A game-theoretical approach to understanding the relation between Honesty-Humility and knowledge hiding

Educational Science and Technology

Master thesis

Brenda de Laat
b.delaat@student.utwente.nl
S1379445

Committee chair:
Reinout de Vries
re.de.vries@vu.nl

Second assessor:
Maaike Endedijk
m.d.endedijk@utwente.nl

Keywords: knowledge hiding, knowledge behaviour, personality, HEXACO, honesty-humility, game theory, PDG, social dilemma

Date: 17 – 3 - 2020

Word count: 7772

Table of content

Summary

Knowledge is an important asset in today's rapidly changing society. If companies effectively manage their knowledge and can stimulate knowledge sharing between their employees, they are likely to be more innovative and to have a competitive advantage over others. Unfortunately, employees often hide their knowledge from each other. This study examines reciprocation of knowledge hiding and the link between knowledge hiding and the personality trait honesty-humility. It does so by using a social dilemma game, in which knowledge hiding behaviour can be studied. In total, 100 participants played the game against an AI. Results showed clear evidence for reciprocation of knowledge hiding. Though honesty-humility did have significant correlations with knowledge hiding, it did not have a significant relation with knowledge hiding in the regression analysis, both as a direct predictor and as a moderator of reciprocation of knowledge hiding. The regression analysis did find that openness to experience, a trait added as a control variable, did significantly affect knowledge hiding behaviour. To counteract (reciprocation of) knowledge hiding among employees, companies would benefit from investing in better interpersonal communication and trust.

Problem statement / introduction

In today's rapidly changing society, knowledge has become one of the most important resources for most companies (Drucker, 1994 in Shi et al., 2006; Bilginoglu, 2019). Effective knowledge management can give companies the capability to innovate and a competitive advantage over others (Peng, 2013; Serenko & Bontis, 2016). Many companies understand this and have taken action to stimulate knowledge sharing among employees. This includes rewards, guidelines about behaviour, and IT systems to facilitate knowledge management (Bock & Kim, 2002). However, these policies and tools do not seem to have an impact on employees' knowledge sharing (Babcock, 2004 in Peng, 2013; Serenko & Bontis, 2016). Some employees not only abstain from knowledge sharing, but intentionally hide it from each other (Connelly et al., 2012).

Shi et al. (2006) state that human nature is often neglected as an influencing factor in knowledge behaviour. Additionally, Bock and Kim (2002) mention that rewards and incentives often do not alter underlying attitudes towards practices of knowledge sharing. To counteract knowledge hiding, it is important to understand the factors that influence an employee's decision to engage in this behaviour. Perhaps an employee's knowledge behaviour is not influenced by external facilitation, but more by an internal predisposition towards certain behaviours. Personality traits are considered to be patterns of behaviour that are relatively stable over the course of some's life (Tett & Burnett, 2003; Pan et al, 2018) and could therefore also be predictors of knowledge hiding. This study will examine the direct and moderated effect of honesty humility (from the HEXACO personality inventory, Lee & Ashton, 2004) on someone's knowledge behaviour.

To study this interaction, game theory will be used. Shi et al (2006) describe game theory as *"the formal study of decision making where several players must make choices that potentially affect the interest of other players"*. This is a relevant approach for this study, as knowledge behaviour can be conceptualized as a social dilemma, where players can choose to defect and maximize their own payoffs or cooperate and maximize collective payoffs (Kieslich, 2014). To simulate a situation where either knowledge hiding or knowledge sharing can occur, an economic non-zero-sum game for two players will be constructed. Results from these games will be used to answer the following research question: *How do honesty-humility and knowledge hiding interact in repeated knowledge exchanges?*

Knowledge hiding

Knowledge hiding emerged as a concept to be studied in response to ineffective knowledge management or the absence of knowledge sharing. However, knowledge hiding and sharing are not each other's opposites. Ford and Staples (2008, in Peng, 2013) even state that someone can engage in both knowledge hiding and sharing at the same time. When someone is sharing their knowledge, they are making their tacit and explicit knowledge accessible to others (Shi et al, 2006). The act of knowledge hiding very specifically takes place in dyadic interactions, where one person asks the other for specific knowledge, but the other does not give it to them, even though they do possess it (Connelly et al, 2012). An example of a situation where a person engages in both knowledge sharing and hiding behaviour could be when a person is asked for knowledge and they don't respond by sharing the requested knowledge, but they do share other knowledge they have, that may or may not be relevant to the request.

The difference in conceptualization between knowledge sharing and hiding can be further illustrated by behaviour that is neither knowledge sharing nor hiding. When someone engages in knowledge hoarding, they keep knowledge to themselves with the expectation that possibly disclosing this knowledge in the future might benefit them (Hislop, 2003 in Connelly et al, 2012; Bilginoglu, 2019). Another behaviour that seems closely related to knowledge hiding is knowledge withholding, where an employee only selectively engages in knowledge sharing (Lin & Huang, 2010 in Pan et al, 2018). When a database of knowledge is available, an employee can also engage in freeriding, meaning that they make use of the public good of knowledge, but do not provide any knowledge themselves (Shi et al, 2006; Sharma & Bhattacharya, 2013). In all of these instances, employees do not share the knowledge they have, but they also do not actively deny a request for knowledge. Another way to not share knowledge, but also not hide it, is when someone is asked for knowledge, but they cannot provide it because they do not have it (Connelly et al, 2012). Having knowledge is therefore a prerequisite for knowledge hiding and/or sharing

Connelly et al (2012) found three different factors of knowledge hiding. Rationalized hiding describes the situation where an employee does not share the knowledge that is requested of them, but they do give an explanation for this behaviour. When an employee engages in evasive hiding, they do not give a direct answer or even a reason for not sharing the knowledge they have, but rather try and avoid the question or give vague reasons for not doing as requested. When an employee plays dumb, they deny that they possess the knowledge that is requested of them, even though they do (Connelly et al, 2012).

Effects of knowledge hiding

Knowledge hiding is considered by many to be a counterproductive and undesirable workplace behaviour. It is easy to see why this is, as most factors of knowledge hiding include some form of deception. However, it is important to note that this behaviour is not inherently negative or used to hurt others. Sometimes, people engage in knowledge hiding with positive goals in mind, like avoiding to hurt someone's feelings or protecting confidentiality (Connelly et al, 2012). It should be noted that the effect of knowledge hiding, either positive or negative, is also dependent on the factor of knowledge hiding. Often times, evasive hiding and playing dumb are perceived as less desirable than rationalized hiding (Connelly et al, 2012). This seems logical, as evasive hiding and playing dumb per definition contain some form of deception, whereas rationalized hiding is more honest and direct.

Though knowledge hiding is not always done out of malicious intent, its effects are mostly negative (Peng, 2013; Cerne et al, 2014). Organizations benefit from efficient use of their resources and when employees engage in knowledge hiding, a lot of time is wasted on reinvention of the wheel (Serenko & Bontis, 2016). Additionally, knowledge hiding disrupts the flow of knowledge through the company, leading to less innovation and competitive advantage (Cerne et al, 2014; Serenko & Bontis, 2016). Hidden knowledge will also stay in possession of an individual, which means that an organization will lose this knowledge when the employee (eventually) leaves (Bilginoglu, 2019; Serenko & Bontis, 2016). All these effects may cost companies money (Babcock, 2004 in Pan et al, 2018).

The knowledge hider will also experience negative effects. Due to reciprocation of knowledge hiding by their fellow employees, their creativity may be decreased (Cerne et al, 2014; Malik et al, 2019). Often times, employees that engage in knowledge hiding will realize that their behaviour is not socially desirable. Especially when they engage in evasive hiding or playing dumb, they will feel guilt or shame (Burmeister, Fasbender & Gerpott, 2018). They can also feel less psychological safety, because they fear punishment for their behaviour (Jiang et al, 2019). These negative emotions have a negative effect on their work performance (Jiang et al, 2019).

Antecedents of knowledge hiding

Nowadays, knowledge is one of the most valuable resources for many companies (Bilginoglu, 2019). Therefore, possession of knowledge can be closely associated with power and status, making it less likely that employees will share their knowledge willingly in every situation. Especially when it is scarce and in high demand in the company, knowledge becomes of great value and employees will be less likely to share it (Ho & Lin, 2011; Bilginoglu, 2019). Additionally, employees often feel psychological ownership of their knowledge. This will cause them to act territorially when they are asked to share this knowledge and thus engage in knowledge hiding (Peng, 2013).

Knowledge behaviour can also be influenced by perceptions of the intentions of the requester. Connelly et al (2012) found that distrust of coworkers is one of the biggest predictors of knowledge hiding. Furthermore, employees are more likely to engage in knowledge hiding when they experience job insecurity (Serenko & Bontis, 2016) or when they experience organizational politics at work (Malik et al, 2019). Knowledge hiding can be a defensive coping mechanism for an employee to protect themselves from perceived threats and exploitation.

Reciprocation of knowledge hiding

In economic game theory, it is often theorized that decisions are made based on the expected payoff. Each player in a game will try to maximize their own wins. However, Rabin (1993) suggests that people tend to go beyond self-interest and choose to treat others in a fair way. This means that both positive and negative behaviour is reciprocated, even when this someone's own payoff is sacrificed (Rabin, 1993).

This principle also seems to apply to knowledge behaviour. Employees reciprocate both positive and negative knowledge behaviour (Connelly et al, 2012; Cerne et al, 2014). Furthermore, it has been found that that organizational climate has an impact on knowledge sharing. Knowledge hiding is negatively predicted by knowledge sharing climate (Connelly, 2012; Serenko & Bontis, 2016) and a culture of positive reciprocity (Shi et al, 2006). It therefore seems that knowledge hiding of employees is dependent on the knowledge hiding that has been done to them.

H1: In repeated games of knowledge exchange, knowledge hiding of one player will lead to knowledge hiding of the other player.

Honesty humility and knowledge hiding

Personality traits are patterns of behaviour within a person that are relatively stable over the course of their life, which enables them to predict future behaviour in the workplace (Tett & Burnett, 2003; Pan et al, 2018). It would therefore seem likely that there are personality traits that can predict knowledge hiding behaviour.

Honesty humility is one the dimensions with the HEXACO model, which contains the dimensions of honesty-humility (H), emotionality (E), extraversion (X), agreeableness (A), conscientiousness (C) and openness to experience (O) (Lee & Ashton, 2004). High scorers on this trait tend to be sincere, fair, greed avoidant and modest, whereas low scorers are likely to cheat or take advantage of other people for their own gain (Lee & Ashton, 2004).

In line with this definition, honesty-humility has been found to be associated with less counterproductive workplace behaviours (Hilbig et al, 2013), less antisocial behaviour (Lee & Ashton, 2012) and cooperation in social dilemma games, even when the risk for defection is low and the temptation is high (Zettler et al, 2013; Hilbig et al, 2018). Contrasly, Pan et al (2018) found that the dark personality traits (Machiavellianism, narcissism and psychopathy), which significantly correlate with low honesty-humility scores, are positively related to knowledge hiding. It can therefore be hypothesized that those who score low on honesty-humility will be more likely to engage in knowledge hiding, while low scorers are less likely.

H2: In repeated games of knowledge exchange, honesty-humility is negatively related to knowledge hiding.

Honesty humility and reciprocation of knowledge hiding

Not only personality traits, but also situations can predict behaviour. The interactionist approach to behaviour suggests that traits and situations interact with each other in bringing out certain behaviours in people (Tett & Guterman, 2000). Specifically, a situation will trigger expression of a personality trait when it contains cues that are relevant to that trait (Tett & Guterman, 2000; Tett & Burnett, 2003). For example, the death of a loved one is quite an emotional experience and will often trigger emotional behaviour in people. How sensitive someone is to trait-relevant situational cues is determined by their personality (Tett & Guterman, 2000). In situations that have moderately strong trait-relevant cues, inter-individual differences in traits are most noticeable (Tett & Guterman, 2000). The example of the death of a loved one contains strong trait-relevant cues for emotionality and will therefore cause most people to

become emotional. Inter-individual differences in emotionality will be difficult to distinguish in this situation. In a situation with moderate trait-relevant cues for emotionality (such as a loved one going away for a couple of months), these differences will likely be more pronounced. Those that score high on emotionality might still be very upset, whereas those who score lower will probably act more calmly.

A denied request for knowledge is a situation of non-cooperation, which can lead to the requesting person to feel wronged. In this situation, there are moderately strong trait-relevant cues for forgiveness or retaliation. Though the trait Honesty-Humility is most often linked with active cooperation (non-exploitment) over reactive cooperation (non-retaliation) (Hilbig et al, 2013), Lee and Ashton (2012) did find that those who score low on honesty-humility are also likely to reciprocate undesirable behaviour. Because of their feelings of entitlement, low scorers on honesty-humility will have a disproportionate reaction to unfair treatment and will retaliate in a targeted and calculated way. This means that they do not simply express their anger in any way possible, but they specifically vent their frustration by reciprocating the undesirable behaviour (Lee & Ashton, 2012). This way, the score will be settled. Therefore, it can be hypothesized that low scorers on honesty-humility are more likely to reciprocate knowledge hiding.

H3: In repeated games of knowledge exchange, honesty/humility of target players negatively moderates the effect of knowledge hiding of other players on knowledge hiding of target players.

The previously mentioned hypotheses and their hypothesized effects are illustrated in figure 1. It shows the direct effect of knowledge hiding of one person on the knowledge hiding of the other person, and both the direct and moderating effect of the trait honesty-humility on knowledge hiding behaviour.

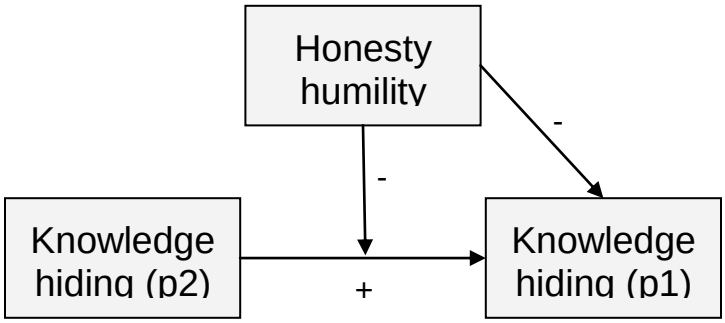

Figure 1: research model

These hypotheses single Honesty-Humility out as the HEXACO trait that will most likely influence someone's knowledge hiding behaviour. This brings with it assumptions about the reasons that people engage in knowledge hiding, namely, manipulation of other people for one's own gain. However, as has been previously discussed, knowledge hiding is not always done out of malicious intent and can be motivated by a wide range of circumstances. Furthermore, Lee and Ashton (2012) found that not only Honesty-Humility, but also Agreeableness can affect someone's tendency to reciprocate undesirable behaviour. To account for this, all HEXACO traits were included in data collection and analysis as part of an exploratory study.

Method

Sample

The concept of knowledge hiding in companies is not restricted to a certain subset of companies or employees. Most companies these days see knowledge as a valuable resource and there seems to be no evidence that knowledge hiding happens more in certain sectors or with a certain type of employee. Therefore, the sample of respondents of this study was only limited by excluding those who are not of working age and thus only include adults.

In total, 100 people participated in this study, of which there were 36 male, 62 female and 2 who identified as "other". Their mean age was 23,4 years (*SD* = 4,9) and most of them were students (36% completed higher secondary education, 53% a Bachelor's degree, 10% a Master's degree and 1 with a completed PhD). This sample consisted mostly Dutch people (81%), while there were also some Germans (11%) and those from other nationalities (8%).

Instrumentation

Honesty-humility

The scores on honesty-humility of participants was measured using the HEXACO 60 items questionnaire by Lee & Ashton (2004). This is a shortened version of the complete HEXACO questionnaire and includes 60 statements regarding personality. HEXACO 60 was used, because it only takes 10 minutes to complete, which decreased the duration of participation and increased the likelihood that people will participate, while still being a valid and reliable measurement for honesty-humility. Participants rated for each statement on a 5-point likert scale (ranging from completely disagree to completely agree) how much the statement is applicable to them. Honesty-humility is measured as the mean score for the 10 items relating to honesty-humility, as described by Lee & Ashton (2004) in their scoring key. The questionnaire was administered in English to make the study also accessible to international participants.

Knowledge hiding

In this study, knowledge hiding is conceptualized in two ways. Firstly, it is measured by the score on self-report items relating to knowledge hiding (KHsr) and secondly by the behaviour in a knowledge exchange game (KHb).

Knowledge Hiding self-report

The self-report items are adapted from Connelly et al. (2012). They made several statements regarding knowledge behaviour that could be used to describe a specific instance in which knowledge was requested from the person rating the items. In this study, the items were changed slightly to be able to apply them not to a specific situation, but to someone's general knowledge behaviour. These items were also rated on a 5-point likert scale (ranging from completely disagree to completely agree). The variable KHsr was then calculated by taking the mean score of the items.

Table 1: Self-report items on knowledge hiding

	"In general, when a colleague asks me for information that I have, I..."
Evasive hiding	Agree to help him/her but never really intend to
	Agree to help him/her but instead give him/her information different from what s/he wants
	Tell him/her that I will help him/her out later but stall as much as possible
	Offer him/her some other information instead of what he/she really wants
Playing dumb	Pretend that I do not know the information
	Say that I do not know, even though I do
	Pretend I do not know what s/he is talking about
	Say that I am not very knowledgeable about the topic
Rationalized hiding	Explain that I would like to tell him/her, but am not supposed to
	Tell him/her that my boss would not let anyone share this knowledge
	Say that I will not answer his/her questions

Game of knowledge behaviour

Knowledge hiding as a behaviour was also measured in another way. As knowledge hiding can be seen as a social dilemma, an economic game was constructed where players can choose to either hide or share knowledge with each other. Knowledge hiding is per definition a behaviour that occurs in dyadic interactions, so this game was made for two players. The core mechanic of the game is that players each get a piece of information, which is either a colour or a shape. Together, they possess full information of an image. For example: one player knows that the image is a triangle, and the other knows that it is purple. The goal of this game is to correctly select the colour and shape combination for each game. There are six colour options and six shape options, leading to 36 possible combinations in total (see figure 2). For each game, players can choose to either share their knowledge with the other player or hide it from them. Players make their choice at the same time. After choices are communicated to each

player, they have to select the right colour and shape combination. Because this study aims to examine the reactions people have to being on the receiving end of knowledge hiding, multiple rounds of this game were played. The variable knowledge hiding behaviour (KHb) follows from these games as the amount of times a participant has chosen to hide their knowledge.

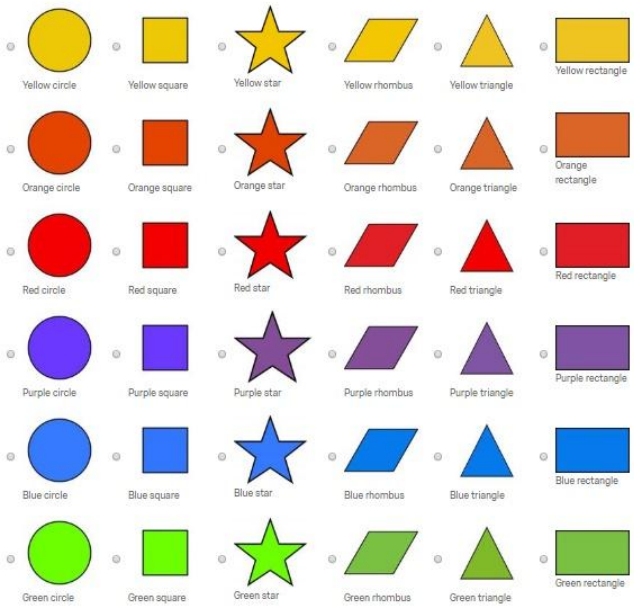

Figure 2: all possible colour and shape combinations

Payoffs

In an economic game, players are given multiple options of actions and must choose one of these. Payoffs for each player are dependent on their own choices, but also on those of the other players. In a social dilemma game, players are asked to either cooperate with the other player or defect. The possible payoffs for a game can be visualized in a payoff matrix. There are zero sum games, where the sum of all payoffs is always 0 (one player's win is the other player's loss) and non-zero-sum games, where at least one combination of choices does not lead to a sum of 0 (either a win-win or lose-lose situation is possible).

In table 2, a basic payoff structure for a social dilemma game is shown. For the various combinations of choices for player 1 and 2, the terms reward, temptation, sucker and punishment are used. If both players cooperate, they both get a similar reward. Players are tempted to defect and betray the other player by the promise of a higher payoff. When one player defects while the other cooperates, the defector gets the tempted higher payoff, while the

co-operator gets less (the sucker). However, if both players choose to defect, they will both be punished by the same low payoff.

Table 2: basic payoff structure for a social dilemma game

Note: R= reward, T = temptation, S= sucker, P= punishment

	Player 2	
Player 1	Cooperates	Defects
Cooperates	R | R	S | T
Defects	T | S	P | P

A well-known example of a non-zero-sum game is the Prisoner's Dilemma Game (PDG). In this game, the payoffs are structured as follows: T > R > P > S, and R + R > T. Individual players can get the highest payoff when they defect and the other player cooperates, but collective payoffs are highest when both players cooperate (Kieslich & Hilbig, 2014). For a collective win, the most logical option for both players is to always cooperate. However, in the PDG there are two mechanisms that can push players to defect regardless: temptation of a bigger individual win (T > R) and fear of defection of the other player (P > S) (Kieslich & Hilbig, 2014; Hilbig et al, 2018; Zettler et al, 2013).

The PDG seems to closely resemble personal considerations when it comes to sharing knowledge. When everyone shares their knowledge (and thus cooperates), the collective payoff is the highest, but here temptation and fear may also influence the decision to either share or hide knowledge. The value of knowledge is higher when it is scarce, so for an individual “win” it is tempting to hide knowledge. Additionally, sharing knowledge while risking the possibility that the other person hides knowledge can mean that you end up in the worst position, having the least knowledge but empowering the other person. The prospect of such a situation can lead people to act defensively and hide knowledge to protect themselves.

For the knowledge exchange game in this study, the basic structure of the PDG is used. However, some small adjustments are made to better fit the payoffs to the format of a game (see table 2). After players choose to either share or hide their knowledge, they have to select the right colour and shape combination. The points that can be gained from each game are not linked to the choice of action (hide or share from both players), but from the correctness of their answers. This means two things: 1) players can still get points while the other player hides their

knowledge by correctly guessing the right shape and 2) players can still lose points if they forget their own piece of knowledge and therefore guess the wrong shape. In this game, the temptation lies in the prospect of being the only player who can provide the right answer, which can be done by hiding knowledge from the other player and remembering your own knowledge.

Table 3: adjusted payoff structure for knowledge exchange games

		Player 2
Player 1	Right answer	Wrong answer
Right answer	R | R	T | S
Wrong answer	S | T	P | P

The participants each played 16 rounds of the knowledge exchange game. After each game, they were shown how many points they earned in the round they just finished, but also the total amount of points they scored in all the games they played. Besides individual scores, the combined total scores of players are also shown. These scores are presented without explanation, leaving it up to personal interpretation of the player what the goal of the game is: maximizing individual or collective points.

Conditions

In this study, one of the independent variables is knowledge hiding, while it is also the dependent variable. This leads to some problems, because it makes it difficult to control the conditions for each participant and to properly analyse the data. Therefore, participants in this study did not play against other participants, but against an “AI”. In the beginning of the study, participants were randomly assigned to one of three possible AI opponents, who chose knowledge hiding in either 4 (25%), 8 (50%) or 12 (75%) games. This way, there was a clear distinction between knowledge hiding as an independent variable (the knowledge hiding of the AI) and as a dependent variable (knowledge hiding of the participant). Additionally, this made sure that there was enough variance in knowledge hiding as the independent variable.

To check if participants actually believed that they were playing against another participant, some final questions were added. Participants were asked to rate statements from 1

to 5 (completely disagree to completely agree) based on how they felt while playing the games. Two of these items were linked to the believability of the AI: “player 2 seems like a real person to me” and “I do not think that player 2 actually exists” (which had to be recoded). To make the items about believability less obvious, items were added that related to likability and selfishness.

Another possible influencer of the choices a player makes in the knowledge exchange games is the payoff matrix. To account for differences in behaviour that could be triggered by different payoff matrices, each participant will encounter 4 different matrices 4 times (resulting in 16 rounds of knowledge exchange games). These matrices are made by varying the effects of the underlying mechanisms of fear (S < P) and temptation (R < T). For example, in a matrix with a small effect of temptation, there is a difference of 2 points between the reward and temptation (see tables 3 to 7). To also account for possible effects of the order of the games, the order of the games (including the different matrices and the computer’s choice for sharing or hiding) was randomized for each participant.

Table 3: 2 by 2 construction of four different payoff structures

	Small effect of fear (2 points)	Big effect of fear (6 points)
Small effect of temptation (2 points)	Matrix 1	Matrix 2
Big effect of temptation (6 points)	Matrix 3	Matrix 4

Table 4: matrix 1 = small effect of temptation, small effect of fear

	Player 2	
Player 1	Right answer	Wrong answer
Right answer	8 | 8	10 | 0
Wrong answer	0 | 10	2 | 2

Table 5: matrix 2 = small effect of temptation, big effect of fear

	Player 2	
Player 1	Right answer	Wrong answer
Right answer	8 | 8	10 | 0
Wrong answer	0 | 10	6 | 6

Table 6: matrix 3 = big effect of temptation, small effect of fear

	Player 2	
Player 1	Right answer	Wrong answer
Right answer	10 | 10	16 | 2
Wrong answer	2 | 16	4 | 4

Table 7: matrix 4 = big effect of temptation, big effect of fear

	Player 2	
Player 1	Right answer	Wrong answer
Right answer	10 | 10	16 | 0
Wrong answer	0 | 16	6 | 6

Game sequence

Every game that is played in this study follows the same structure. First, the player is shown the matrix that will be applicable for the game that is coming, as well as their knowledge (shape or colour). This screen is shown for 5 seconds. The next screen shows the matrix again and asks the participant to make a choice: share or hide their knowledge with the other player. This screen is also shown for 5 seconds. After this, a screen is shown that shows the choice of the AI opponent. If the AI chooses to share their knowledge, this knowledge is shown on the page. If they choose to hide, it is not shown. On the same page, players have to select the right shape and colour combination from 36 possible options. After they do this, they are shown the points that both players earned from this round and, in the next screen, how many points they both scored in total up until that point.

While testing the games, it showed that it took some time before participants were fully able to grasp how the game worked. To make sure that this did not influence the results, two trials rounds were implemented before the actual games (one where the AI shared their knowledge, one where they hid it). In these rounds, there was no time limit of 5 seconds in the first two screens. This way, participants were given the time to fully process the information that was shown on their screen. After the trials rounds, a waiting screen was shown, giving the illusion that participants were waiting for the other player to start the actual rounds.

Procedure

Participation in this study was done through playing economic games of knowledge exchange against an AI player. However, it is important that participants of this study think that they can influence the other player's decision by their own decisions. Participants should think that they are playing against another person and that they can only communicate with that other player through their decisions made in the game. Therefore, two players were invited to participate in the study at the same time, playing the games on separate laptops against AI, but under the assumption that they are playing against the other participant. To make sure there was no communication possible, they played the games in separate rooms as well.

The different elements of the study are presented to the participants in the following order:

- Informed consent
- Knowledge Hiding questionnaire (randomized items)
- HEXACO questionnaire (randomized items)
- Knowledge hiding games
    - Instructions
    - 2 trials rounds
    - Waiting screen
    - 16 rounds
- Final questions (believability, likability, selfishness)

After final questions were filled in and participants waited for each other to be finished, participants were debriefed. They were told about the goals of the study and about the fact that they played against the AI and not each other.

Results

Reliability of the data

Certain checks were done to see if the collected data was reliable enough to use. In the correlation matrix (Table 8), the Cronbach's alpha for relevant concepts are shown. The alphas ranged from 0.70 to 0.88 and are thus high enough.

In the knowledge exchange games, different payoff matrices were used to create different conditions for knowledge behaviour. In table 9, the frequencies of hiding and sharing for each matrix are shown. The total for each row is 400, because each participant encountered each payoff matrix four times. Using a chi² analysis, it was calculated that there was a significant difference between the matrices in the frequency of sharing and hiding of knowledge (p > 0,01). This proves that the manipulation with different matrices in the games worked.

Table 8: frequencies of knowledge sharing and hiding for each payoff matrix

	Share	Hide
Matrix 1 (small temptation, small fear)	289	111
Matrix 2 (small temptation, big fear)	271	129
Matrix 3 (big temptation, small fear)	245	155
Matrix 4 (big temptation, big fear)	228	172

Lastly, a check was done to see if participants believed they were playing against another player. A mean score of the items relating to believability was calculated and a t-test was done to test if this score was significantly higher than 3 (with a score of 3 meaning “neutral” and higher than 3 meaning that the deception was believed). The mean score of believability was 3.38 (SD = 1.05) and the mean score was significantly higher than 3.00 (p > 0,01).

*Table 9: Descriptive statistics for all variables, * p < 0.05, ** p < 0.01*

Variables	Correlations													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age														
2. Gender (0 = male, 1 = female)	-.10													
3. Education (0 = low, 1 = high)	.28**	-.16												
4. Nationality (0 = Dutch, 1 = other)	-.11	.09	-.22*											
5. Believability	-.10	.24*	-.05	-.10										
6. Honesty-humility	-.03	.21*	-.17	.08	.05									
7. Emotionality	-.07	.57**	.04	-.04	.33**	.01								
8. Extraversion	.05	-.23*	.16	.07	-.03	-.17	-.06							
9. Agreeableness	-.05	.08	-.05	.02	.06	.26**	-.03	-.02						
10. Conscientiousness	.06	.15	-.01	-.03	-.01	.31**	.06	-.08	-.13					
11. Openness to experience	.07	.07	.00	.14	-.16	.19	.21*	.12	.02	-.04				
12. Knowledge Hiding AI	-.05	.07	-.03	.10	-.09	-.16	.18	.20*	.12	-.09	.16			
13. Knowledge Hiding Self-report	-.16	.18	-.04	-.11	.28**	-.23*	.20*	.02	-.12	-.31**	-.01	.12		
14. Knowledge Hiding Behaviour	-.18	-.00	-.06	-.15	.23**	-.23*	.13	.09	-.10	-.11	-.24*	.38**	.29**	
(Cronbach's α)					.88	.70	.78	.78	.74	.78	.76		.80	
M (SD)	23.4 (4.9)	.63 (.48)	.64 (.48)	.19 (.39)	3.38 (1.10)	3.52 (.57)	3.38 (.63)	3.36 (.61)	3.23 (.57)	3.59 (.60)	3.74 (.59)	7.76 (3.31)	1.84 (.47)	6,67 (3.60)

Testing of hypotheses

The correlation matrix in table 9 shows descriptive statistics of all variables that were measured in this study, including demographics, believability, all HEXACO traits, Knowledge Hiding of the AI and Knowledge Hiding of the participant. The dependent variable of this study, knowledge hiding of the participant, is measured in both the mean score on the Knowledge Hiding self-report questions and as behaviour in the Knowledge Hiding games. These different measures for Knowledge Hiding show different significant correlations with the other variables. They both correlate significantly with believability and honesty-humility, but KHsr also shows a significant correlation with emotionality and conscientiousness and KHb with openness to experience and KHai.

To test the hypotheses of this study, multiple regression analyses were done with both KHsr and KHb. As can be seen in table 9, none of the demographic variables showed a significant correlation with KHsr or KHb, so they were left out of the regression analyses. For KHsr, the HEXACO traits emotionality and conscientiousness were added in the first step as control variables, as they both showed a significant correlation with KHsr. In step 2, honesty-humility, the hypothesized predictor of KH, was added. KHai, the other hypothesized predictor of knowledge hiding, was not included in this regression. This is because KHai is a variable that is part of the knowledge exchange game and has no direct impact on KHsr. As can be seen in Table 10, both emotionality ($p < 0.05$) and conscientiousness ($p < 0.01$) were significant in this regression analysis, while honesty-humility was not.

*Table 10: Regression analysis with dependent variable KHsr, * p < 0.05, ** p < 0.01*

		Step 1 (b)	Step 2 (b)
Step 1			
	Emotionality	.22*	.22*
	Conscientiousness	-.33**	-.28**
Step 2			
	Honesty-humility		-.14
ΔR^2		.15**	.16**

The regression analysis for KHb is partly based on the results of the regression analysis of KHsr. Though knowledge hiding as self-report scores and actual behaviour are treated as separate variables in this study, they refer to the same concept. It can therefore be argued that significant predictors of KHsr are also likely to predict KHb. This overlap can be further supported by the significant correlation between KHsr and KHb.

In step one of the regression analysis for KHb, control variables were added. Included is openness to experience, which showed a significant correlation with KHb, as well as the traits that were significant in the regression for KHsr (emotionality and conscientiousness). Additionally, agreeableness was also added. This is because of the expected interaction effect of agreeableness with KHai. To be able to include the moderating effect of agreeableness, it is also tested for a direct effect in this first step.

In step two, the hypothesized predictors of KHb are added (honesty-humility and KHai), followed by the interaction variables (HH * KHai and A * KHai) in the third step. In the fourth and last step, believability was added. This variable was not hypothesized as a predictor of KHb, but it was included in the regression analysis to check if it significantly altered the results from the previous steps.

Table 11 shows the results for this second regression analysis. Here, it can be seen that KHai has a significant effect on KHb ($p < 0.01$) in all steps of the analysis, while the predictor honesty-humility, again, does not. Of the control variables, openness to experience also has a significant effect in all steps of the regression ($p < 0.01$). Adding believability in the final steps doesn't change any of the results, but it does have a significant effect on KHb ($p < 0.05$).

*Table 11: Regression analysis with dependent variable KHb, * p < 0.05, ** p < 0.01*

		Step 1 (b)	Step 2 (b)	Step 3 (b)	Step 4 (b)
Step 1					
	Emotionality	.20*	.13	.13	.04
	Agreeableness	-.11	-.14	-.15	-.16
	Conscientiousness	-.14	-.09	-.08	-.06
	Openness to experience	-.29**	.33**	-.33**	-.27**
Step 2					
	Honesty-humility		-.04	-.06	-.08
	Knowledge hiding AI		.41**	.40**	.43**
Step 3					
	HH * KHai			-.06	-.06
	A * KHai			-.13	-.15
Step 4					
	Believability				.23*
ΔR^2		.12*	.29**	.31**	.35**

Discussion/conclusion

This research studied the direct and moderating effect of the personality trait honesty-humility on knowledge hiding, as well as the reciprocation of knowledge hiding. This was done by letting 100 participants fill out questionnaires about knowledge hiding behaviour, the HEXACO60 and by letting them play games of knowledge exchange against a randomized AI opponent. Results from a multiple regression analysis showed significant support for the fact that knowledge hiding behaviour was reciprocated. Honesty-humility was not a significant predictor of knowledge hiding or a moderator of the relation between knowledge hiding of one person on knowledge hiding of the other person in the regression equation, though it did show a significant negative relation with knowledge hiding in both self-report scores and behaviour in the correlation matrix. Interestingly, there were other variables that showed a significant relation to knowledge hiding behaviour in the multiple regression analysis, namely the trait openness to experience and believability of the AI.

There are some limitations of this study that have to be noted to bring some nuance to these results, starting with the most significant conclusion: reciprocation of knowledge hiding behaviour. In this study, reciprocation of knowledge hiding was measured by comparing the frequency of knowledge hiding chosen by the participant with knowledge hiding by the AI over all 16 games. The frequency of the AI opponent was completely independent of actions by the actual participant. However, to truly be able to prove that the AI's knowledge hiding caused the participant to engage in more knowledge hiding, information is also needed about the order of the games and the choices that were made by both the AI and the participant. Specifically, it needs to be known if knowledge hiding by the AI precedes knowledge hiding of the participant and if the participant reacted to this behaviour with more knowledge hiding. Unfortunately, participants played 16 games in a randomized order which was not recorded in the data collection and could therefore also not be used in the analyses. A causal relation could therefore not be proven without a doubt, but because of the evidence from other literature and the high correlation, it does seem likely that knowledge hiding of the AI increased knowledge hiding of the participant.

Another limitation of the study is the way knowledge hiding behavior was conceptualized, which could possibly explain the difference between what was hypothesized and what was found with regards to the role of Honesty-Humility. To be able to build a knowledge exchange game as an experiment, knowledge hiding was operationalized as one of two choices in behaviour relating to knowledge: you can either hide or share it. In this experimental simulation of knowledge behaviour, there was no distinction made in the kinds of knowledge behaviour that Connelly et al. (2012) describe, namely playing dumb, evasive hiding and rationalized hiding. The game used in this study provided no options to engage in any of these behaviours, as the opponent always knew that the player did possess the knowledge they requested (so playing dumb was not an option) and players were forced to make a decision without explaining it. It can be argued that honesty-humility would have had a bigger impact on knowledge hiding behaviour if the game would have allowed lying, as low scorers on honesty-humility are known to lie if it suits them (Hilbig et al., 2003; Lee & Ashton, 2004). Further research can look into this relation by using (an adapted version of) the cheap talk game, where one player has control over communication and the other over action that influences both payoffs.

The dichotomy of share/hide when talking about knowledge behaviour also limits the validity of this study's results when the trait of openness to experience is considered. In both correlation and regression, this trait showed a significant negative effect on knowledge hiding,

and that seems to suggest that those who score low on openness to experience would engage more in knowledge hiding. Seeing as this trait relates to a curiosity when it comes to knowledge (Lee & Ashton, 2004), this seems fairly reasonable. However, it is not clear if this conclusion can actually be drawn. As stated in the theoretical framework, knowledge behaviour consists of many concepts besides just sharing and hiding and even sharing and hiding can sometimes (partly) overlap. So, in practice, knowledge hiding and sharing are not mutually exclusive. Of the two variables in this study that represented knowledge hiding, KHsr and KHb, only KHsr actually framed knowledge hiding in this way. Knowledge hiding behaviour, the dependent variable of the regression analysis that test the hypotheses of this study, does treat knowledge hiding and sharing as mutually exclusive. This makes it hard to determine if openness to experience actually negatively influences someone's knowledge hiding behaviour, or if it leads to more knowledge sharing. Making this distinction becomes even harder when considering the amount of evidence there is for the positive effect that openness has on knowledge sharing (Cabrera et al, 2006; Lotfi et al, 2016; Matzler et al, 2008), as well as the evidence for openness to experience leading to more cooperative answers in PDG (Lönnqist et al, 2010). To provide a better insight into the role of this trait on knowledge hiding, more research is needed.

Besides the conceptualisation of knowledge hiding in this study, there were some other limitations. Connelly et al. (2012) found (dis)trust to be a significant predictor of knowledge hiding. In this study, it was not measured how much the participants trusted each other. Even though the participants did not actually play the knowledge games against each other, a lot of participants reported afterwards that their choices in the games were influenced by the behaviour they expected from the other player before the games started. Additionally, the sample used in this study consisted mostly of students, which lowers its external validity and makes it difficult to apply these results to the context it was intended for: knowledge behaviour in the workplace. Finally, the time limits during the games also had some unexpected effects. In each game, participants were first presented with the payoff matrix and their piece of knowledge on the same page. They had five seconds to take in all this information and for some, this proved to be too little time. This resulted in some games where participants got knowledge from the AI, but were unable to answer the final question correctly, because they had forgotten their own. It could be that someone's ability to remember their own information has affected the results, but because this variable was not recorded (or even expected), this cannot be known for sure.

In conclusion, this study found some evidence for the effect of personality on knowledge hiding behaviour through the trait of openness to experience. However, the biggest effect that

was found was for the fact that knowledge hiding behaviour is reciprocated by their targets. This suggests that knowledge hiding by employees is not only something to be prevented, but also a cycle to be broken. In companies where a large number of employees engage in knowledge hiding, there needs to be a cultural shift to be able to change the behaviours of a big group of people. In game theoretical terms, someone has to be the first to cooperate and quit their knowledge hiding behaviour, but that person also risks lowering their individual payoffs if the other players don't do the same. This brings us back to one of the biggest predictors of knowledge hiding in Connelly et al.'s (2012) study: interpersonal distrust. For future research, it could be proposed that interpersonal distrust does not only predict knowledge hiding, but also moderates the reciprocation of knowledge hiding.

To break the cycle of knowledge hiding between employees, it is good to look at variables that influence cooperation in social dilemma games. Communication between players has been found to positively affect cooperation in these games, mostly through forming a group identity and shared norms (Orbell, van de Kragt, & Dawes 1988 and Kerr et al, 1997 in Balliet, 2010; Jensen et al., 2000). Furthermore, communication, especially face-to-face in small groups, can create trust (Jensen et al., 2000; Rothstein, 2000). Therefore, in order to counteract knowledge hiding or break knowledge hiding cycles, a company would benefit from investing in the foundations of good interpersonal relationships and foster better (direct) communication and trust among all employees.

References

Ackermann, K. A., Fleiß, J., & Murphy, R. O. (2016). Reciprocity as an individual difference. *Journal of Conflict Resolution*, *60*(2), 340-367.

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution*, 54(1), 39-57.

Bilginoğlu, E. (2019). Knowledge hoarding: A literature review. *Management Science Letters*, *9*(1), 61-72.

Bock, G. W., & Kim, Y. G. (2002). Breaking the myths of rewards: An exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal (IRMJ)*, *15*(2), 14-21.

Burmeister, A., Fasbender, U., & Gerpott, F. H. (2019). Consequences of knowledge hiding: The differential compensatory effects of guilt and shame. *Journal of occupational and organizational psychology*, *92*(2), 281-304.

Černe, M., Nerstad, C. G., Dysvik, A., & Škerlavaj, M. (2014). What goes around comes around: Knowledge hiding, perceived motivational climate, and creativity. *Academy of Management Journal*, *57*(1), 172-192.

Connelly, C. E., Zweig, D., Webster, J., & Trougakos, J. P. (2012). Knowledge hiding in organizations. *Journal of Organizational Behavior*, *33*(1), 64-88.

Hilbig, B. E., Kieslich, P. J., Henninger, F., Thielmann, I., & Zettler, I. (2018). Lead us (not) into temptation: Testing the motivational mechanisms linking honesty–humility to cooperation. *European Journal of Personality*, *32*(2), 116-127.

Hilbig, B. E., Zettler, I., Leist, F., & Heydasch, T. (2013). It takes two: Honesty–Humility and Agreeableness differentially predict active versus reactive cooperation. *Personality and Individual Differences*, *54*(5), 598-603.

Ho, S. P., Hsu, Y., & Lin, E. (2011). Model for knowledge-sharing strategies: A game theory analysis. *The Engineering Project Organization Journal*, *1*(1), 53-65.

Jiang, Z., Hu, X., Wang, Z., & Jiang, X. (2019). Knowledge hiding as a barrier to thriving: The mediating role of psychological safety and moderating role of organizational cynicism. *Journal of Organizational Behavior*, *40*(7), 800-818.

Jensen, C., Farnham, S. D., Drucker, S. M., & Kollock, P. (2000, April). The effect of communication modality on cooperation in online environments. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 470-477).

Kieslich, P. J., & Hilbig, B. E. (2014). Cognitive conflict in social dilemmas: An analysis of response dynamics. *Judgment & Decision Making*, *9*(6).

Lee, K., & Ashton, M. C. (2004). Psychometric properties of the HEXACO personality inventory. *Multivariate behavioral research*, *39*(2), 329-358.

Lee, K., & Ashton, M. C. (2012). Getting mad and getting even: Agreeableness and Honesty-Humility as predictors of revenge intentions. *Personality and Individual Differences*, *52*(5), 596-600.

Lin-gang, Z. (2010, November). Examining knowledge exchange in an organization: A game theory perspective. In *2010 International Conference on Management Science & Engineering 17th Annual Conference Proceedings* (pp. 958-963). IEEE.

Lönnqvist, J. E., Verkasalo, M., & Walkowitz, G. (2011). It pays to pay–Big Five personality influences on co-operative behaviour in an incentivized and hypothetical prisoner's dilemma game. *Personality and Individual Differences*, *50*(2), 300-304.

Lotfi, M., Muktar, S. N. B., Ologbo, A. C., & Chiemeke, K. C. (2016). The influence of the big-five personality traits dimensions on knowledge sharing behavior. *Mediterranean Journal of Social Sciences*, *7*(1 S1), 241.

Matzler, K., Renzl, B., Müller, J., Herting, S., & Mooradian, T. A. (2008). Personality traits and knowledge sharing. *Journal of economic psychology*, *29*(3), 301-313.

Pan, W., Zhang, Q., Teo, T. S., & Lim, V. K. (2018). The dark triad and knowledge hiding. *International Journal of Information Management*, *42*, 36-48.

Rothstein, B. (2000). Trust, social dilemmas and collective memories. *Journal of theoretical politics*, *12*(4), 477-501.

Serenko, A., & Bontis, N. (2016). Understanding counterproductive knowledge behavior: antecedents and consequences of intra-organizational knowledge hiding. *Journal of Knowledge Management*, *20*(6), 1199-1224.

Sharma, R. S., & Bhattacharya, S. (2013). Knowledge dilemmas within organizations: Resolutions from game theory. *Knowledge-Based Systems*, *45*, 100-113.

Shih, M. H., Tsai, H. T., Wu, C. C., & Lu, C. H. (2006). A holistic knowledge sharing framework in high-tech firms: game and co-opetition perspectives. *International Journal of Technology Management*, 36(4), 354-367.

Tett, R. P., & Burnett, D. D. (2003). A personality trait-based interactionist model of job performance. *Journal of Applied psychology*, *88*(3), 500.

Tett, R. P., & Guterman, H. A. (2000). Situation trait relevance, trait expression, and cross-situational consistency: Testing a principle of trait activation. *Journal of Research in Personality*, *34*(4), 397-423.

Zettler, I., Hilbig, B. E., & Heydasch, T. (2013). Two sides of one coin: Honesty–Humility and situational factors mutually shape social dilemma decision making. *Journal of Research in Personality*, 47(4), 286-295.