFolder,saveName,"----HalfPercentileSumOutcome.
          txt");
77     dlmwrite(fn,percSumOutcomes,'delimiter','\t');
78
79     if (bconditionalOutcomes)
80         fn=strcat(saveFolder,saveName,"----
              HalfPercentileConditionalOutcomes.txt");
81         dlmwrite(fn,percCondOutcomes,'delimiter','\t');
82     end
83 end
84
85 complete=1;
86
87
88 end
```

SCR-10.2.3 Load Study 1 function [extract]

```
1 function [ popChoices ] = loadStudy1
2
```

```
3
4  popChoices=zeros(100,25);
5  round1=[40
6  40
7  8
8  40
9  40
10 8
11 40
12 8
13 8
14 40
15 40
16 40
17 40
18 40
19 8
20 8
21 8
22 40
23 8
24 8
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44 8
45 8
46 8
47 40
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40];

[....rounds 2-24 omitted here ]

round25=[40
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40];

popChoices=[round1,round2,round3,round4,round5,round6,round7,
    round8,...
     round9,round10,round11,round12,round13,round14,round15,
         round16,round17,...
     round18,round19,round20,round21,round22,round23,round24,
         round25];

popChoices=(popChoices-8)/32;


end
```

SCR-10.2.4 Load Study 2 function [extract]

```
function [ popChoices ] = loadStudy2(gameNr)

round1=[40
40
40
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40
8
40];

round2=[40
8
40
8
8
8
...
...

[rest of round 2 and rounds 2-25 omitted here]

popChoicesFull=[round1,round2,round3,round4,round5,round6,round7,
    round8,...
     round9,round10,round11,round12,round13,round14,round15,
        round16,round17,...
     round18,round19,round20,round21,round22,round23,round24,
        round25];

%popChoicses=zeros(100,25);


switch gameNr
    case 1
        popChoices=popChoicesFull(1:100,1:25);

    case 2
        popChoices=popChoicesFull(101:200,1:25);

    case 3
        popChoices=popChoicesFull(201:300,1:25);

    case 4
```

```
633         popChoices=popChoicesFull(301:400,1:25);
634
635     case 5
636         popChoices=popChoicesFull(401:500,1:25);
637
638     case 6
639         popChoices=popChoicesFull(501:600,1:25);
640
641 end
642
643
644 popChoices=(popChoices-8)/32;
```

SCR-10.3 Simulation code (Matlab): Simulation runs

These are the top level files controlling the simulations whose results are presented in this document.

SCR-10.3.1 Theoretical simulation: Fixed proportion of cooperators and competitors

```
1  tic;
2  %------------------------------
3  % SET BASIC GAME PARAMETERS
4  %------------------------------
5  popSize=100;
6  numberRounds=25; % Number of game rounds (25)
7  passiveRisk=0; % Probability of switching color after each round
       (0, not used)
8  interactionRisks=[0.05,0.15,0.25];  % Probability of switching
       colors for
9              % G-G / H-G or G-H / H-H interactions if colors are
                   mixed
10             % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are switched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 %------------------------------
19
```

```
20
21 % ------------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 % ------------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 % ------------------------------
27
28
29 % ------------------------------
30 % DETERMINE SIM TYPE
31 % ------------------------------
32 simType="PropStable";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 % ------------------------------
43
44 for simParameter =0:20
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\
       resStableProportion\";
48   saveName=strcat("PropStable-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter
          /20,...
55    bconditionalOutcomes);
56
57   complete  = saveReducedSimulationResults_v02(...
58      saveFolder,saveName,numberRounds,...
59      saveSumOutcomes,saveInfectionRate,...
60      saveConditionalOutcomes,...
61      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
```

```
62      bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.2 Theoretical simulation: Fixed probability of cooperation

```
1  tic;
2  %-----------------------------
3  % SET BASIC GAME PARAMETERS
4  %-----------------------------
5  popSize=100;
6  numberRounds=25; % Number of game rounds (25)
7  passiveRisk=0; % Probability of switching color after each round
       (0, not used)
8  interactionRisks=[0.05,0.15,0.25];  % Probability of switching
       colors for
9              % G-G / H-G or G-H / H-H interactions if colors are
                   mixed
10             % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are swittched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 %-----------------------------
19
20
21 %-----------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 %-----------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 %-----------------------------
27
28
29 %-----------------------------
30 % DETERMINE SIM TYPE
31 %-----------------------------
32 simType="RandomPropIndividual";
```

```
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 %-----------------------------
43
44 for simParameter =0:20
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\
       resVariableProportion\";
48   saveName=strcat("PropVariable-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter
          /20,...
55    bconditionalOutcomes);
56
57   complete  = saveReducedSimulationResults_v02(...
58      saveFolder,saveName,numberRounds,...
59      saveSumOutcomes,saveInfectionRate,...
60      saveConditionalOutcomes,...
61      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
62      bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.3 Theoretical simulation: Decreasing cooperation (stable decrease)

```
1 tic;
2 %-----------------------------
3 % SET BASIC GAME PARAMETERS
4 %-----------------------------
5 popSize=100;
```

```
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching colors for
            % G-G / H-G or G-H / H-H interactions if colors are mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs. initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are swittched to purple before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------



% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="ConstantDecreaseStable";


bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
bPercentileSave=1;  %save percentiles


% ------------------------------

for simParameter =0:20
  disp(int2str(simParameter))
```

```
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\resDecrease\";
48   saveName=strcat("DecreaseStab-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter
          /100,...
55    bconditionalOutcomes);
56
57   complete  = saveReducedSimulationResults_v02(...
58      saveFolder,saveName,numberRounds,...
59      saveSumOutcomes,saveInfectionRate,...
60      saveConditionalOutcomes,...
61      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
62      bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.4 Theoretical simulation: Decreasing cooperation (variable decrease)

```
1  tic;
2  %-------------------------------
3  % SET BASIC GAME PARAMETERS
4  %-------------------------------
5  popSize=100;
6  numberRounds=25; % Number of game rounds (25)
7  passiveRisk=0; % Probability of switching color after each round
       (0, not used)
8  interactionRisks=[0.05,0.15,0.25];  % Probability of switching
       colors for
9              % G-G / H-G or G-H / H-H interactions if colors are
                   mixed
10             % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are swittched to purple
       before R1
```

```
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 %------------------------------
19
20
21 %------------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 %------------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 %------------------------------
27
28
29 %------------------------------
30 % DETERMINE SIM TYPE
31 %------------------------------
32 simType="ConstantDecreaseIndividual";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 %------------------------------
43
44 for simParameter =0:20
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\resVarDecrease
         \";
48   saveName=strcat("VarDecrease-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
         ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter
         /100,...
55    bconditionalOutcomes);
```

```
56
57   complete  = saveReducedSimulationResults_v02(...
58       saveFolder,saveName,numberRounds,...
59       saveSumOutcomes,saveInfectionRate,...
60       saveConditionalOutcomes,...
61       bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
62       bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.5 Theoretical simulation: Optimal switching point

```
1  tic;
2  % ----------------------------
3  % SET BASIC GAME PARAMETERS
4  % ----------------------------
5  popSize=100;
6  numberRounds=25; % Number of game rounds (25)
7  passiveRisk=0; % Probability of switching color after each round
       (0, not used)
8  interactionRisks=[0.05,0.15,0.25];  % Probability of switching
       colors for
9              % G-G / H-G or G-H / H-H interactions if colors are
                   mixed
10             % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are switched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 % ----------------------------
19
20
21 % ----------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 % ----------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 % ----------------------------
```

```
27
28
29 % ------------------------------
30 % DETERMINE SIM TYPE
31 % ------------------------------
32 simType="SwitchHGall";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 % ------------------------------
43
44 for simParameter =1:26
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\resHG\";
48   saveName=strcat("SwitchHG-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
55    bconditionalOutcomes);
56
57   complete  = saveReducedSimulationResults_v02(...
58      saveFolder,saveName,numberRounds,...
59      saveSumOutcomes,saveInfectionRate,...
60      saveConditionalOutcomes,...
61      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
62      bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.6 Theoretical simulation: Non-optimal switching pattern

```
1 tic;
```

```
2  %-------------------------------
3  % SET BASIC GAME PARAMETERS
4  %-------------------------------
5  popSize=100;
6  numberRounds=25; % Number of game rounds (25)
7  passiveRisk=0; % Probability of switching color after each round
       (0, not used)
8  interactionRisks=[0.05,0.15,0.25];  % Probability of switching
       colors for
9              % G-G / H-G or G-H / H-H interactions if colors are
                   mixed
10             % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are swittched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 %-------------------------------
19
20
21 %-------------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 %-------------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 %-------------------------------
27
28
29 %-------------------------------
30 % DETERMINE SIM TYPE
31 %-------------------------------
32 simType="SwitchGHall";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
```

```
%-------------------------------

for simParameter =1:26
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\resGH\";
  saveName=strcat("SwitchGH-", int2str(simParameter));

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
       ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
   bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
end
toc
```

SCR-10.3.7 Theoretical simulation: HG-switching with five AllH-players

```
tic;
%-------------------------------
% SET BASIC GAME PARAMETERS
%-------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
   (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
   colors for
            % G-G / H-G or G-H / H-H interactions if colors are
               mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs.
   initial individual
              % probability (value 0)
```

```
initialPerc=8; % X% of the population are swittched to purple before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="SwitchHGallButFiveH";


bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
bPercentileSave=1;  %save percentiles


% ------------------------------

for simParameter =1:26
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\resHGButFiveH\";
  saveName=strcat("SwitchHGBut5H-", int2str(simParameter));

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
```

```
    bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
end
toc
```

SCR-10.3.8 Theoretical simulation: GH-switching with five AllH-players

```
tic;
%------------------------------
% SET BASIC GAME PARAMETERS
%------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
    (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
    colors for
             % G-G / H-G or G-H / H-H interactions if colors are
                 mixed
             % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs.
    initial individual
               % probability (value 0)
initialPerc=8; % X% of the population are swittched to purple
    before R1
                % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
%------------------------------


%------------------------------
% SET BASIC SIMULATION PARAMETERS
%------------------------------
numTrials=1000000;
%numRiskTests=25;
```

```
26 %-------------------------------
27
28
29 %-------------------------------
30 % DETERMINE SIM TYPE
31 %-------------------------------
32 simType="SwitchGHallButFiveH";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 %-------------------------------
43
44 for simParameter =1:26
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\resGHButFiveH
       \";
48   saveName=strcat("SwitchGHBut5H-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
55    bconditionalOutcomes);
56
57   complete  = saveReducedSimulationResults_v02(...
58      saveFolder,saveName,numberRounds,...
59      saveSumOutcomes,saveInfectionRate,...
60      saveConditionalOutcomes,...
61      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
62      bPercentileSave)
63
64  toc
65 end
66 toc
```

SCR-10.3.9 Theoretical simulation: HG-switching with five AllG-players

```
tic;
% ------------------------------
% SET BASIC GAME PARAMETERS
% ------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching colors for
            % G-G / H-G or G-H / H-H interactions if colors are mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs. initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are switched to purple before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="SwitchHGallButFiveG";


bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
```

```
bPercentileSave=1;  %save percentiles


%-------------------------------

for simParameter =1:26
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\resHGButFiveG
      \";
  saveName=strcat("SwitchHGBut5G-", int2str(simParameter));

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
      ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
   bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
end
toc
```

SCR-10.3.10 Theoretical simulation: GH-switching with five AllG-players

```
tic;
%-------------------------------
% SET BASIC GAME PARAMETERS
%-------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
   (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
   colors for
            % G-G / H-G or G-H / H-H interactions if colors are
               mixed
```

```
10            % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12               % probability (value 0)
13 initialPerc=8; % X% of the population are switched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 % ------------------------------
19
20
21 % ------------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 % ------------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 % ------------------------------
27
28
29 % ------------------------------
30 % DETERMINE SIM TYPE
31 % ------------------------------
32 simType="SwitchGHallButFiveG";
33
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40
41
42 % ------------------------------
43
44 for simParameter =1:26
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\resGHButFiveG
       \";
48   saveName=strcat("SwitchGHBut5G-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
```

```
    transmissionPlaySimulationBasev01_14jul20(...
    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
        ,...
    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
    bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
end
toc
```

SCR-10.3.11 Theoretical simulation: Staggered H-strategy

```
tic;
% ------------------------------
% SET BASIC GAME PARAMETERS
% ------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
    (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
    colors for
            % G-G / H-G or G-H / H-H interactions if colors are
                mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs.
    initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are switched to purple
    before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
```

```
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="AllFiveHStaggered";


bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
bPercentileSave=1;  %save percentiles


% ------------------------------

for simParameter =1:1
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\staggeredFive
      \";
  saveName=strcat("AllFiveHStaggered-", int2str(simParameter));

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
       ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
   bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
```

```
end
toc
```

SCR-10.3.12 Theoretical simulation: HG-strategy with one-percent roundwise risk

```
%%%%%%% ONE PERC    %%%%%%%

tic;
% ------------------------------
% SET BASIC GAME PARAMETERS
% ------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0.01; % Probability of switching color after each
    round (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
    colors for
            % G-G / H-G or G-H / H-H interactions if colors are
                mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs.
    initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are swittched to purple
    before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="SwitchHGall";
```

```
35
36
37 bconditionalOutcomes=1; %save information on behavioral patterns
38 bSingleSave=0; %save trial-wise results
39 bMeanSave=1; % save average results
40 bStandardDeviationSave=1; %save standard deviations
41 bPercentileSave=1;  %save percentiles
42
43
44 %-----------------------------
45
46 for simParameter =1:26
47   disp(int2str(simParameter))
48
49   saveFolder="U:\WoikeJan\transmissionGame\july20\resHGonePerc\";
50   saveName=strcat("SwitchHGonePerc-", int2str(simParameter));
51
52   [savePopState,saveOutcomeState,saveSumOutcomes,...
53     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
54     transmissionPlaySimulationBasev01_14jul20(...
55    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
56    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
57    bconditionalOutcomes);
58
59   complete  = saveReducedSimulationResults_v02(...
60      saveFolder,saveName,numberRounds,...
61      saveSumOutcomes,saveInfectionRate,...
62      saveConditionalOutcomes,...
63      bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
64      bPercentileSave)
65
66  toc
67 end
68 toc
```

SCR-10.3.13 Theoretical simulation: GH-strategy with one-percent roundwise risk

```
1 %%%%%%% ONE PERC    %%%%%%%
2
3 tic;
4 %-----------------------------
5 % SET BASIC GAME PARAMETERS
6 %-----------------------------
```

```
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0.01; % Probability of switching color after each round (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching colors for
            % G-G / H-G or G-H / H-H interactions if colors are mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs. initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are swittched to purple before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="SwitchHGall";


bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
bPercentileSave=1;  %save percentiles


% ------------------------------

for simParameter =1:26
```

```
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\resHGonePerc\";
  saveName=strcat("SwitchHGonePerc-", int2str(simParameter));

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
      ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
   bconditionalOutcomes);

  complete  = saveReducedSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     saveSumOutcomes,saveInfectionRate,...
     saveConditionalOutcomes,...
     bconditionalOutcomes,bMeanSave,bStandardDeviationSave,...
     bPercentileSave)

 toc
end
toc
```

SCR-10.3.14 Analysis of empirical data (Study 1)

```
tic;
% ------------------------------
% SET BASIC GAME PARAMETERS
% ------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
   (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
   colors for
            % G-G / H-G or G-H / H-H interactions if colors are
               mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs.
   initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are switched to purple
   before R1
               % or X% chance for each individual (standard: 8)
```

```
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 % ------------------------------
19
20
21 % ------------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 % ------------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 % ------------------------------
27
28
29 % ------------------------------
30 % DETERMINE SIM TYPE
31 % ------------------------------
32 simType="Study1";
33 simParameter=0;
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40 bDecileSave=1; %save deciles
41
42 % ------------------------------
43
44 for simParameter =1:1
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\res\";
48   saveName=strcat("Study1");
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
55    bconditionalOutcomes);
56
57
58   complete = saveSimulationResults_v02(...
```

```
59        saveFolder,saveName,numberRounds,...
60        savePopState,saveOutcomeState,saveSumOutcomes,
              saveInfectionRate,...
61        saveActionRate,saveConditionalOutcomes,...
62        bconditionalOutcomes,bSingleSave,bMeanSave,
              bStandardDeviationSave,...
63        bPercentileSave,bDecileSave)
64    toc
65  end
66  toc
```

SCR-10.3.15 Analysis of empirical data (Study 2)

```
1
2   tic;
3   %--------------------------------
4   % SET BASIC GAME PARAMETERS
5   %--------------------------------
6   popSize=100;
7   numberRounds=25; % Number of game rounds (25)
8   passiveRisk=0; % Probability of switching color after each round
        (0, not used)
9   interactionRisks=[0.05,0.15,0.25];  % Probability of switching
        colors for
10              % G-G / H-G or G-H / H-H interactions if colors are
                    mixed
11              % (0.05 / 0.15 /0.25)
12  bfixedPerc=1; % initial percentage (value 1, standard) vs.
        initial individual
13                % probability (value 0)
14  initialPerc=8; % X% of the population are switched to purple
        before R1
15                % or X% chance for each individual (standard: 8)
16
17  bonusG=8;  % generated points for each G action (8)
18  bonusH=40; % generated points for each H action (40)
19  %--------------------------------
20
21
22  %--------------------------------
23  % SET BASIC SIMULATION PARAMETERS
24  %--------------------------------
25  numTrials=1000000;
26  %numRiskTests=25;
27  %--------------------------------
```

```
28
29
30 % ------------------------------
31 % DETERMINE SIM TYPE
32 % ------------------------------
33 simType="Study2";
34
35 bconditionalOutcomes=1; %save information on behavioral patterns
36 bSingleSave=0; %save trial-wise results
37 bMeanSave=1; % save average results
38 bStandardDeviationSave=1; %save standard deviations
39 bPercentileSave=1;  %save percentiles
40 bDecileSave=1; %save deciles
41
42 % ------------------------------
43
44 for simParameter =2:6
45   disp(int2str(simParameter))
46
47   saveFolder="U:\WoikeJan\transmissionGame\july20\res\";
48   saveName=strcat("Study2-", int2str(simParameter));
49
50   [savePopState,saveOutcomeState,saveSumOutcomes,...
51     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
52     transmissionPlaySimulationBasev01_14jul20(...
53    popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
          ,...
54    initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
55    bconditionalOutcomes);
56
57
58   complete = saveSimulationResults_v02(...
59      saveFolder,saveName,numberRounds,...
60      savePopState,saveOutcomeState,saveSumOutcomes,
           saveInfectionRate,...
61      saveActionRate,saveConditionalOutcomes,...
62      bconditionalOutcomes,bSingleSave,bMeanSave,
           bStandardDeviationSave,...
63      bPercentileSave,bDecileSave)
64  toc
65 end
66 toc
```

SCR-10.3.16 Analysis of empirical data: Resampling populations (Study 1)

```
tic;
% ------------------------------
% SET BASIC GAME PARAMETERS
% ------------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching colors for
            % G-G / H-G or G-H / H-H interactions if colors are mixed
            % (0.05 / 0.15 /0.25)
bfixedPerc=1; % initial percentage (value 1, standard) vs. initial individual
              % probability (value 0)
initialPerc=8; % X% of the population are swittched to purple before R1
               % or X% chance for each individual (standard: 8)

bonusG=8;  % generated points for each G action (8)
bonusH=40; % generated points for each H action (40)
% ------------------------------


% ------------------------------
% SET BASIC SIMULATION PARAMETERS
% ------------------------------
numTrials=1000000;
%numRiskTests=25;
% ------------------------------


% ------------------------------
% DETERMINE SIM TYPE
% ------------------------------
simType="Study1Resample";
simParameter=0;

bconditionalOutcomes=1; %save information on behavioral patterns
bSingleSave=0; %save trial-wise results
bMeanSave=1; % save average results
bStandardDeviationSave=1; %save standard deviations
bPercentileSave=1;  %save percentiles
```

```
bDecileSave=1; %save deciles

%-------------------------

for simParameter =1:1
  disp(int2str(simParameter))

  saveFolder="U:\WoikeJan\transmissionGame\july20\resResample\";
  saveName=strcat("Study1Resample");

  [savePopState,saveOutcomeState,saveSumOutcomes,...
    saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
    transmissionPlaySimulationBasev01_14jul20(...
   popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
      ,...
   initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
   bconditionalOutcomes);


  complete = saveSimulationResults_v02(...
     saveFolder,saveName,numberRounds,...
     savePopState,saveOutcomeState,saveSumOutcomes,
        saveInfectionRate,...
     saveActionRate,saveConditionalOutcomes,...
     bconditionalOutcomes,bSingleSave,bMeanSave,
        bStandardDeviationSave,...
     bPercentileSave,bDecileSave)
 toc
end
toc
```

SCR-10.3.17 Analysis of empirical data: Resampling populations (Study 2)

```
  tic;
%-------------------------
% SET BASIC GAME PARAMETERS
%-------------------------
popSize=100;
numberRounds=25; % Number of game rounds (25)
passiveRisk=0; % Probability of switching color after each round
   (0, not used)
interactionRisks=[0.05,0.15,0.25];  % Probability of switching
   colors for
            % G-G / H-G or G-H / H-H interactions if colors are
               mixed
```

```
10              % (0.05 / 0.15 /0.25)
11 bfixedPerc=1; % initial percentage (value 1, standard) vs.
       initial individual
12                % probability (value 0)
13 initialPerc=8; % X% of the population are switched to purple
       before R1
14                % or X% chance for each individual (standard: 8)
15
16 bonusG=8;  % generated points for each G action (8)
17 bonusH=40; % generated points for each H action (40)
18 %--------------------------
19
20
21 %--------------------------
22 % SET BASIC SIMULATION PARAMETERS
23 %--------------------------
24 numTrials=1000000;
25 %numRiskTests=25;
26 %--------------------------
27
28
29 %--------------------------
30 % DETERMINE SIM TYPE
31 %--------------------------
32 simType="Study2Resample";
33
34 bconditionalOutcomes=1; %save information on behavioral patterns
35 bSingleSave=0; %save trial-wise results
36 bMeanSave=1; % save average results
37 bStandardDeviationSave=1; %save standard deviations
38 bPercentileSave=1;  %save percentiles
39 bDecileSave=1; %save deciles
40
41 %--------------------------
42
43 for simParameter =2:6
44   disp(int2str(simParameter))
45
46   saveFolder="U:\WoikeJan\transmissionGame\july20\resResample\";
47   saveName=strcat("Study2Resample-", int2str(simParameter));
48
49   [savePopState,saveOutcomeState,saveSumOutcomes,...
50     saveInfectionRate,saveActionRate,saveConditionalOutcomes]=...
51     transmissionPlaySimulationBasev01_14jul20(...
```

```
52      popSize,numberRounds,passiveRisk,interactionRisks,bfixedPerc
            ,...
53      initialPerc,bonusG,bonusH,numTrials,simType,simParameter,...
54      bconditionalOutcomes);
55
56
57    complete = saveSimulationResults_v02(...
58        saveFolder,saveName,numberRounds,...
59        savePopState,saveOutcomeState,saveSumOutcomes,
              saveInfectionRate,...
60        saveActionRate,saveConditionalOutcomes,...
61        bconditionalOutcomes,bSingleSave,bMeanSave,
              bStandardDeviationSave,...
62        bPercentileSave,bDecileSave)
63   toc
64  end
65  toc
```