When Philosophy (of Science) Meets Formal Methods: a Citation Analysis of Early Approaches between Research Fields

Supplementary Materials

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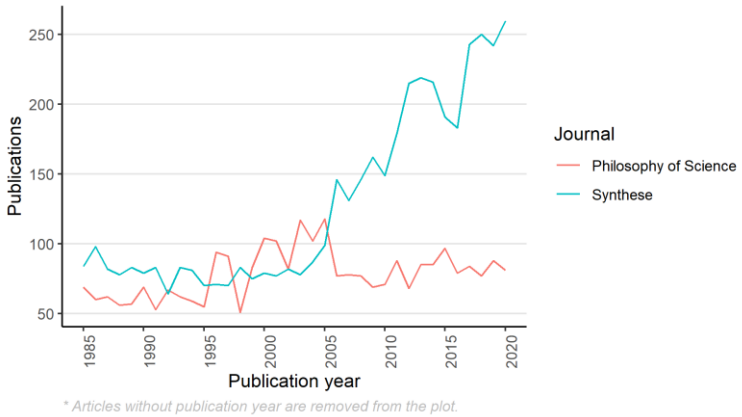
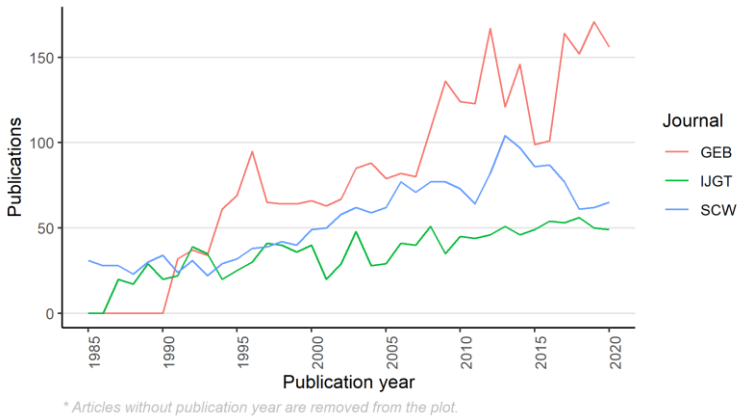
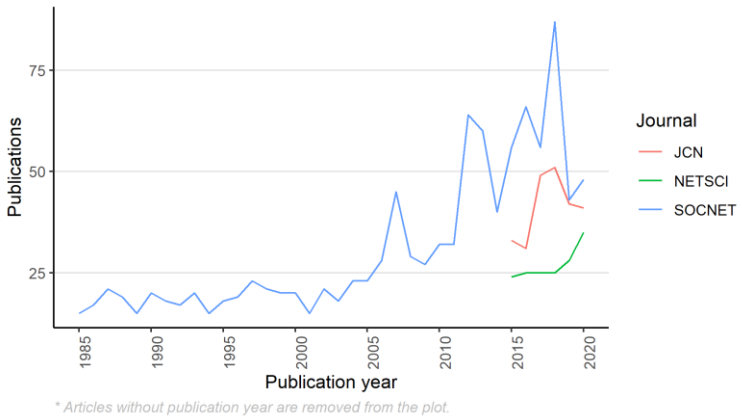
Journal articles over time



S1a: Articles in Philosophy journals over time broken down by journal.

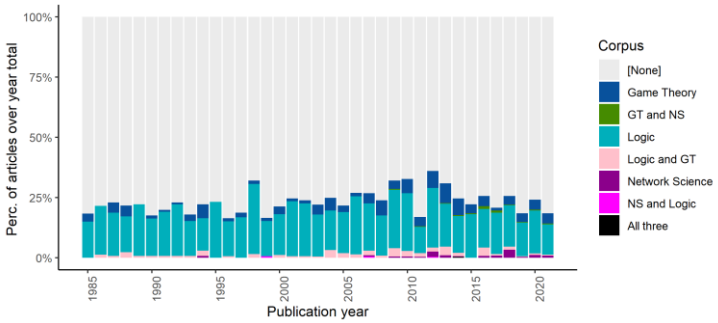


S1b: Articles in Game Theory journals over time, broken down by journal.

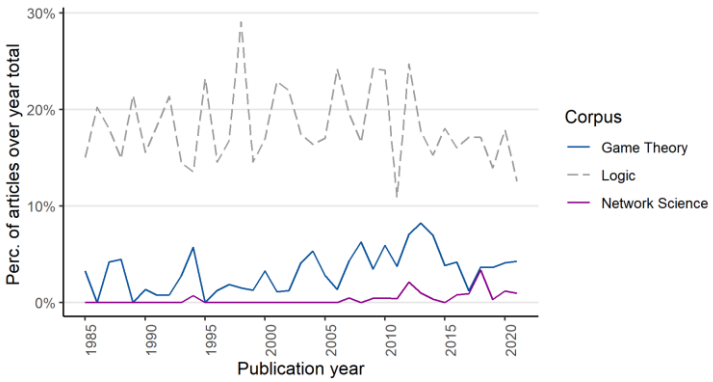


S1c: Articles in Network Science journals, broken down by journal.

Corpora over time

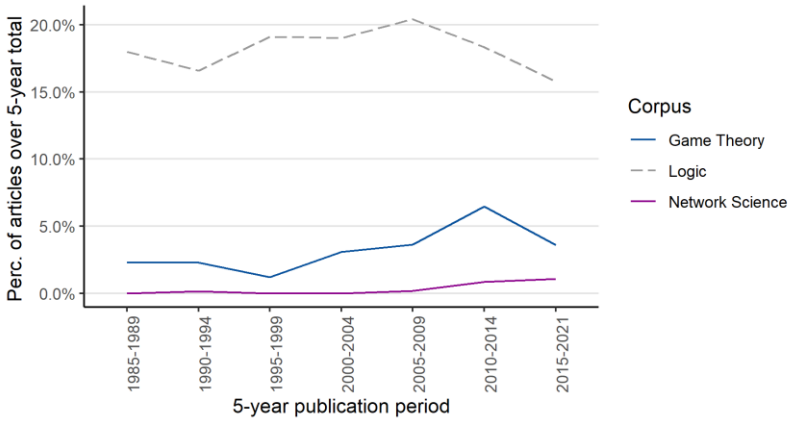


S2a: Percentage of articles over year total, broken down by corpus (all corpora).



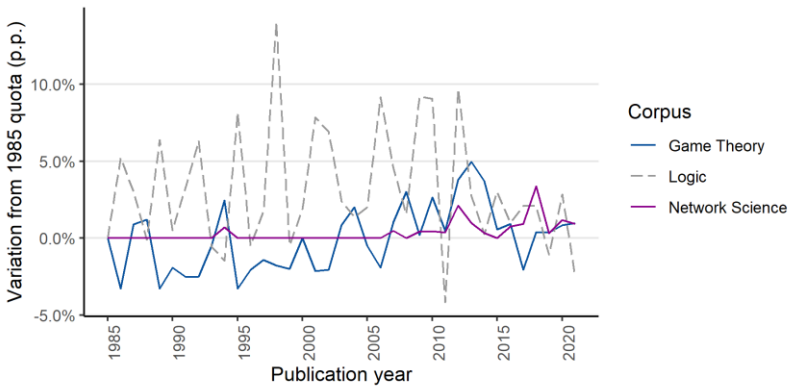
** Data from articles occurring in multiple corpora are not shown on the plot.*

S2b: Percentage of articles over year total, broken down by corpus (only main corpora).



** Data from articles occurring in multiple corpora are not shown on the plot.*

S2c: Percentage of articles over year total, broken down by corpus (only main corpora) and averaged over a 5-year period.

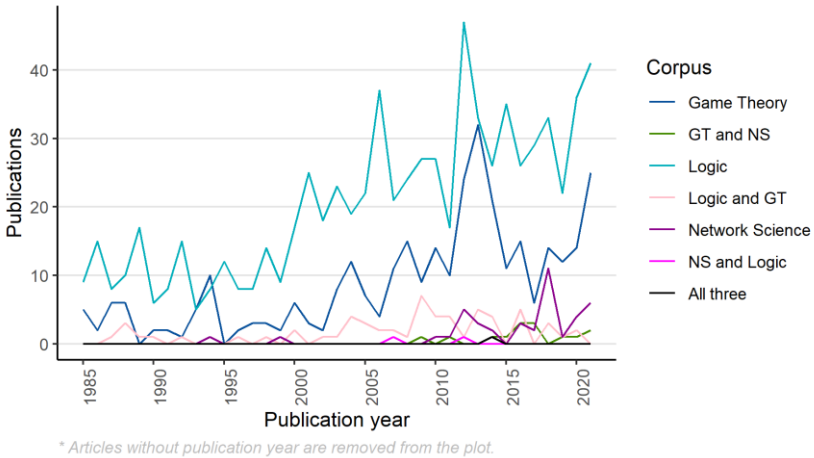


** Data from articles occurring in multiple corpora are not shown on the plot.*

Baselines (1985): Logic = 15%; Game Theory = 3%; Network Science = 0%

S2d: Variation (in percentage points) of articles over year total, broken down by corpus (only main corpora) using 1985 value as baseline.

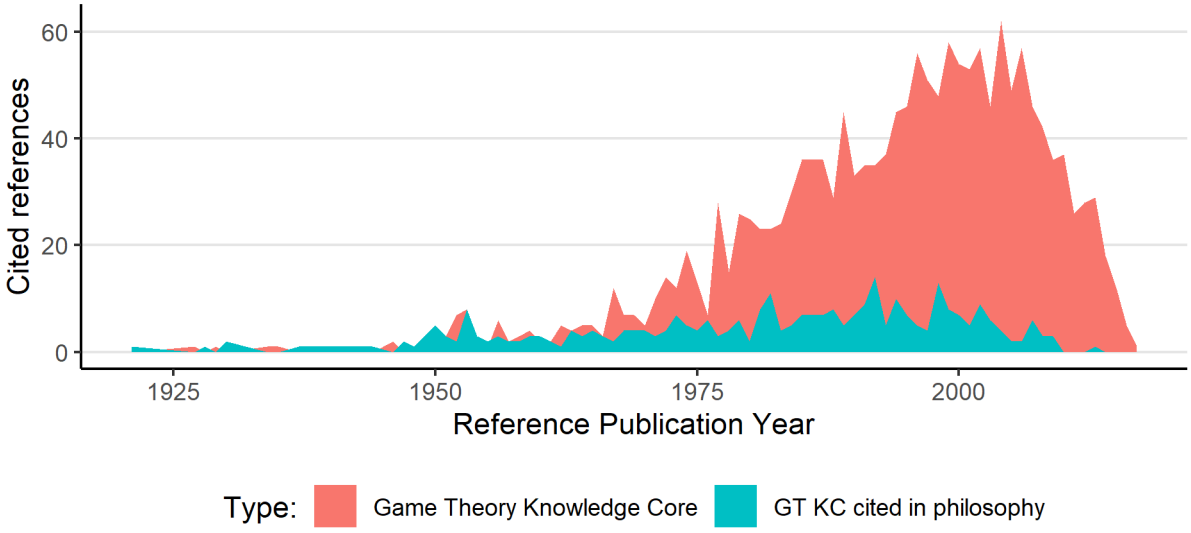
Corpora over time



** Articles without publication year are removed from the plot.*

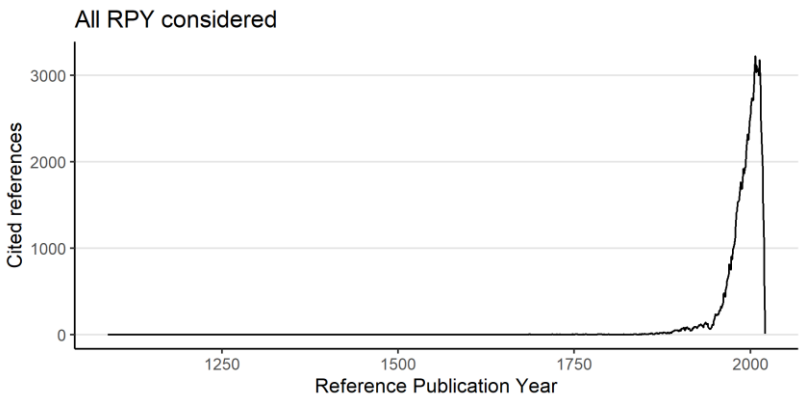
S2e: Absolute number of philosophy papers broken down by corpus.

RPY spectroscopies

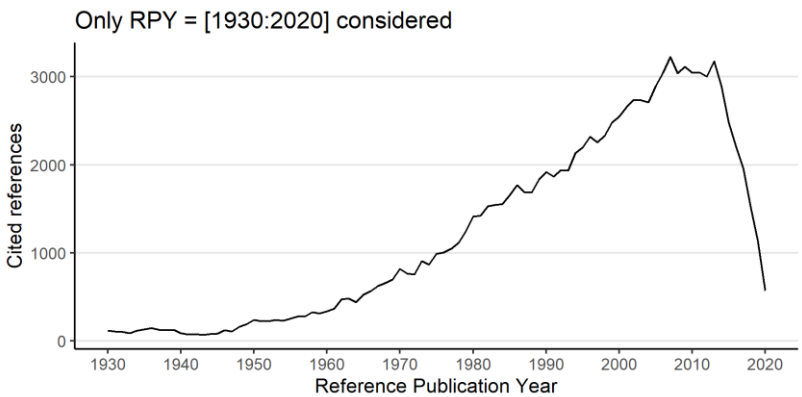


** 2 cited reference published before 1900 are removed from the plot*

S3: RPY spectroscopy of the Game Theory knowledge core, compared with the RPY spectroscopy of the Game Theory references cited in philosophy.



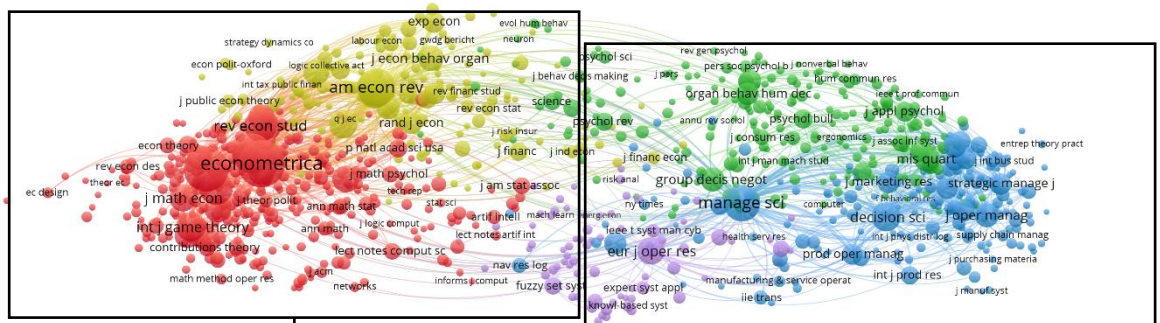
S4a: RPY spectroscopy for philosophy, all RPYs considered.

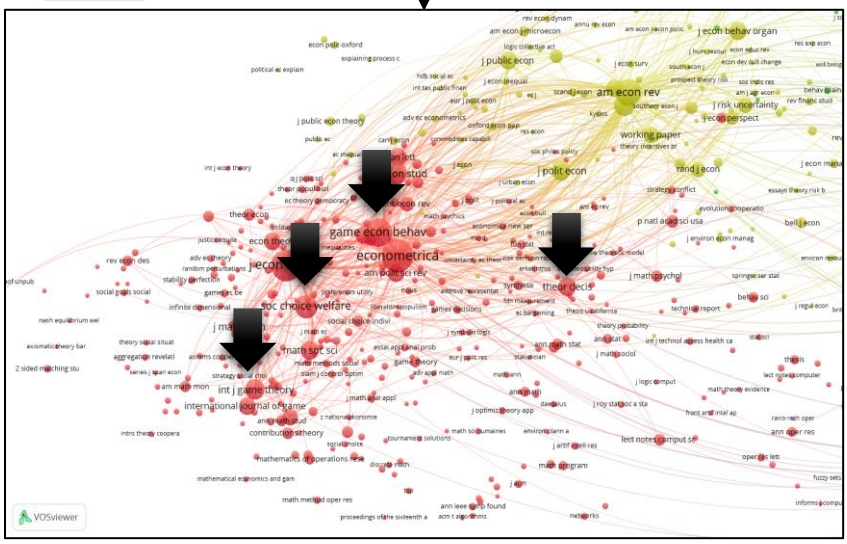


S4b: RPY spectroscopy for philosophy, only RPYs in the period 1930 to 2020 considered.

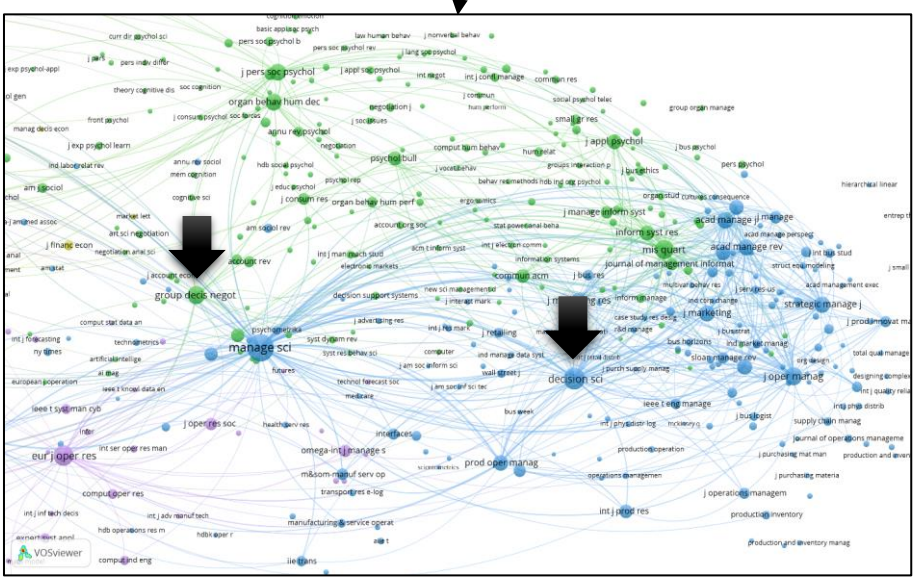
Game theory journals

*S5: Journal co-citation map extracted from five game theory journals (*IJGT, GEB, SCW, Theory and Decision, Decision Sciences, Group Decisions and Negotiations*). Threshold = 20 cits, visualized with VOSviewer).*





Journal	Cluster	Cits
game econ behav	Red	8519
int j game theory	Red	4751
soc choice welfare	Red	4731
decision sci	Blue	3023
theor decis	Red	2096
group decis negot	Green	1500

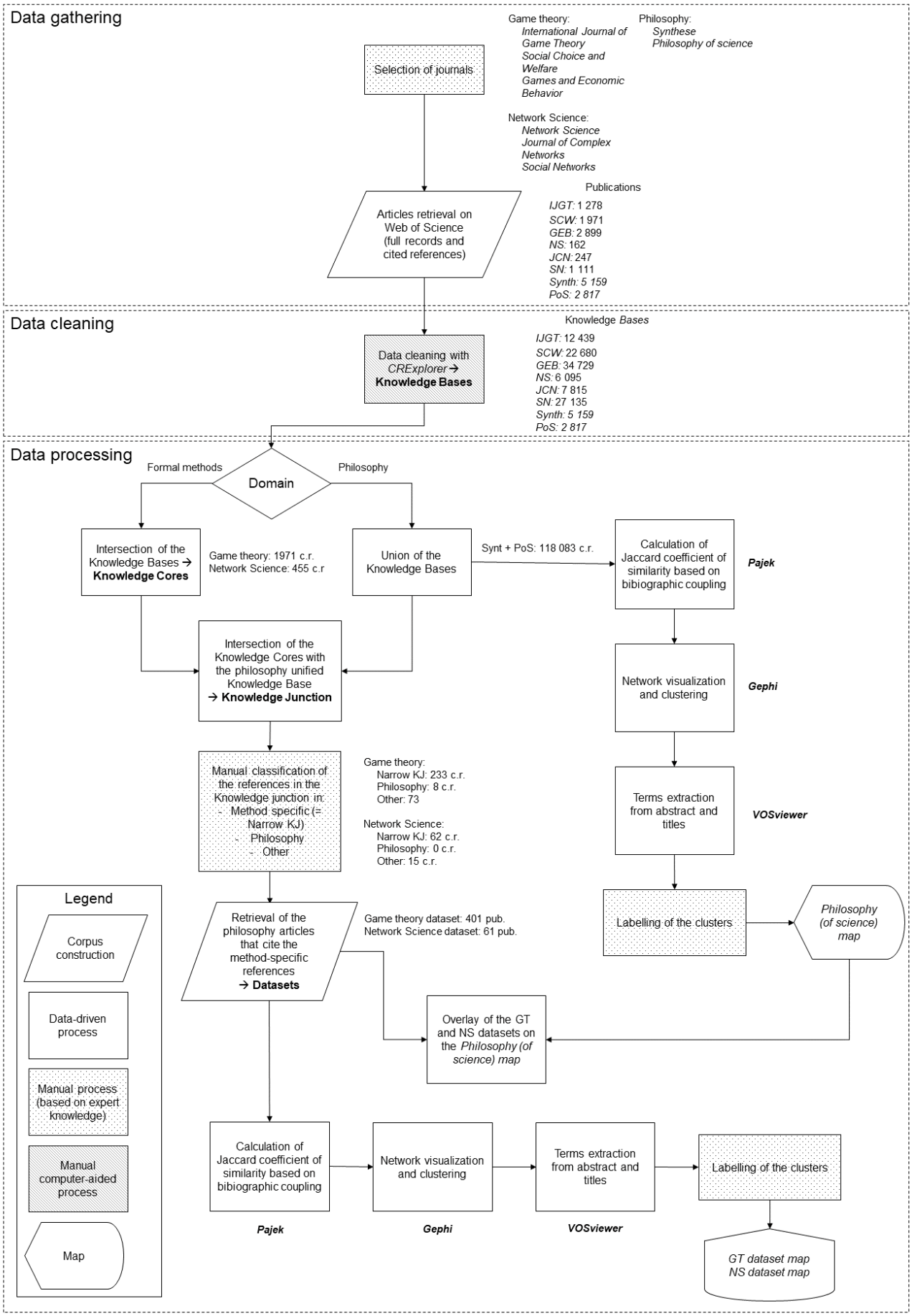


Further data on philosophy journals

Rank	Journal	Papers citing GT references (% on journal total papers)
1	*Synthese*	*308 (6.0%)*
2	*Philosophy of Science*	*93 (3.3%)*
3	Journal of Philosophy	34 (4.0%)
4	British Journal for the Philosophy of Science	41 (2.3%)
5	Mind	12 (1.6%)
6	Philosophical Review	6 (1.6%)
7	Nous	12 (1.0%)
8	Philosophy and Phenomenological Research	8 (0.5%)

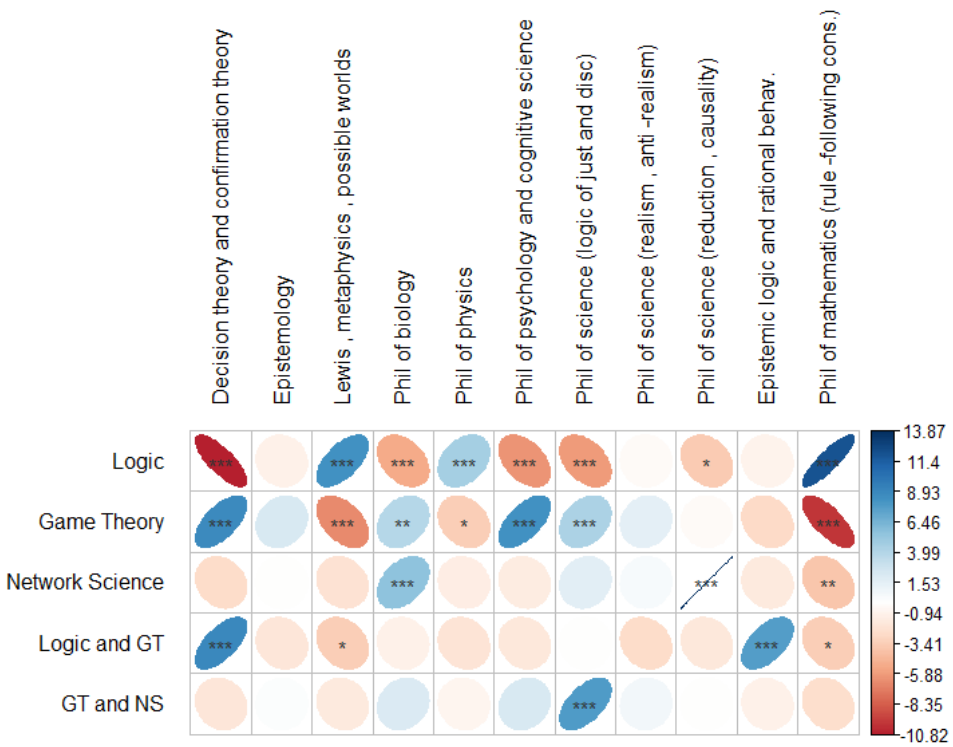
S6: Number of articles in 8 Philosophy journals that cite GT method-specific references (all articles available in WoS in the timespan 1985-2021 considered).

Flowchart of the methodology



S7: Flowchart representing the methodology of corpus construction followed in the article.

Association plot



S8: Association plot between corpora and research areas with significance codes. One star indicates (corrected) significance at the level of 0.05, two stars 0.01 and three stars 0.001. No stars indicate that the test was not significant.

```
################################################################################
                "When Philosophy (of Science) Meets Formal Methods.
            A Citation Analysis of Early Approaches between Research Fields"

                                R SCRIPTS

                  - Eugenio Petrovich, Ph.D. (eugenio.petrovich@unisi.it) -
################################################################################

library(dplyr)
library(ggplot2)
library(reshape2)
library(corrplot)
library(rcompanion)
library(chisq.posthoc.test)

### Figures in the article

# Figure 1: Citations to formal and empirical references by publication year of
the citing paper.

dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")

dati <- dati %>% select(c("PY", "N_Empirical","N_Formal"))

dati = melt(dati, id.vars = c("PY"), value.name = "CR")

dati$variable <- factor(dati$variable, levels = c("N_Empirical","N_Formal"))

levels(dati$variable) <- c("Empirical", "Formal")

lineplot_abs_GT <- ggplot(data = dati, aes (x = PY, y = CR, group = variable,
color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "References", color = "CR Type")+
      theme(panel.grid.major.y = element_line(color = "grey90"))+
      scale_color_manual(values = c("#08519c", "#6baed6"))+
      scale_x_continuous(breaks = seq(1985, 2020, 5))
```

```
lineplot_abs_GT


ggsave("GT_abs_over_time.png", lineplot_abs_GT, width = 16, height = 9, units =
"cm", dpi = "print")


# Figure 2: Quota of citations to formal and empirical references on the
publication year's total, by

publication year


dati <- dati %>% select(c("PY", "Perc_Empirical","Perc_Formal"))


dati = melt(dati, id.vars = c("PY"), value.name = "Perc_CR")


dati$variable <- factor(dati$variable, levels =
c("Perc_Empirical","Perc_Formal"))


levels(dati$variable) <- c("Empirical", "Formal")


lineplot_perc_GT <- ggplot(data = dati, aes (x = PY, y = Perc_CR, group =
variable, color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "References (% on PY total)", color = "CR
Type")+
      theme(panel.grid.major.y = element_line(color = "grey90"))+
      scale_color_manual(values = c("#08519c", "#6baed6"))+
      scale_y_continuous(labels = scales::percent) +
      scale_x_continuous(breaks = seq(1985, 2020, 5))


lineplot_perc_GT


ggsave("GT_perc_over_time.png", lineplot_perc_GT, width = 16, height = 9, units
= "cm", dpi = "print")


# Figure 6: RPY spectroscopy (Thor et al., 2016) of the network science
knowledge core, compared

with the RPY spectroscopy of the network science references cited in
philosophy.


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")
```

```
dati <- dati %>% select(c("RPY", "N_CR_KC","N_CR_Phil"))


dati = melt(dati, id.vars = c("RPY"), value.name = "CR")


dati$variable <- factor(dati$variable, levels = c("N_CR_KC","N_CR_Phil"))


levels(dati$variable) <- c("Network Science Knowledge Core", "NS KC cited in
philosophy")



KC_lineplot <- ggplot(data = dati, aes (x = RPY, y = CR, group = variable, fill
= variable)) +
      geom_area(position = position_dodge(width = 0))+
      theme_classic()+
      labs(x="Reference Publication Year", y = "Cited references", fill =
"Type:")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            legend.position = "bottom")
KC_lineplot


ggsave("NS_KC_over_time.png", KC_lineplot, width = 16, height = 8, units =
"cm", dpi = "print")


# Figure 7: Ratio between the number of network science references cited in
philosophy and the
number of network science references in the network science knowledge core,
over reference
publication year.


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("RPY", "Ratio"))


ratio_lineplot <- ggplot(data = dati, aes (x = RPY, y = Ratio)) +
      geom_line(color = "#00AFBB")+
      theme_classic()+
      labs(x="Reference Publication Year", y = "N CR phil / N CR Net Science
KC",
```

```
            caption = "* Data for RPY < 1999 removed from the plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0))+
      scale_x_continuous(breaks = seq(2000, 2020, 2)) +
      scale_y_continuous(limits = c(0,1), breaks = seq(0, 1, .2))

ratio_lineplot

ggsave("NS_CR_ratio_over_time.png", ratio_lineplot, width = 16, height = 8,
units = "cm", dpi = "print")

# Figure 8: Number of philosophy articles citing network science over time.

dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")

# Seleziono le colonne che mi servono

dati <- dati %>% select(c("Year", "NS.articles"))

barplot <- ggplot(data = dati, aes (x = Year, y = NS.articles))+
      geom_bar(stat = "identity", fill = "#00AFBB")+
      theme_classic()+
      labs(x="Publication Year", y = "Articles")+
      theme(panel.grid.major.y = element_line(color = "grey90"))+
      scale_y_continuous(breaks = seq(0, 14, 2))

barplot

ggsave("NS_corpus_over_time.png", barplot, width = 16, height = 8, units =
"cm", dpi = "print")

# Figure 9: Average age of network science cited reference by citing paper
publication year by cited
reference type.

dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")

dati <- dati %>% select(c("PY", "All.CR", "Empirical.CR","Formal.CR"))
```

```
dati = melt(dati, id.vars = c("PY"), value.name = "CR")


dati$variable <- factor(dati$variable, levels = c("All.CR", "Empirical.CR",
"Formal.CR"))


levels(dati$variable) <- c("All CR", "Empirical CR", "Formal CR")


lineplot <- ggplot(data = subset(dati, PY > 2000), aes (x = PY, y = CR, color =
variable, size = variable, linetype = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication Year", y = "CR avg age", color = "CR type", size ="CR
type", linetype = "CR type",
            caption = "* Data from articles before 2000 removed from the
plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0))+
      scale_x_continuous(breaks = seq(2000, 2020, 2)) +
      scale_color_manual(values = c("#08306b", "#08519c", "#6baed6"))+
      scale_size_manual(values = c(1.5, 1, 1)) +
      scale_y_continuous(breaks = seq(0, 30, 5)) +
      scale_linetype_manual(values=c("solid", "longdash", "dashed"))


lineplot


ggsave("NS_CR_age_over_time.png", lineplot, width = 16, height = 8, units =
"cm", dpi = "print")


# Figure 11: Association plot between corpora and research areas. The strength
and direction of the
association is shown by the size, orientation, and color of the ellipses.


dati <- read.delim(file.choose(), sep = ";", row.names = 1)


dati[is.na(dati)] <- 0


dati


dt <- as.table(as.matrix(dati))
```

```
rownames(dt) <- c("Logic",
      "Game Theory",
      "Network Science",
      "Logic and GT",
      "GT and NS")

colnames(dt) <- c("Decision theory and confirmation theory",
      "Epistemology",
      "Lewis, metaphysics, possible worlds",
      "Phil of biology",
      "Phil of physics",
      "Phil of psychology and cognitive science",
      "Phil of science (logic of just and disc)",
      "Phil of science (realism, anti-realism)",
      "Phil of science (reduction, causality)",
      "Epistemic logic and rational behav.",
      "Phil of mathematics (rule-following cons.)")

# Chi-squared test
chisq <- chisq.test(dt)
chisq

### Results ####
### X-squared = 807.17, df = 40, p-value < 2.2e-16
#####

chisq$observed
round(chisq$expected,2)
round(chisq$residuals, 3)
chisq$p.value
chisq$statistic

# Correlation plot with residuals in colored ellipses
corrplot(chisq$residuals, is.cor = FALSE, cl.ratio = 0.4, method = "ellipse",
col = col2(100),
      tl.col = "black", tl.offset = 1)

# Correlation plot with residuals in numbers
```

```
corrplot(dt, is.cor = FALSE, cl.ratio = 0.4, method = "number", col = "black",
      tl.col = "black", tl.offset = 1)



# Cramer's V
cramerV(dt, verbose = TRUE)

### Results ###
# Rows          = 5
# Columns       = 11
# N             = 1861
# Chi-squared   = 807.2
# Phi           = 0.4337
# Corrected Phi = NA
# V             = 0.3293
# Corrected V   = NA

# Cramer V
#  0.3293
########################

# Post-hoc test
chisq_posthoc <-chisq.posthoc.test(dt)


chisq_p_values <- chisq_posthoc[chisq_posthoc$Value == 'p values',]
chisq_p_values <- chisq_p_values[, !names(chisq_p_values) %in% c("Dimension",
"Value")]


chisq_residuals <- chisq_posthoc[chisq_posthoc$Value == 'Residuals',]
chisq_residuals <- chisq_residuals[, !names(chisq_residuals) %in%
c("Dimension", "Value")]


colnames(chisq_residuals) <- c("Decision theory and confirmation theory",
      "Epistemology",
      "Lewis , metaphysics , possible worlds",
      "Phil of biology",
      "Phil of physics",
      "Phil of psychology and cognitive science",
      "Phil of science (logic of just and disc)",
```

```
      "Phil of science (realism , anti -realism)",
      "Phil of science (reduction , causality)",
      "Epistemic logic and rational behav.",
      "Phil of mathematics (rule -following cons.)")

rownames(chisq_residuals) <- c("Logic",
      "Game Theory",
      "Network Science",
      "Logic and GT",
      "GT and NS")

corrplot(
      data.matrix(chisq_residuals),
      p.mat = data.matrix(chisq_p_values),
      method = "ellipse",
      is.cor = FALSE,
      tl.col = "black",
      tl.offset = 1,
      sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
      insig = 'label_sig', pch.col = 'grey20'
      )



--------------------------------------------------------------------------------
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### Figures in the Supplementary Materials ###


# Figures S1: Journal articles over time


# S1a: articles in philosophy journals over time


file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Overall
map/Philosophy_articles_over_time.csv"


dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "Philosophy.of.Science", "Synthese"))


dati = melt(dati, id.vars = c("PY"), value.name = "articles")
```

```
dati$variable <- factor(dati$variable, levels = c("PY",
"Philosophy.of.Science", "Synthese"))


levels(dati$variable) <- c("PY", "Philosophy of Science", "Synthese")


lineplot_journal <- ggplot(data = dati, aes (x = PY, y = articles, group =
variable, color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Publications", color = "Journal",
            caption = "* Articles without publication year are removed from the
plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_x_continuous(breaks = seq(1985, 2020, 5))


lineplot_journal


ggsave("Phil_journals_over_time.png", lineplot_journal, width = 16, height = 9,
units = "cm", dpi = "print")


# S1b: articles in Game Theory journals over time


file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Game
Theory analyses/GT_journals_over_time.csv"


dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


dati[is.na(dati)] <- 0


dati <- dati %>% select(c("PY", "GEB", "IJGT", "SCW"))


dati = melt(dati, id.vars = c("PY"), value.name = "articles")


dati$variable <- factor(dati$variable, levels = c("PY", "GEB", "IJGT", "SCW"))


levels(dati$variable) <- c("PY", "GEB", "IJGT", "SCW")
```

```
lineplot_GT_journal <- ggplot(data = dati, aes (x = PY, y = articles, group = variable, color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Publications", color = "Journal",
            caption = "* Articles without publication year are removed from the plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust = 0),
            axis.text.x = element_text(angle = 90))+
      scale_x_continuous(breaks = seq(1985, 2020, 5))


lineplot_GT_journal


ggsave("GT_journals_over_time.png", lineplot_GT_journal, width = 16, height = 9, units = "cm", dpi = "print")


# S1c: articles in Network Science journals over time


file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Network Science analyses/Correct analyses/NS_journals_over_time.csv"


dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "JCN", "NETSCI", "SOCNET"))


dati = melt(dati, id.vars = c("PY"), value.name = "articles")


dati$variable <- factor(dati$variable, levels = c("PY", "JCN", "NETSCI", "SOCNET"))


levels(dati$variable) <- c("PY", "JCN", "NETSCI", "SOCNET")


lineplot_NS_journal <- ggplot(data = dati, aes (x = PY, y = articles, group = variable, color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Publications", color = "Journal",
            caption = "* Articles without publication year are removed from the plot.")+
```

```
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_x_continuous(breaks = seq(1985, 2020, 5))


lineplot_NS_journal


ggsave("NS_journals_over_time.png", lineplot_NS_journal, width = 16, height =
9, units = "cm", dpi = "print")


# Figures S2: Corpora over time


# S2a: Composition over time (barplot)


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "X.None.", "Game.Theory", "GT_NT", "Logic",
"Logic_GT",
      "Network.Theory", "NT_Logic", "Logic_GT_NT"))


dati = melt(dati, id.vars = c("PY"), value.name = "p_articles")


dati$variable <- factor(dati$variable, levels = c("X.None.", "Game.Theory",
"GT_NT", "Logic", "Logic_GT",
      "Network.Theory", "NT_Logic", "Logic_GT_NT"))


levels(dati$variable) <- c("[None]", "Game Theory", "GT and NS", "Logic",
"Logic and GT", "Network Science", "NS and Logic", "All three")


Barplot_corpora_1_year <- ggplot(data = dati, aes (x = PY, y = p_articles,
group = variable, fill = variable))+
      geom_bar(position = "fill", stat = "identity")+
      theme_classic()+
      labs(x="Publication year", y = "Perc. of articles over year total ", fill
= "Corpus")+
      theme(plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_fill_manual(values = c("grey92", "#08519c", "chartreuse4",
"#00AFBB", "pink", "magenta4", "magenta1", "black"))+
      scale_y_continuous(labels = scales::percent) +
```

```
      scale_x_continuous(breaks = seq(1985, 2020, 5))


Barplot_corpora_1_year


ggsave("Barplot_Corpora_over_time_1_year.png", Barplot_corpora_1_year, width =
20, height = 9, units = "cm", dpi = "print")



# S2b: 1-year perc on 1-year total


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "Game.Theory", "Logic", "Network.Theory"))


dati = melt(dati, id.vars = c("PY"), value.name = "p_articles")


dati$variable <- factor(dati$variable, levels = c("Game.Theory", "Logic",
"Network.Theory"))


levels(dati$variable) <- c("Game Theory", "Logic", "Network Science")


lineplot_corpora_1_year <- ggplot(data = dati, aes (x = PY, y = p_articles,
group = variable, color = variable, linetype = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Perc. of articles over year total ", color
= "Corpus", linetype = "Corpus",
            caption = "* Data from articles occurring in multiple corpora are
not shown on the plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_color_manual(values = c("#08519c", "#999999", "magenta4"))+
      scale_y_continuous(labels = scales::percent) +
      scale_x_continuous(breaks = seq(1985, 2020, 5))+
      scale_linetype_manual(values=c("solid", "longdash", "solid"))


lineplot_corpora_1_year
```

```
ggsave("Corpora_over_time_1_year.png", lineplot_corpora_1_year, width = 16,
height = 9, units = "cm", dpi = "print")


# S2c: 5-year perc on 5-year total


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "Game.Theory", "Logic", "Network.Theory"))


dati = melt(dati, id.vars = c("PY"), value.name = "p_articles")


dati$PY <- factor(dati$PY, levels = c("1985-1989", "1990-1994", "1995-1999",
"2000-2004", "2005-2009", "2010-2014", "2015-2021"))


dati$variable <- factor(dati$variable, levels = c("Game.Theory", "Logic",
"Network.Theory"))


levels(dati$variable) <- c("Game Theory", "Logic", "Network Science")


lineplot_corpora_5_year <- ggplot(data = dati, aes (x = PY, y = p_articles,
group = variable, color = variable, linetype = variable))+
      geom_line()+
      theme_classic()+
      labs(x="5-year publication period", y = "Perc. of articles over 5-year
total ", color = "Corpus", linetype = "Corpus",
            caption = "* Data from articles occurring in multiple corpora are
not shown on the plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_color_manual(values = c("#08519c", "#999999", "magenta4"))+
      scale_y_continuous(labels = scales::percent) +
      scale_linetype_manual(values=c("solid", "longdash", "solid"))


lineplot_corpora_5_year


ggsave("Corpora_over_time_5_year.png", lineplot_corpora_5_year, width = 16,
height = 9, units = "cm", dpi = "print")


# S2d: Variation over time (1985 = 0)
```

```
# 1-year perc - 1985 perc


dati <- read.delim(file.choose(), header = TRUE, sep = ";", dec =",")


dati <- dati %>% select(c("PY", "Game.Theory", "Logic", "Network.Theory"))


dati = melt(dati, id.vars = c("PY"), value.name = "p_articles")


dati$variable <- factor(dati$variable, levels = c("Game.Theory", "Logic",
"Network.Theory"))


levels(dati$variable) <- c("Game Theory", "Logic", "Network Science")


lineplot_variation_corpora_1_year <- ggplot(data = dati, aes (x = PY, y =
p_articles, group = variable, color = variable, linetype = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Variation from 1985 quota (p.p.)", color =
"Corpus", linetype = "Corpus",
            caption = "* Data from articles occurring in multiple corpora are
not shown on the plot.\n
                  Baselines (1985): Logic = 15%; Game Theory = 3%; Network
Science = 0%")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_color_manual(values = c("#08519c", "#999999", "magenta4"))+
      scale_y_continuous(labels = scales::percent) +
      scale_x_continuous(breaks = seq(1985, 2020, 5))+
      scale_linetype_manual(values=c("solid", "longdash", "solid"))


lineplot_variation_corpora_1_year


ggsave("Variation_Corpora_over_time_1_year.png",
lineplot_variation_corpora_1_year, width = 16, height = 9, units = "cm", dpi =
"print")


# S2e: Corpora over time (abs)


file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Overall
map/Philosophy_articles_over_time_by_corpus.csv"
```

```
dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


dati[is.na(dati)] <- 0


dati <- dati %>% select(c("PY", "Game_Theory", "GT_NS", "All_three", "Logic",
"Network_Science", "NS_Logic", "GT_Logic"))


dati = melt(dati, id.vars = c("PY"), value.name = "articles")


dati$variable <- factor(dati$variable, levels = c("Game_Theory", "GT_NS",
"All_three", "Logic", "Network_Science", "NS_Logic", "GT_Logic"))


levels(dati$variable) <- c("Game Theory", "GT and NS", "All three", "Logic",
"Network Science", "NS and Logic", "Logic and GT")


dati$variable <- factor(dati$variable, levels = c("Game Theory", "GT and NS",
"Logic", "Logic and GT", "Network Science", "NS and Logic", "All three"))




lineplot_corpus_abs <- ggplot(data = dati, aes (x = PY, y = articles, group =
variable, color = variable))+
      geom_line()+
      theme_classic()+
      labs(x="Publication year", y = "Publications", color = "Corpus",
            caption = "* Articles without publication year are removed from the
plot.")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust =
0),
            axis.text.x = element_text(angle = 90))+
      scale_x_continuous(breaks = seq(1985, 2020, 5)) +
      scale_color_manual(values = c("#08519c", "chartreuse4", "#00AFBB", "pink",
"magenta4", "magenta1", "black"))


lineplot_corpus_abs


ggsave("Phil_corpora_over_time.png", lineplot_corpus_abs, width = 16, height =
9, units = "cm", dpi = "print")


# Figure S3: GT Knowledge Core over time
```

```
file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Game Theory analyses/GT_KC_over_time.csv"


dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


dati[is.na(dati)] <- 0


dati <- dati %>% select(c("RPY", "Yes", "No"))


dati = melt(dati, id.vars = c("RPY"), value.name = "articles")


dati$variable <- factor(dati$variable, levels = c("RPY", "Yes", "No"))


dati$variable <- factor(dati$variable, levels = c("RPY", "No", "Yes"))


levels(dati$variable) <- c("RPY", "Game Theory Knowledge Core", "GT KC cited in philosophy")


dati$variable <- factor(dati$variable, levels = c("Game Theory Knowledge Core", "GT KC cited in philosophy"))




KC_GT_lineplot <- ggplot(data = dati, aes (x = RPY, y = articles, group = variable, fill = variable)) +
      geom_area(position = position_dodge(width = 0))+
      theme_classic()+
      labs(x="Reference Publication Year", y = "Cited references", fill = "Type:",
            caption = "* 2 cited reference published before 1900 are removed from the plot")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust = 0),
            legend.position = "bottom")
KC_GT_lineplot


ggsave("KC_GT_over_time.png", KC_GT_lineplot, width = 16, height = 8, units = "cm", dpi = "print")


# Figure S4: RPY spectroscopy for philosophy articles
```

```
# S4a

file_name = "C:/Users/petrovich/Dropbox/Formal Methods in Philosophy/Overall map/RPY_philosophy.csv"


dati <- read.delim(file_name, header = TRUE, sep = ";", dec =",")


RPY_phil <- ggplot (data = dati, aes (x = RPY, y = CR)) +
      geom_line()+
      theme_classic()+
      labs(x="Reference Publication Year", y = "Cited references", title = "All RPY considered")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust = 0),
            legend.position = "bottom")
RPY_phil


ggsave("RPY_phil_overall.png", RPY_phil, width = 16, height = 8, units = "cm", dpi = "print")


dati <- dati %>% filter(RPY %in% (1930:2020))


# S4b
RPY_phil_focus <- ggplot (data = dati, aes (x = RPY, y = CR)) +
      geom_line()+
      theme_classic()+
      labs(x="Reference Publication Year", y = "Cited references", title = "Only RPY = [1930:2020] considered")+
      theme(panel.grid.major.y = element_line(color = "grey90"),
            plot.caption = element_text(color = "grey", face = "italic", hjust = 0),
            legend.position = "bottom")+
      scale_x_continuous(breaks = seq(1930, 2020, 10))
RPY_phil_focus


ggsave("RPY_phil_focus.png", RPY_phil_focus, width = 16, height = 8, units = "cm", dpi = "print")


# S8


corrplot(
```

```
data.matrix(chisq_residuals),
p.mat = data.matrix(chisq_p_values),
method = "ellipse",
is.cor = FALSE,
tl.col = "black",
tl.offset = 1,
sig.level = c(0.001, 0.01, 0.05), pch.cex = 0.9,
insig = 'label_sig', pch.col = 'grey20'
)
```