% MATLAB code that produces all figures and tables (tested in MATLAB version R2015a)

clear variables;close all;clc

reps=100000;

NN=floor(logspace(log10(5),log10(1000),25));

D=[ 0 0 0 0 1 0

-0.000405 0 0.040845 0 0.879467 0

0.001808 0 -0.140177 0 1.347438 0

-0.002232 0 0.096303 0 0.727709 0

-0.001521 0 -0.020907 0 1.081481 0

0.00278 0 0.01498 0 0.907394 0

0.00083 0 0.021453 0 0.920482 0

4.4e-005 -0.006394 0.068431 0.416907 0.621071 -0.397725

0.000159 -0.003675 0.0335 0.318764 0.80056 -0.30774

9.2e-005 -0.002108 0.021276 0.265362 0.867102 -0.259037

5.5e-005 -0.001367 0.015466 0.23161 0.900716 -0.227508

1.4e-005 -0.000474 0.007345 0.165391 0.950794 -0.163968

4e-006 -0.000166 0.003573 0.117433 0.975534 -0.116936

1e-006 -5.8e-005 0.001762 0.083192 0.987806 -0.083017

0.000752 0 -0.035711 0 1.093437 0

0.001285 0.005014 -0.045284 -0.123347 1.104252 0.108304

0.001344 0.008004 -0.044151 -0.186705 1.089085 0.162694

0.001279 0.01001 -0.04117 -0.229379 1.071403 0.199348

-0.003879 -0.000117 0.027783 -0.065172 0.969217 0.065524

-0.00505 -0.007933 0.041896 0.188093 0.927568 -0.164296

-0.002025 0.00549 -0.003307 0.091123 1.02248 -0.107593

0.003962 -0.000356 0.028078 0.346926 0.712411 -0.345859];

% 1 & 2 = polynomial parameters from D matrix

% 3 = target population Pearson correlation coefficient

% 4 = figure number & scatter plot

% 5 = figure number

II=[1 1 0 0 93; % 1. Figure S3 (normal distribution, Rp = 0)

1 1 .2 0 2; % 2. Figure 2 (normal distribution, Rp = .2)

1 1 .4 0 94; % 3. Figure S4 (normal distribution, Rp = .4)

1 1 .8 0 95; % 4. Figure S5 (normal distribution, Rp = .8)

8 8 .4 0 0; % 5. No Figure (xsi^2, df = 1, with Rp = .4) % Conditions 5-7 are also used for creating Figure S6

9 9 .4 3 4; % 6. Figures 3 & 4 (exponential with Rp = .4)

14 14 .4 0 0; % 7 No Figure (xsi^2, df = 32, with Rp = .4)

18 9 .4 104 105; % 8. Figures S14 & S15 (beta with exponential)

9 9 .2 100 101; % 9. Figures S10 & S11 (exponential with Rp = .2)

9 9 .8 102 103 % 10. Figures S12 & S13 (exponential with Rp = .8)

1 1 .2 0 106]; % 11. Figure S16 (normal distribution, Rp = .2). rt instead of rs

RES=NaN(size(II,1),length(NN),8);

for i0=1:length(II);

rp=NaN(length(NN),reps);rs=rp;

c1=D(II(i0,1),:);

c2=D(II(i0,2),:);

ry=II(i0,3); % target population Pearson correlation coefficient

% 1 = Gaussian

% 2 = Logistic

% 3 = Uniform

% 4 = Laplace (double exponential)

% 5 = Triangular

% 6 = t (7 df)

% 7 = t (10 df)

% 8 = xsi^2 (1 df)

% 9 = xsi^2 (2 df) (exponential)

% 10 = xsi^2 (3 df)

% 11 = xsi^2 (4 df)

% 12 = xsi^2 (8 df)

% 13 = xsi^2 (16 df)

% 14 = xsi^2 (32 df)

% 15 = beta (alpha = 4, beta = 4)

% 16 = beta (alpha = 4, beta = 2)

% 17 = beta (alpha = 4, beta = 3/2)

% 18 = beta (alpha = 4, beta = 5/4)

% 19 = Weibull (alpha = 6, beta = 10)

% 20 = Gamma (alpha = beta = 10)

% 21 = Rayleigh (alpha = 1/2, mu = sqrt(pi/2)

% 22 = Pareto (theta = 10, alpha = 1)

syms rz

X= 3\*c1(2)\*c2(6) + 3\*c1(2)\*c2(4) + 9\*c1(2)\*c2(2) + c1(6)\*(c2(6) + c2(4) + 3\*c2(2)) +c1(5)\*c2(5)\*rz + 3\*c1(3)\*c1(5)\*rz + 15\*c1(1)\*c2(5)\*rz + 3\*c1(5)\*c2(3)\*rz +9\*c1(3)\*c2(3)\*rz + 45\*c1(1)\*c2(3)\*rz + 15\*c1(5)\*c2(1)\*rz + 45\*c1(3)\*c2(1)\*rz+225\*c1(1)\*c2(1)\*rz + 12\*c1(2)\*c2(4)\*(rz)^2 + 72\*c1(2)\*c2(2)\*(rz)^2 +6\*c1(3)\*c2(3)\*(rz)^3 + 60\*c1(1)\*c2(3)\*(rz)^3 + 60\*c1(3)\*c2(1)\*(rz)^3 +600\*c1(1)\*c2(1)\*(rz)^3 + 24\*c1(2)\*c2(2)\*(rz)^4 + 120\*c1(1)\*c2(1)\*(rz)^5+c1(4)\*(c2(6) + c2(4) + 3\*c2(2) + 2\*c2(4)\*(rz)^2 + 12\*c2(2)\*(rz)^2)-ry;

s=solve(X,rz);s=double(s);

r=sqrt(min(s(s>0)));

if isempty(r)

r=0;

end

disp(['Condition = ' num2str(i0)])

if II(i0,1)==1 && II(i0,2)==1; % if bivariate normal

R=II(i0,3); % population Pearson correlation coefficient

if i0==11 % if Kendall tau

P=2/pi\*asin(R); % population Kendall correlation coefficient

else

P=6/pi\*asin(R/2); % population Spearman correlation coefficient

end

else % if not bivariate normal

N=10^7;

w=randn(N,1);

z1=r\*w+randn(N,1)\*sqrt(1-r^2);z2=r\*w+randn(N,1)\*sqrt(1-r^2);

x=polyval(c1,z1);y=polyval(c2,z2);

R=corr(x,y); % population Pearson correlation coefficient (calculated with very large N)

P=corr(x,y,'type','spearman'); % population Pearson correlation coefficient (calculated with very large N)

disp(['Population skewness x = ' num2str(skewness(x)) ])

disp(['Population skewness y = ' num2str(skewness(y)) ])

disp(['Population kurtosis x = ' num2str(kurtosis(x)) ])

disp(['Population kurtosis y = ' num2str(kurtosis(y)) ])

end

for i1=1:length(NN)

N=NN(i1);

disp(['Condition = ' num2str(i0) ', N = ' num2str(N)]) % display counter

for i2=1:reps;

w=randn(N,1);

z1=r\*w+randn(N,1)\*sqrt(1-r^2);

z2=r\*w+randn(N,1)\*sqrt(1-r^2);

x=polyval(c1,z1);

y=polyval(c2,z2);

rp(i1,i2)=corr(x,y);

if i0==11 % if Kendall tau

rs(i1,i2)=corr(x,y,'type','kendall');

else

rs(i1,i2)=corr(x,y,'type','spearman');

end

if i1==length(NN) && II(i0,4)>0 && i2==1 % make a scatter plot

if II(i0,4)<80;figure('name',['Figure ' num2str(II(i0,4))],'numbertitle','off');else figure('name',['Figure S' num2str(II(i0,4)-90)],'numbertitle','off');end

plot(x,y,'ko')

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

xlabel('\itx', 'FontSize',20)

ylabel('\ity', 'FontSize',20)

disp(['Sample Pearson correlation coefficient = ' num2str(rp(i1,i2)) ])

if i0==11

disp(['Sample Kendall correlation coefficient = ' num2str(rs(i1,i2)) ])

else

disp(['Sample Spearman correlation coefficient = ' num2str(rs(i1,i2)) ])

end

axis equal

set(gca,'xlim',[floor(min([x;y])) ceil(max([x;y]))])

set(gca,'ylim',[floor(min([x;y])) ceil(max([x;y]))])

end

end

end

if II(i0,5)>0

if II(i0,5)<80;figure('name',['Figure ' num2str(II(i0,5))],'numbertitle','off');else figure('name',['Figure S' num2str(II(i0,5)-90)],'numbertitle','off');end

hold on

plot([0 5],[R R],'g','Linewidth',3')

plot([0 5],[P P],'m:','Linewidth',3')

plot(log10(NN),mean(rp,2),'k-o','Linewidth',3)

plot(log10(NN),prctile(rp,95,2),'k-o','Linewidth',1)

plot(log10(NN),mean(rs,2),'-s','Linewidth',3,'color',[255 165 0]/255)

plot(log10(NN),prctile(rs,95,2),'-s','Linewidth',1,'color',[255 165 0]/255)

plot(log10(NN),prctile(rs,5,2),'-s','Linewidth',1,'color',[255 165 0]/255)

plot(log10(NN),prctile(rp,5,2),'k-o','Linewidth',1)

if i0==11 % if Kendall

legend(['\it{R\_p}\rm = ' num2str(round(1000\*R)/1000)], ['\it{R\_t}\rm = ' num2str(round(1000\*P)/1000)],'mean \it{r\_p}','P5/P95 \it{r\_p}','mean \it{r\_t}','P5/P95 \it{r\_t}','location','southeast')

else

legend(['\it{R\_p}\rm = ' num2str(round(1000\*R)/1000)], ['\it{R\_s}\rm = ' num2str(round(1000\*P)/1000)],'mean \it{r\_p}','P5/P95 \it{r\_p}','mean \it{r\_s}','P5/P95 \it{r\_s}','location','southeast')

end

set(gca,'xtick',log10(NN(1:3:end)))

set(gca,'xticklabel',NN(1:3:end))

set(gca,'xlim',[0.6 3.1])

xlabel('\it{N}\rm', 'FontSize',20)

if i0==11 % if Kendall

ylabel('\it{r\_p}\rm or \it{r\_t}\rm ','Fontsize',20)

else

ylabel('\it{r\_p}\rm or \it{r\_s}\rm ','Fontsize',20)

end

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

end

disp(['Condition = ' num2str(i0) ', N = ' num2str(N)]) % display counter

RES(i0,:,:)=[transpose(1:length(NN)) ... % 1

NN' ... % 2

mean(rp,2) ... % 3

mean(rs,2) ... % 4

std(rp,[],2) ... % 5

std(rs,[],2) ... % 6

std(rp,[],2)./std(rs,[],2) ... % 7

sqrt(mean((rp-R).^2,2))./sqrt(mean((rs-P).^2,2))]; % 8

disp(squeeze(RES(i0,:,:)))

end

labels={'1 df','2 df','3 df','4 df','8 df','16 df','32 df'};

figure('name','Figure S6','numbertitle','off');hold on

V=5;

plot(log10(NN),log10(squeeze(RES(5,:,V))'),'k-o','Linewidth',3)

plot(log10(NN),log10(squeeze(RES(6,:,V))'),'g-o','Linewidth',3)

plot(log10(NN),log10(squeeze(RES(7,:,V))'),'m-o','Linewidth',3)

ax = gca;ax.ColorOrderIndex = 1;

plot(log10(NN),log10(squeeze(RES(5,:,V+1))'),'k--s','Linewidth',3)

plot(log10(NN),log10(squeeze(RES(6,:,V+1))'),'g--s','Linewidth',3)

plot(log10(NN),log10(squeeze(RES(7,:,V+1))'),'m--s','Linewidth',3)

legend('\it{SD}\rm \it{r\_p}\rm, 1 df','\it{SD}\rm \it{r\_p}\rm, 2 df','\it{SD}\rm \it{r\_p}\rm, 32 df','\it{SD}\rm \it{r\_s}\rm, 1 df','\it{SD}\rm \it{r\_s}\rm, 2 df','\it{SD}\rm \it{r\_s}\rm, 32 df')

RR=[0.025 .03 .04 .05 .07 .1 .15 .2 .25 .3 .4 .5];

set(gca,'ytick',log10(RR))

set(gca,'yticklabel',RR)

set(gca,'ylim',[-1.65 -0.25])

set(gca,'xtick',log10(NN(1:3:end)))

set(gca,'xticklabel',NN(1:3:end))

set(gca,'xlim',[0.5 3.2])

xlabel('\it{N}\rm', 'FontSize',20)

ylabel('\it{SD}\rm (\it{r\_p}\rm)\rm or \it{SD}\rm (\it{r\_s}\rm)\rm','Fontsize',20)

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

%%

V=0:0.01:1;

figure('name','Figure S1','numbertitle','off');hold on

plot(V,V,'k--','Linewidth',3)

plot(V,asin(V/2)\*6/pi,'-','Linewidth',3,'color',[255 165 0]/255);

plot(V,2/pi\*asin(V),'g:','Linewidth',3);

xlabel('\it{R\_p}\rm', 'FontSize',20)

ylabel('\it{R\_p}\rm / \it{R\_s}\rm / \it{R\_t}\rm', 'FontSize',20)

legend('\it{R\_p}\rm','\it{R\_s}\rm','\it{R\_t}\rm','location','southeast')

h = findobj(gcf,'FontName','Helvetica');

axis equal

set(h,'FontSize',20)

grid on

set(gca,'xtick',0:.1:1)

set(gca,'ytick',0:.1:1)

set(gca,'ylim',[0 1])

set(gca,'xlim',[0 1])

set(gca,'ylim',[0 1])

%%

Ri=0.5;

N=100000;

x=randn(N,1);

y=Ri\*x+sqrt((1-Ri^2))\*randn(N,1);

x=zscore(x); y=zscore(y);

V=-2.05:0.1:2.05;

xx=NaN(1,length(V)-1);

yy=NaN(1,length(V)-1);

xx2=NaN(1,length(V)-1);

yy2=NaN(1,length(V)-1);

for i=1:length(V)-1

temp=find(x>V(i) & x<=V(i+1));

xx(i)=mean(x(temp));

yy(i)=mean(y(temp));

end

figure('name','Figure S8','numbertitle','off');hold on

plot(x(1:N),y(1:N),'kx','markersize',3);

Ri=0.95;

x=randn(N,1);

y=Ri\*x+sqrt((1-Ri^2))\*randn(N,1);

x=zscore(x); y=zscore(y);

for i=1:length(V)-1

temp=find(x>V(i) & x<=V(i+1));

xx2(i)=mean(x(temp));

yy2(i)=mean(y(temp));

end

plot(x(1:N),y(1:N),'s','color','m','markersize',3)

plot(xx,yy,'g','Markerfacecolor','g','linewidth',3);hold on

plot(xx2,yy2,'g:','Markerfacecolor','g','linewidth',3);hold on

legend('Data point for \it{R\_p}\rm = 0.500','Data point for \it{R\_p}\rm = 0.950','Mean \ity\rm for given \itx\rm when \it{R\_p}\rm = 0.500','Mean \ity\rm for given \itx\rm when \it{R\_p}\rm = 0.950','location','southeast')

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

xlabel('\itx', 'FontSize',20)

ylabel('\ity', 'FontSize',20)

set(gca,'xlim',[-5 5])

set(gca,'ylim',[-5 5])

axis equal

%%

figure('name','Figure S9','numbertitle','off');hold on

rng('default');load DBQ1.mat;X=DBQ1;RP=corr(X);RS=corr(X,'type','spearman');M=mean(X);SK=skewness(X);K=kurtosis(X);

x=X(:,33);y=X(:,5);

V=unique(x);

xx=NaN(6,1);yy=xx;

for i=1:length(V)

temp=find(x==V(i) );

xx(i)=mean(x(temp));

yy(i)=mean(y(temp));

end

plot(x+0.05\*randn(size(x,1),1),y+0.05\*randn(size(y,1),1),'k.','Markerfacecolor','k','linewidth',3);hold on

plot(xx,yy,'r-o','Markerfacecolor','r','linewidth',3);hold on

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

xlabel('\itx', 'FontSize',20)

ylabel('\ity', 'FontSize',20)

axis equal

set(gca,'xlim',[.5 6.5])

set(gca,'ylim',[.5 6.5])

%%

N=200;r=0.2;MM=5;RES=.05; rng('default')

X1=randn(N,1); % sample with population mean = D

X2=r\*(X1)+sqrt((1-r^2))\*randn(N,1); % sample with population mean = 0

rp=corr(X1,X2);rs=corr(X1,X2,'type','spearman');

temp=find(abs(rp-0.2)<.001);

V1=-MM:RES:MM;V2=-MM:RES:MM;

CCP=NaN(length(V1),length(V2));CCS=NaN(length(V1),length(V2));CCPb=NaN(length(V1),length(V2));CCSb=NaN(length(V1),length(V2));CCPc=NaN(length(V1),length(V2));CCSc=NaN(length(V1),length(V2));

for i1=1:length(V1);

for i2=1:length(V2);

X1a=[X1;V1(i1)];

X2a=[X2;V2(i2)];

X1b=[X1;MM;V1(i1)];

X2b=[X2;MM;V2(i2)];

X1c=[X1;MM;V1(i1)];

X2c=[X2;-MM;V2(i2)];

CCP(i1,i2)=corr(X1a,X2a);

CCS(i1,i2)=corr(X1a,X2a,'type','spearman');

CCPb(i1,i2)=corr(X1b,X2b);

CCSb(i1,i2)=corr(X1b,X2b,'type','spearman');

CCPc(i1,i2)=corr(X1c,X2c);

CCSc(i1,i2)=corr(X1c,X2c,'type','spearman');

end

end

%%

figure('name','Figure 5','numbertitle','off');hold on

colormap(([linspace(0,1,1000)' linspace(0,1,1000)' linspace(0,1,1000)']))

colormap(gray)

subplot(1,2,1)

contourfm(V1,V2,log10(abs(CCP-rp)),log10(10^-20:.005:1),'linecolor','m')

hold on

plot3(X1,X2,ones(size(X1)),'o','markersize',10,'linewidth',2,'markeredgecolor','g')

view(0,90)

contourcbar

axis equal

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

set(gca,'xlim',[-MM MM])

set(gca,'ylim',[-MM MM])

xlabel('\itx', 'FontSize',20)

ylabel('\ity', 'FontSize',20)

caxis([-3, -0.9])

cbr = contourcbar();

set(cbr, 'Ylim',[-3 -0.9],'YTickLabel',{'0.005','0.01','0.02','0.03','0.05','0.07','0.10'}, 'YTick', log10([0.005 0.01 0.02 0.03 0.05 0.07 0.10]),'tickdirection','out')

subplot(1,2,2)

contourfm(V1,V2,log10(abs(CCS-rs)),log10(10^-20:.005:1),'linecolor','m');

hold on

plot3(X1,X2,ones(size(X1)),'ko','markersize',10,'linewidth',2,'markeredgecolor','g')

view(0,90)

contourcbar

axis equal

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

set(gca,'xlim',[-MM MM])

set(gca,'ylim',[-MM MM])

xlabel('\itx', 'FontSize',20)

ylabel('\ity', 'FontSize',20)

caxis([-3, -0.9])

cbr = contourcbar();

set(cbr, 'Ylim',[-3 -0.9],'YTickLabel',{'0.005','0.01','0.02','0.03','0.05','0.07','0.10'}, 'YTick', log10([0.005 0.01 0.02 0.03 0.05 0.07 0.10]),'tickdirection','out')

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

disp(['Sample Pearson correlation coefficient = ' num2str(round(1000\*rp)/1000) ])

disp('Min Max with one outlier')

disp(round(1000\*[min(min(CCP)) max(max(CCP))])/1000)

disp('Min Max two outliers, first outlier at 5,5')

disp(round(1000\*[min(min(CCPb)) max(max(CCPb))])/1000)

disp('Min Max two outliers, first outlier at 5,-5')

disp(round(1000\*[min(min(CCPc)) max(max(CCPc))])/1000)

disp('Percentage differing more than .05 from rp')

disp(round(100\*[mean(mean(abs(CCP-rp)>.05)) mean(mean(abs(CCPb-rp)>.05)) mean(mean(abs(CCPc-rp)>.05))]))

disp(['Sample Spearman correlation coefficient = ' num2str(round(1000\*rs)/1000) ])

disp('Min Max with one outlier')

disp(round(1000\*[min(min(CCS)) max(max(CCS))])/1000)

disp('Min Max two outliers, first outlier at 5,5')

disp(round(1000\*[min(min(CCSb)) max(max(CCSb))])/1000)

disp('Min Max two outliers, first outlier at 5,-5')

disp(round(1000\*[min(min(CCSc)) max(max(CCSc))])/1000)

disp('Percentage differing more than .05 from rs')

disp(round(100\*[mean(mean(abs(CCS-rs)>.05)) mean(mean(abs(CCSb-rs)>.05)) mean(mean(abs(CCSc-rs)>.05))]))

%%

clear variables;close all;clc

syms n R r

ddShieh= (n-2)\*(1-R^2)^((n-1)/2)\*(1-r^2)^((n-4)/2)/(n^.5\*(n-2)\*beta(0.5,n-1/2)\*(1-R\*r)^(n-3/2))\*hypergeom([1/2,1/2],n-1/2,(R\*r+1)/2); % Shieh (2010)

r=-1:0.001:1;

RR=[.2 .4 .8];NN=[5 50];

td=NaN(length(RR),length(NN),length(r));

for i1=1:length(RR);

R=RR(i1);

for i2=1:length(NN);

n=NN(i2);

disp([R n])

tdShieh=double(subs(ddShieh));tdShieh=tdShieh./sum(tdShieh);

td(i1,i2,:)=tdShieh;

end

end

%%

figure('name','Figure 1','numbertitle','off');hold on

for i1=1:length(RR);

for i2=1:length(NN);

if i1==1 && i2==1

plot(r,squeeze(td(i1,i2,:))/.001,'k-','Linewidth',3);

elseif i1==1 && i2==2

plot(r,squeeze(td(i1,i2,:))/.001,'k--','Linewidth',3);

end

if i1==2 && i2==1

plot(r,squeeze(td(i1,i2,:))/.001,'g-','Linewidth',3);

elseif i1==2 && i2==2

plot(r,squeeze(td(i1,i2,:))/.001,'g--','Linewidth',3);

end

if i1==3 && i2==1

plot(r,squeeze(td(i1,i2,:))/.001,'m-','Linewidth',3);

elseif i1==3 && i2==2

plot(r,squeeze(td(i1,i2,:))/.001,'m--','Linewidth',3);

end

set(gca,'xlim',[-1 1])

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

xlabel('\it{r\_p}\rm','Fontsize',20)

Erp=(2\*gamma(n/2)^2) / ((n-1)\*(gamma((n-1)/2)^2))\*R\*hypergeom([1/2,1/2],(n+1)/2,R^2);

disp([Erp sum(tdShieh.\*r)])

end

end

plot([0.2 0.2],[-1 1000],'k:','Linewidth',1)

plot([0.4 0.4],[-1 1000],'g:','Linewidth',1)

plot([0.8 0.8],[-1 1000],'m:','Linewidth',1)

set(gca,'ylim',[0 8])

legend('\it{R\_p}\rm = 0.200, \it{N}\rm = 5','\it{R\_p}\rm = 0.200, \it{N}\rm = 50', '\it{R\_p}\rm = 0.400, \it{N}\rm = 5','\it{R\_p}\rm = 0.400, \it{N}\rm = 50', '\it{R\_p}\rm = 0.800, \it{N}\rm = 5','\it{R\_p}\rm = 0.800, \it{N}\rm = 50','location','northwest')

%% Analysis of Equations 6 and 7

RR2=0:.1:1;

NN2=[5 20];

Erp=NaN(length(RR2),length(NN2));

Ers=NaN(length(RR2),length(NN2));

for i1=1:length(RR2);

R=RR2(i1);

for i2=1:length(NN2);

n=NN2(i2);

Ers(i1,i2)=6/(pi\*(n+1)) \* (asin(R)+(n-2)\*asin(R/2));

Erp(i1,i2)=(2\*gamma(n/2)^2) / ((n-1)\*(gamma((n-1)/2)^2))\*R\*hypergeom([1/2,1/2],(n+1)/2,R^2);

end

end

RR2s=(6/pi)\*asin(RR2/2);

disp('Rp Rs Erp(n=5) Ers(n=5) Erp(n=20) Ers(n=20)')

disp(round(10000\*[RR2' RR2s' Erp(:,1) Ers(:,1) Erp(:,2) Ers(:,2)])/10000)

disp(round(10000\*[RR2' RR2'-Erp(:,1) RR2s'-Ers(:,1) RR2'-Erp(:,2) RR2s'-Ers(:,2)])/10000)

%%

syms dd4 n R r

dd4= (n-2)\*(1-R^2)^((n-1)/2)\*(1-r^2)^((n-4)/2)/(n^.5\*(n-2)\*beta(0.5,n-1/2)\*(1-R\*r)^(n-3/2))\*hypergeom([1/2,1/2],n-1/2,(R\*r+1)/2); % Shieh 2010

R=.2;n=5;res=0.01;r=-1:res:1;

reps=10^7;

rp=NaN(reps,1);rs=NaN(reps,1);

for i=1:reps

x=randn(n,1);

y=R\*x+sqrt((1-R^2))\*randn(n,1);

temp=corrcoef(x,y);

rp(i)=temp(1,2);

temp=corrcoef(tiedrank(x),tiedrank(y));

rs(i)=temp(1,2);

end

td4=double(subs(dd4));td4=td4./sum(td4);

hp=histc(rp,r);

hs=NaN(size(hp));for i=1:length(r);hs(i)=sum(abs(rs-r(i))<10^-7);end

hp=hp./sum(hp);hs=hs./sum(hs);

figure('name','Figure S2','numbertitle','off');hold on

plot([-1+res/2:res:1 1],hp,'ko-','Linewidth',3)

plot(r,hs,'r-s','Linewidth',3,'color',[255 165 0]/255)

plot(r,td4,'g--','Linewidth',3);

legend('\it{r\_p}\rm distribution','\it{r\_s}\rm distribution','\it{r\_p}\rm distribution, calculated','location','northwest')

set(gca,'xlim',[-1 1])

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

xlabel('\it{r\_p}\rm or \it{r\_s}\rm ','Fontsize',20)

%%

close all;clear variables;clc

NN=200;DD=NaN(length(NN),10);reps=50000;

rng('default')

for i3=1:5

if i3==1

X=csvread('default-4a816ddd92097.csv',2); X=X(:,35:44);% X matrix with scale scores, used to determine which participants to discard (12685 x 10 matrix)

G=csvread('default-4a854301d307e.csv',2); % gender (12685 x 1 vector)

A=csvread('age2.csv',2); % age (12684 x 5 matrix)

X3=csvread('default\_asvab\_raw.csv',2); % X matrix with item scores (12685 x 14 matrix)

X(X<0)=NaN;

temp=find(sum(isnan(X')));

X=X3(:,5:end);

G(temp)=[]; A(temp,:)=[];X(temp,:)=[]; % remove 807 participants with missing data, so that G, A, and X have length 11878

M=mean(X);SK=skewness(X);K=kurtosis(X);RPM=corr(X);RSM=corr(X,'type','spearman');

elseif i3==2 % BFI items

% load BFI.mat

% X(X<0)=NaN;

% temp1=var(X(1:1000000,5:end),[],2);

% temp2=var(X(1000001:2000000,5:end),[],2);

% temp3=var(X(2000001:end,5:end),[],2);

% iv=find([temp1;temp2;temp3]>0 & X(:,1)==1 & X(:,2)>=18 & X(:,2)<=98); % only data which has variance, only English version of questionnaire, and only respondents who are between 18 and 98 years old

% SC=X(iv,2:4); % extract sample characteristics (age, gender, self-esteem)

% X=X(iv,5:end); % extracted the 44 BFI items

% clear iv temp1 temp2 temp3

% RPM=corr(X);

% RSM=corr(X,'type','spearman');

% M=mean(X);

% SK=skewness(X);

% K=kurtosis(X);

% save BFI\_Pi X RPM RSM M SK K

load BFI\_Pi

elseif i3==3 % BFI scales

% load BFI.mat

% X(X<0)=NaN;

% temp1=var(X(1:1000000,5:end),[],2);

% temp2=var(X(1000001:2000000,5:end),[],2);

% temp3=var(X(2000001:end,5:end),[],2);

% iv=find([temp1;temp2;temp3]>0 & X(:,1)==1 & X(:,2)>=18 & X(:,2)<=98); % only data which has variance, only English version of questionnaire, and only respondents who are between 18 and 98 years old

% SC=X(iv,2:4); % extract sample characteristics (age, gender, self-esteem)

% X=X(iv,5:end); % extracted the 44 BFI items

% clear iv temp1 temp2 temp3

% A=sum(X(:,1:9),2);

% C=sum(X(:,10:18),2);

% E=sum(X(:,19:26),2);

% O=sum(X(:,27:36),2);

% N=sum(X(:,37:44),2);

% X=[A C E O N];

% RPM=corr(X);

% RSM=corr(X,'type','spearman');

% M=mean(X);

% SK=skewness(X);

% K=kurtosis(X);

% save BFI\_P X RPM RSM M SK K

load BFI\_P

elseif i3==4 % DBQ items

load DBQ1.mat;X=DBQ1;

RPM=corr(X);RSM=corr(X,'type','spearman');M=mean(X);SK=skewness(X);K=kurtosis(X);

EV=NaN(reps,size(RPM,1),2);

elseif i3==5 % DBQ scales

load DBQ1.mat;X=DBQ1\_scales;

RPM=corr(X);RSM=corr(X,'type','spearman');M=mean(X);SK=skewness(X);K=kurtosis(X);

end

% show general characteristics of population correlation matrices

LL=size(X,1);

id=itriu(size(RPM),1); % indexes of off-diagonal correlations of the correlation matrix (function available online by Bruno Luong, 21 March 2009

Rp=RPM(id);

Rs=RSM(id);

disp(['Condition = ' num2str(i3)])

disp('POPULATION STATISTICS')

disp('Mean and SD of item score')

disp([mean(M) std(M)])

[a,b]=min(M);

disp('Min item score')

disp([b a])

[a,b]=max(M);

disp('Max item score')

disp([b a])

disp('Mean, SD, min, and max of item skewness')

disp(round(100\*[mean(SK) std(SK) min(SK) max(SK)])/100)

disp('Mean, SD, min, and max of item kurtosis')

disp(round(100\*[mean(K) std(K) min(K) max(K)])/100)

disp('Mean absolute correlation coefficient (Rp, Rs)')

disp(round(10000\*[mean(abs(Rp)) mean(abs(Rs))])/10000)

disp('Spearman correlation between kurtosis and skewness (rs, N)')

disp([corr(K',SK','type','spearman') length(K)])

disp('SD absolute correlation coefficient (Rp, Rs)')

disp(round(10000\*[std(abs(Rp)) std(abs(Rs))])/10000)

disp('Min absolute correlation coefficient (Rp, Rs)')

disp(round(10000\*[min(abs(Rp)) min(abs(Rs))])/10000)

disp('Max absolute correlation coefficient (Rp, Rs)')

disp(round(10000\*[max(abs(Rp)) max(abs(Rs))])/10000)

[a,b]=min(Rp);

[c,d]=ind2sub(size(RPM),id(b));

disp('Min. correlation coefficient')

disp([c d a Rs(b)])

[a,b]=max(Rp);

[c,d]=ind2sub(size(RPM),id(b));

disp('Max. correlation coefficient')

disp([c d a Rs(b)])

SS=NaN(length(M),length(M));

KK=NaN(length(M),length(M));

disp('END OF POPULATION STATISTICS')

for i4=1:length(M)

for i5=1:length(M)

SS(i4,i5)=SK(i4)+SK(i5); % sum of skewness of both variables

KK(i4,i5)=K(i4)+K(i5); % sum of kurtosis of both variables

end

end

%

for i2=1:length(NN);

N=NN(i2);rp=NaN(reps,length(id)); rs=NaN(reps,length(id));

i=1;i4=1;

while i<=reps

S=ceil(rand(N,1)\*LL); % sampling with replacement

Xs=X(S,:); % random sample of length N

rpm=corr(Xs); % Pearson correlation matrix

rsm=corr(Xs,'type','spearman'); % Spearman correlation matrix

if i3==2 || i3 == 4; % store eigenvalues of correlation matrix (only for DBQ items analysis)

try EV(i,:,:)=[eig(rpm) eig(rsm)];catch error;end

end

i4=i4+1;

if sum(isnan(rpm(id)))==0

rp(i,:)=rpm(id);rs(i,:)=rsm(id); i=i+1;

end

end

disp(['Reps stored = ' num2str(i-1) ' , Reps done = ' num2str(i4-1)])

% show Tables with results

disp(['Condition = ' num2str(i3) ', N = ' num2str(N)])

disp('Table 3')

D=[mean(abs(mean(rp)))

mean(abs(mean(rs)))

mean(abs(mean(rp)')-abs(Rp)) % rp vs Rp

mean(abs(mean(rs)')-abs(Rs)) % rp vs Rp

mean(std(rp))

mean(std(rs))

mean(mean(abs(rp-repmat(Rp,1,reps)'))) % rp vs Rp

mean(mean(abs(rp-repmat(Rs,1,reps)'))) % rp vs Rs

mean(mean(abs(rs-repmat(Rp,1,reps)'))) % rs vs Rp

mean(mean(abs(rs-repmat(Rs,1,reps)')))]; % rs vs Rs

DD(i2,:)=D';

disp(round(D\*10000)/10000)

if i3== 4 % only for DBQ items analysis

disp('Table S3')

disp('Mean eigenvalues')

disp([round(1000\*mean(EV(:,1:6,1)))/1000;round(1000\*mean(EV(:,1:6,2)))/1000]')

disp('SD eigenvalues')

disp([round(1000\*std(EV(:,1:6,1)))/1000;round(1000\*std(EV(:,1:6,2)))/1000]')

disp('SD eigenvalues rp / SD eigenvalues rs')

disp((round(1000\*std(EV(:,1:6,1))./std(EV(:,1:6,2)))/1000)')

disp('Population eigenvalues')

EVM=[eig(RPM) eig(RSM)];disp(round(1000\*EVM(1:6,:))/1000)

end

end

temp=find(Rp>-1);

KKK=KK(id);

SSS=SS(id);

if i3==4

figure('name','Figure S7','numbertitle','off');hold on

plot(-1,-1,'k.','markerfacecolor','k','markersize',20);hold on;

plot(-1,-1,'.','markerfacecolor','r','markersize',20,'color',[255 165 0]/255)

for i=1:length(temp)

plot(log10([KKK(temp(i)) KKK(temp(i))]),[mean(abs(rp(:,temp(i))-repmat(Rp(temp(i)),1,reps)'))' mean(abs(rs(:,temp(i))-repmat(Rs(temp(i)),1,reps)'))'],'-','color',[.8 .8 .8]);hold on; % plot lines

end

plot(log10(KKK(temp)),mean(abs(rp(:,temp)-repmat(Rp(temp),1,reps)'))','k.','markerfacecolor','k','markersize',20) % plot dots

plot(log10(KKK(temp)),mean(abs(rs(:,temp)-repmat(Rs(temp),1,reps)'))','.','markerfacecolor','r','markersize',20,'color',[255 165 0]/255)

legend('mean |\it{r\_p}\rm-\it{R\_p}\rm|','mean |\it{r\_s}\rm-\it{R\_s}\rm|','location','northwest')

set(gca,'xlim',[0.77 2.1])

set(gca, 'xTickLabel',{'6','7','10','15','20','40','60','80','100','120'}, 'XTick', log10([6 7 10 15 20 40 60 80 100 120]))

xlabel('kurtosis(\it{x}\rm) +kurtosis(\it{y}\rm)', 'FontSize',20)

ylabel('mean |\it{r\_p}\rm-\it{R\_p}\rm| or mean |\it{r\_s}\rm-\it{R\_s}\rm|','Fontsize',20)

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

end

% studies across different sample sizes

if i3==4 % only for DBQ items analysis

temp=find(Rp>-1);

KKK=KK(id);

[a,c]=min(KKK);[a,b]=find(KK==a);V(1,:)=[a(2) b(2) c];

[a,c]=max(KKK);[a,b]=find(KK==a);V(2,:)=[a(2) b(2) c];

for i3s=2:size(V,1)

disp(['Kurtosis of selected pair nr. ' num2str(i3s)])

disp(KKK(V(i3s,3)))

disp(['Skewness of selected pair nr. ' num2str(i3s)])

disp(SS(V(i3s,3)))

disp('Joint distribution of selected pair nr. (top to bottom = variable 1, left to right = variable 2)')

disp(round(10000\*hist3(X(:,V(2,1:2)),[max(unique(X(:,V(2,1:2)))) max(unique(X(:,V(2,1:2))))])./LL)/100)

disp('mean |r\_p-R\_p|')

disp(mean(abs(rp(:,V(i3s,3))-repmat(Rp(V(i3s,3)),1,reps)')))

disp('mean |r\_s-R\_s|')

disp(mean(abs(rs(:,V(i3s,3))-repmat(Rs(V(i3s,3)),1,reps)')))

NNss=floor(logspace(log10(5),log10(1000),25));repsss=reps;

rps=NaN(length(NNss),repsss);rss=rps;

for i1s=1:length(NNss);

N=NNss(i1s);

i2s=1;i2s2=1;

while i2s<=repsss

S=ceil(rand(N,1)\*LL); % sampling with replacement

Xs=X(S,V(i3s,1:2)); % random sample of length N

temp=corr(Xs(:,1),Xs(:,2));

i2s2=i2s2+1;

if ~isnan(temp);

i2s=i2s+1;

rps(i1s,i2s)=temp;

rss(i1s,i2s)=corr(Xs(:,1),Xs(:,2),'type','spearman');

end

end

disp(['Reps stored = ' num2str(i2s) ' , Reps done = ' num2str(i2s2)])

end

R=Rp(V(i3s,3));

P=Rs(V(i3s,3));

if i3s==1

figure('name','Figure X','numbertitle','off');hold on

elseif i3s==2

figure('name','Figure 6','numbertitle','off');hold on

end

plot([0 5],[R R],'g','Linewidth',3')

plot([0 5],[P P],'b:','Linewidth',3')

plot(log10(NNss),nanmean(rps,2),'k-o','Linewidth',3)

plot(log10(NNss),prctile(rps,95,2),'k-o','Linewidth',1)

plot(log10(NNss),nanmean(rss,2),'-s','Linewidth',3,'color',[255 165 0]/255)

plot(log10(NNss),prctile(rss,95,2),'-s','Linewidth',1,'color',[255 165 0]/255)

plot(log10(NNss),prctile(rss,5,2),'-s','Linewidth',1,'color',[255 165 0]/255)

plot(log10(NNss),prctile(rps,5,2),'k-o','Linewidth',1)

legend(['\it{R\_p}\rm = ' num2str(round(1000\*R)/1000)], ['\it{R\_s}\rm = ' num2str(round(1000\*P)/1000)],'mean \it{r\_p}','P5/P95 \it{r\_p}','mean \it{r\_s}','P5/P95 \it{r\_s}',4)

set(gca,'xtick',log10(NNss(1:3:end)))

set(gca,'xticklabel',NNss(1:3:end))

set(gca,'xlim',[0.6 3.1])

xlabel('\it{N}\rm', 'FontSize',20)

ylabel('\it{r\_p}\rm or \it{r\_s}\rm ','Fontsize',20)

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',20)

disp('SD rp / SD rs across sample sizes')

disp([NNss' nanstd(rps,[],2) nanstd(rss,[],2) nanstd(rps,[],2)./nanstd(rss,[],2)])

end

end

% figure showing SD(r) and SD(rs) as a function of Rp

if i3==1

figure('name','Figure 7a','numbertitle','off');

elseif i3==2

figure('name','Figure 7b','numbertitle','off');

elseif i3==3

figure('name','Figure 7c','numbertitle','off');

elseif i3==4

figure('name','Figure 7d','numbertitle','off');

elseif i3==5

figure('name','Figure 7e','numbertitle','off');

end

hold on

plot(Rp,std(rp),'k.','markersize',20);hold on;

plot(Rp,std(rs),'.','markersize',20,'color',[255 165 0]/255)

xlabel('\it{R\_p}', 'FontSize',40)

ylabel('\it{SD r\_p}\rm or \it{SD r\_s}', 'FontSize',40)

legend('\it{SD r\_p} ','\it{SD r\_s}')

set(gca,'Color',[1 1 1]);

set(gcf,'Color',[1 1 1]);

set(gca,'xlim',[-.53 1])

set(gca,'ylim',[0 0.151])

h = findobj(gcf,'FontName','Helvetica');

set(h,'FontSize',40)

end

%%

% 1 langu {1.00, en}...

% 2 age Age None

% 3 sex Gender {.00, female}...

% 4 se ...Has high self-esteem {1.00, disagree}...

% 5 1 agr01r ...Tends to find fault with others {1.00, disagree}...

% 6 2 agr02 ...Is helpful and unselfish with others {1.00, disagree}...

% 7 3 agr03r ...Starts quarrels with others {1.00, disagree}...

% 8 4 agr04 ...Has a forgiving nature {1.00, disagree}...

% 9 5 agr05 ...Is generally trusting {1.00, disagree}...

% 10 6 agr06r ...Can be cold and aloof {1.00, disagree}...

% 11 7 agr07 ...Is considerate and kind to almost everyone {1.00, disagree}...

% 12 8 agr08r ...Is sometimes rude to others {1.00, disagree}...

% 13 9 agr09 ...Likes to cooperate with others {1.00, disagree}...

% 14 10 cns01 ...Does a thorough job {1.00, disagree}...

% 15 11 cns02r ...Can be somewhat careless {1.00, disagree}...

% 16 12 cns03 ...Is a reliable worker {1.00, disagree}...

% 17 13 cns04r ...Tends to be disorganized {1.00, disagree}...

% 18 14 cns05r ...Tends to be lazy {1.00, disagree}...

% 19 15 cns06 ...Perseveres until the task is finished {1.00, disagree}...

% 20 16 cns07 ...Does things efficiently {1.00, disagree}...

% 21 17 cns08 ...Makes plans and follows through with them {1.00, disagree}...

% 22 18 cns09r ...Is easily distracted {1.00, disagree}...

% 23 19 ext01 ...Is talkative {1.00, disagree}...

% 24 20 ext02r ...Is reserved {1.00, disagree}...

% 25 21 ext03 ...Is full of energy {1.00, disagree}...

% 26 22 ext04 ...Generates a lot of enthusiasm {1.00, disagree}...

% 27 23 ext05r ...Tends to be quiet {1.00, disagree}...

% 28 24 ext06 ...Has an assertive personality {1.00, disagree}...

% 29 25 ext07r ...Is sometimes shy, inhibited {1.00, disagree}...

% 30 26 ext08 ...Is outgoing, sociable {1.00, disagree}...

% 31 27 opn01 ...Is original, comes up with new ideas {1.00, disagree}...

% 32 28 opn02 ...Is curious about many different things {1.00, disagree}...

% 33 29 opn03 ...Is ingenious, a deep thinker {1.00, disagree}...

% 34 30 opn04 ...Has an active imagination {1.00, disagree}...

% 35 31 opn05 ...Is inventive {1.00, disagree}...

% 36 32 opn06 ...Values artistic, aesthetic experiences {1.00, disagree}...

% 37 33 opn07r ...Prefers work that is routine {1.00, disagree}...

% 38 34 opn08 ...Likes to reflect, play with ideas {1.00, disagree}...

% 39 35 opn09r ...Has few artistic interests {1.00, disagree}...

% 40 36 opn10 ...Is sophisticated in art, music, or literature {1.00, disagree}...

% 41 37 neu01 ...Is depressed, blue {1.00, disagree}...

% 42 38 neu02r ...Is relaxed, handles stress well {1.00, disagree}...

% 43 39 neu03 ...Can be tense {1.00, disagree}...

% 44 40 neu04 ...Worries a lot {1.00, disagree}...

% 45 41 neu05r ...Is emotionally stable, not easily upset {1.00, disagree}...

% 46 42 neu06 ...Can be moody {1.00, disagree}...

% 47 43 neu07r ...Remains calm in tense situations {1.00, disagree}...

% 48 44 neu08 ...Gets nervous easily {1.00, disagree}...

% DBQ items

% 1 1st 6mths, how often brake too quickly on slippery road or steer wrong in skid

% 2 1st 6mths, how often do drive away from traffic lights at too high a gear

% 3 1st 6mths, how often do overtake a slow driver on inside

% 4 1st 6mths, how often do have to confirm youre in right gear

% 5 1st 6mths, how often attempt to overtake and hadnt noticed signalling right

% 6 1st 6mths, how often forget where left car in carpark

% 7 1st 6mths, how often sound horn to indicate annoyance

% 8 1st 6mths, how often switch on one thing when meant to switch on other

% 9 1st 6mths, how often do change into wrong gear when driving along

% 10 1st 6mths, how often pull out of junction so far that driver has to let you out

% 11 1st 6mths, how often have used plates to warn drivers you are a new driver

% 12 1st 6mths, how often realised have no recollection of road been travelling

% 13 1st 6mths, how often crossed junction knowing lights have turned against you

% 14 1st 6mths, how often failed to notice people crossing when turned into sidestreet

% 15 1st 6mths, how often become angered by driver and given chase

% 16 1st 6mths, how often misread signs and taken wrong turning off roundabout

% 17 1st 6mths, how often drive in either too low or high gear for conditions

% 18 1st 6mths, how often disregard speed limit on residential road

% 19 1st 6mths, how often when turning left have nearly hit cyclist on inside

% 20 1st 6mths, how often used mobile phone without hands free kit

% 21 1st 6mths, how often stay in motorway lane know will be closed

% 22 1st 6mths, how often when queing to turn left nearly hit car in front

% 23 1st 6mths, how often drive when suspect over legal alcohol limit

% 24 1st 6mths, how often forget to take handbrake off before moving off

% 25 1st 6mths, how often become angered by driver and indicate hostility

% 26 1st 6mths, how often speed of oncoming vehicle when overtaking

% 27 1st 6mths, how often hit something when reversing that hadnt seen

% 28 1st 6mths, how often raced away from traffic lights to beat other driver

% 29 1st 6mths, how often used a hands free kit

% 30 1st 6mths, how often selected wrong gear when wanting to go in reverse

% 31 1st 6mths, how often noticed on different road to destination want to go

% 32 1st 6mths, how often get into wrong lane when approaching roundabout/junct

% 33 1st 6mths, how often drive so close to car that wouldn’t be able to stop

% 34 1st 6mths, how often forget headlights were on full beam

% 35 1st 6mths, how often missed giveway signs and avoided colliding with traffic

% 36 1st 6mths, how often have disregarded speed limit on motorway

% 37 1st 6mths, how often failed to check rear-view mirror before manoervering

% 38 1st 6mths, how often drove after taking drugs which think affected you

% DBQ items short

% 1 how often do drive away from traffic lights at too high a gear

% 2 how often do overtake a slow driver on inside

% 3 how often do have to confirm youre in right gear

% 4 how often attempt to overtake and hadnt noticed signalling right

% 5 how often forget where left car in carpark

% 6 how often sound horn to indicate annoyance

% 7 how often switch on one thing when meant to switch on other

% 8 how often do change into wrong gear when driving along

% 9 how often pull out of junction so far that driver has to let you out

% 10 how often realised have no recollection of road been travelling

% 11 how often crossed junction knowing lights have turned against you

% 12 how often failed to notice people crossing when turned into sidestreet

% 13 how often become angered by driver and given chase

% 14 how often misread signs and taken wrong turning off roundabout

% 15 how often drive in either too low or high gear for conditions

% 16 how often disregard speed limit on residential road

% 17 how often when turning left have nearly hit cyclist on inside

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% 19 how often when queing to turn left nearly hit car in front

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% 24 how often hit something when reversing that hadnt seen

% 25 how often raced away from traffic lights to beat other driver

% 26 how often selected wrong gear when wanting to go in reverse

% 26 how often noticed on different road to destination want to go

% 28 how often get into wrong lane when approaching roundabout/junction

% 29 how often drive so close to car that wouldn’t be able to stop

% 30 how often forget headlights were on full beam

% 31 how often missed giveway signs and avoided colliding with traffic

% 32 how often have disregarded speed limit on motorway

% 33 how often brake too quickly on slippery road or steer wrong in skid

% 34 how often has followed happened-brake/swerve to avoid accident