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Exploring Scientists' Communication Behaviour

A Theory of Planned Behaviour Approach

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Abstract

Exploring Scientists' Communication Behaviour: A Theory of Planned Behaviour Approach

In this globalised world, the interest of the general public in scientific knowledge is ever increasing. Research institutions and especially the scientists are more and more in demand to communicate their research findings and inform the general public. Surveys, however, suggest that the scientists' engagement is lacking, as only a small amount of is actually engaging. This study explores key factors that lead scientists to engage in science communication activities. Built on the theory of planned behaviour by Fishbein and Ajzen (1975, 1991), attitudes, subjective norms and perceived control as well as intentions were examined regarding their predictive effects towards engagement. A cross-sectional self-administered online survey was conducted among scientists at non-university research institutions in Germany over a span of five weeks. The study showed that engagement could be divided into two different kinds: engagement in classic PR activities and direct engagement with the lay public. The factors that contributed most towards predicting intentions and engagement were the number of colleagues in the direct professional environment who engaged, moral obligations and the importance that is put on engagement. These results can now serve as guidelines for communication departments at the research institutions to help develop measures that aim at increasing engagement.

Keyword: Science communication, public relations, theory of planned behaviour, scientists' perception of communication, scientists' participation, public engagement, Germany

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1 Introduction

"Nothing in science has any value to society if it is not communicated, and scientists are beginning to learn their social obligations."

Anne Roe, The Making of a Scientist (1953)

Already in 1953, Anne Roe, an American psychologist and researcher, recognised the importance of science communication. More than half a century later, her statement has not lost its relevance, if anything it has become more meaningful than ever. As the world has grown in complexity and issues such as climate change or virus epidemics are discussed on a global scale, the need to communicate research results and scientific activities has become increasingly more important. The often-overstated picture of the "ivory tower" that paints a sheltered world where scientists only keep to themselves, isolated from everything but their community, has to be discarded in favour of establishing a dialogue with the general public that aims at exchanging information and ideas.

Needless to say, this ideal world is far from being attained, however, first steps in this direction can be observed. The interest of the public in scientific topics is growing, as several surveys suggest. The German survey "Wissenschaftsbarometer 2016" showed that 41% of Germans have a high interest in scientific topics (Wissenschaft im Dialog, 2016). In the U.S., even higher results were found as the Pew Research Center (2015b) reports that 70% of U.S. adults are interested in health and medicine and 59% are interested in science and technology. At the same time, the Special Eurobarometer 401 showed that 58% of Europeans feel not very well or not at all informed about developments in science and technology (European Commission, 2013) and in Germany 39% of the public think that scientists do not make enough of an effort to inform the

public about their work (Wissenschaft im Dialog, 2016). Contrary to that, more than 80% of the surveyed U.S. scientists see a major problem in the public's lack of knowledge about science (Pew Research Center, 2015a). All these numbers suggest a rather large gap between how scientists and the public perceive the other. This gap might be attributed to a lack of communication, meaning that the scientists do not engage enough in bringing their research closer to the general public. However, it cannot be said that scientists do not communicate in general, as there are still scientists who take initiative. The question that now arises is what sets these scientists apart from the ones that decide to not engage? This thesis will build on this question by focusing on examining key factors that lead scientists to engage in science communication activities. The research question is thus:

Why do scientists engage in science communication activities?

The study will be aimed at scientists in Germany, as studies there are few with the majority of research being focused on the U.S. and the UK. The scientific landscape in Germany is dominated by four big societies and associations, to which each a multitude of research institutes belongs. Science communication is indeed practiced at these institutes, compared to the U.S. or the UK however the efforts appear minor. To examine the role that science communication plays in the daily work life of scientists in Germany more closely, the thesis follows a quantitative research approach that is based on a non-experimental survey design. A cross-sectional self-administered online questionnaire will be used to collect data and will thus be distributed among scientists in Germany.

The survey will be developed using the theory of planned behaviour as a framework. Built on the concept that attitudes, subjective norms and perceived behavioural control influence intentions and behaviour, the survey and the subsequent analysis aim at

identifying the most prominent and relevant factors that lead scientists to engage in order to see how the results might contribute to science communication practice. The results will most likely be most usable for the communication and public relations departments of the respective research institution as these are in the best starting position to implement possible changes.

Before commencing with the main part of the thesis, two terms have to be clarified. Firstly, the thesis focuses on science communication. Similar to other communication disciplines, there is no one definition of science communication. Burns et al. (2003) outline science communication as measures aimed at eliciting *"one or the following personal responses to sciences (the vowel analogy)*

> ***A****wareness, including familiarity with new aspects of science*
>
> ***E****njoyment or other affective responses, e.g. appreciating science as entertainment or art*
>
> ***I****nterest, as evidenced by voluntary involvement with science or its communication*
>
> ***O****pinions, the forming, reforming, or confirming of science-related attitudes*
>
> ***U****nderstanding of science, its content, processes, and social factors"* (p.191)

Science communication activities are therefore aligned with these responses and can include a variety of different measures such as engaging directly with the public through dialogues or indirectly through the media. Secondly, it has to be clarified who is included when talking about the general public. In its simplest form, the general public includes all people in a specific country or area, in this case in Germany. This usually assumes a very heterogeneous group of people of all ages, genders and social and academic backgrounds. Often the general public is put on the same level as the lay public and therefore non-experts.

This thesis deals with establishing and testing a model that explores scientists' communication behaviour. The examined population is restricted to the perceptions and behaviours of scientists in Germany and will only focus on science communications practitioners when discussing the implications of the results. The data will be gathered from the end of March to the end of April 2017, thus setting a time frame of five weeks.

2 Literature Review

Over the past decades, the academic field of communication studies has been rapidly growing and evolving. Various disciplines emerged, becoming stronger by interlinking and drawing from each other's theoretical perspectives and frameworks. Science communication can, similar to the field of strategic communication, be seen as an overall umbrella concept, having grown from a small network of public communication of science and technology scholars to an international community in the last 50 years (Gascoigne et al., 2010). As a multidisciplinary area of study, it draws among others upon public relations (PR), journalism, public diplomacy and sociology in order to be most effective in reaching its different objectives (Gascoigne et al., 2010). Claessens (2014) outlines science communication as an important necessity of democracy to "build trust and legitimacy for activities funded in great part by the public" (p.3). The following part will give an overview over the dominant paradigms in science communication and explain how they can be connected to the field of public relations research. Additionally, the role of scientists' engagement in science communication activities will be examined more closely with a focus on the scientific landscape in Germany.

2.1 Is it Science Communication or Public Relations?

In science communication research, there are different models on how information and knowledge is distributed, discussed or created. Bucchi (2008) describes a framework that features three main models that show how the view on communicating science to the public has changed over the years. The first model was considered the dominant paradigm for a long time and is known as the deficit model. Bucchi (2008) describes this as a "process concerned with the transfer of knowledge from one subject or group of subjects to another subject or group of subjects" (p.66). It relies on a one-way flow of

information from science to its passive publics. The second model developed from this and turned away from a one-way communication to a dialogue model where the public is active by taking part in discussions, focusing on the interaction between science and its publics (Burns et al., 2003). This evolved to an even deeper involvement of the public in the participation model. Hereby, "non-experts and their local knowledge can be conceived as […] essential for the production of knowledge itself" (Bucchi, 2008, p.68). The public is not only invited to take part in discussions, but is instead actively participating in the scientific research process. 'Citizen science' is the keyword, a concept where citizens work as volunteers together with professional scientists on collecting data or supporting the research in other ways they are able to (Silvertown, 2009). However, it cannot be said that the last model is the dominant model that is used in every communication situation nowadays. Instead, all three models exist simultaneously or even in combination, depending on the context and situation (Bucchi, 2008). These three models suggest that engagement in science communication activities exists on several levels, with different activities being part of different levels. This needs to be taken into account when designing the study, as different kinds of engagement could be influenced by diverging activities.

A similar framework can be found in PR research. PR in general often draws on Grunig and Hunt's four models of PR (1984) as an illustration of the historical development of the field. When comparing the four models of PR to the three models Bucchi describes, a lot of similarities can be found. Grunig and Hunt (1984) start with a one-way asymmetrical press agentry model that aims at creating favourable publicity using targeted messages (Borchelt & Nielsen, 2014). This transitioned to the public information model and from there to a two-way asymmetrical model where public opinion is taken into account. The fourth and according to Grunig and Grunig (1992) ideal model for practicing PR is the two-way symmetrical model that "uses research to

facilitate understanding and communication rather than to identify messages most likely to motivate or persuade publics" (p.289). When looking at both overall frameworks, a paradigm shift from an unbalanced passive model towards an open participatory model can be observed.

However, science communication and PR cannot be put on the same level in all areas. Shipman (2014) commented that science communication includes "anything that conveys information about scientific findings or concepts" (p.1) whereas PR is aimed at improving the reputation and public image of the institution. Insofar it can be said that PR is a tool used by science communicators to achieve their strategic goals and to build relationships between the scientific community and the public (Borchelt & Nielsen, 2014; Carver, 2014). Science communication instead can include various different activities that range from internal communications to public affairs and media relations. It is still possible though that these follow the same strategic motives as the PR activities but are aimed at different target groups.

2.2 Scientists' Engagement in Science Communication Activities in Germany

One important actor in communicating scientific findings and information to the general public are the scientists themselves. In our globalised society where topics such as climate change, stem cell research, genetically modified crops or health issues are at the forefront of the public's minds, the expertise of scientists is increasingly in demand. Scientists take on the roles of both policy advisers to politicians and governments as well as public communicators who aim at sharing their research with the lay public (Peters, 2014). They are involved in decision-making processes, providing the necessary information and giving advice that is based on their scientific knowledge (Peters, 2014). According to Shughart and Racaniello (2015), scientists are obligated to participate in the public dialogue to enable the public to "make informed decisions about the complex

issues that face us in our technologically advanced society" (p.1). Expectations are high, given that scientists are considered to be able to communicate both in their scientific language as well as in the language of everyday life, no matter if this corresponds to their actual abilities (Peters, 2013). The possibilities to communicate are endless and range from classic PR work such as writing press releases and providing information for brochures or websites to engaging in a direct dialogue with the public on social media or blogs. Thereby, target groups besides the lay public can vary considerably, ranging from governments to the industry or funding agencies to reviewers from journals and other members of the scientific community. This puts a lot of pressure on the scientists to relate relevant information in a way that is interesting and comprehensible to each target group without necessarily having undergone any kind of communication training (Shughart & Racaniello, 2015). It appears to be necessary to educate scientists on how to communicate with the lay public and other target groups as well as dissolve the existing clichés scientists have about science communication activities (Claessens, 2014). Additionally, Peters (2014) stresses, that science communication "cannot be understood as *translation*" (p.78), meaning that the scientific language is not easily understood by the general public, thus making direct translations impossible. Instead, scientists need to make themselves clear through comparisons or metaphors that the public can relate to in their everyday life (Peters, 2014).

To fulfil all these expectations and obligations, different initiatives have been launched that aim at supporting scientific institutions in establishing a dialogue with the public. In Germany, one of these was initiated by the Donors' Association for the Promotion of Sciences and Humanities in Germany in form of a memorandum that among others the four main science societies (Max Planck Society, Fraunhofer Society, Helmholtz Association and Leibniz Association) as well as the Rector's Conference that includes the majority of German universities and universities of applied sciences signed. The

memorandum directly addresses the scientists to promote a dialogue between science and society to facilitate a permanent exchange of knowledge (Stifterverband der Deutschen Wissenschaft, 2000). Incentives for engaging as well as opportunities for communication training are provided both for the scientists directly but also for the scientific institutions (Stifterverband der Deutschen Wissenschaft, 2000). However, Lehmkuhl (2012) notes that it is questionable, how much this and the PR efforts done by the research institutions and the Donors' Association can help to actually contribute towards a dialogue with the public that aims at popularising science instead of only popularising their own organisation.

When looking at previous studies that examined the engagement of scientists in science communication activities, participation for example in talking to journalists has been rather low. In a survey from the Royal Society (2006), 24% of the surveyed scientists in the UK stated that they were interviewed at least one or more times by newspaper journalists in the last year. Similarly, 23% of U.S. scientists stated that they occasionally or often talk with journalists (Pew Research Center, 2009). A German survey done by Pansegrau et al. (2011) showed that 35.1% answered inquiries from journalists 1-2 times (Pansegrau et al., 2011). Reasons for this low participation are put down to a lack of time and resources but also on fears of consequences that engaging might have such as being looked down upon by their peers or sending out the wrong messages (Pansegrau et al., 2011; Royal Society, 2006). However, general interest to engage exists and a lot of scientists rate participation as very important (Royal Society, 2006). In Germany, only a few studies have examined scientists' communication behaviour. In addition to the survey done by Pansegrau et al. (2011), Peters et al. (2009) examined biomedical researchers in five different countries regarding their contact with journalists and the public. They found that legitimising their research is one of the scientists' main aims of contacting the media, while insecurity and the feeling of not

having enough control stops scientists from engaging (Peters et al., 2009). When evaluating the different studies, it becomes apparent that most studies were conducted for informative reasons, simply asking a variety of questions about all kinds of topics and issues. What seems to be missing, however, is an examination of the relationship between the different communication activities and factors that enable or prevent engagement in order to detect possible explanations in regards to the engagement in science communication activities. Additionally, the aforementioned studies focused in large parts on the media behaviour of scientists as well as on the relationship between the scientific community and science journalists. Research that examines relationships between scientists and the general public in terms of predictive factors regarding engagement is rather lacking. The aforementioned studies lay down a good groundwork for other research to build on, leaving an opening for this study to explore interactions and influences of different factors that explain why some scientists decide to participate in science communication activities while others do not.

2.3 Theoretical Framework

This study follows a reasoned action approach where behaviour is directed towards a specific goal or guided by conscious processes. Reasoned action presumes that human information processes and decision-making are based on controlled and conscious aspects that underlie behaviour and are not done automatically or mindlessly (Ajzen, 2012). It follows the assumption that action is performed consistently on the basis of the available information, thus building on reason. The available information, and therefore the behaviour, is heavily influenced by "expected consequences, perceived normative pressures and anticipated difficulties" (Ajzen, 2012, p. 451).

Fishbein and Ajzen first developed this approach in their theory of reasoned action (1975) and later extended it to the theory of planned behaviour (TPB) (Ajzen, 1991).

The TPB explores human behaviour and focuses on the assumption that behaviour is guided by intentions, which in turn are influenced by different factors. The theory is often used in social science research as a framework to explain and predict behaviour in different areas, from the use of public transportation or consumer behaviour (see Bamberg et al., 2003; Shaw et al., 2000) to health-related issues such as leisure activities, condom use or diets (see Ajzen & Driver, 1991; Albarracín et al., 2001; Conner et al., 2002). There are a few studies in communication research, focusing for example on the impact of public relations or branding (see Bang et al., 2014; Thornhill et al., 2017). In science communication research, the TPB has been previously used as a framework for explaining scientists' engagement in science communication activities, focusing on the U.S. and the UK (see Dudo, 2012; Poliakoff & Webb, 2007). This study will further contribute to the field of public relations and science communication, extending the setting to Germany. The following gives a brief explanation of the different factors that contribute to the TPB as well as limitations and problems of applying the TPB as a framework for this study.

2.3.1 The Theory of Planned Behaviour

The central assumption of the TPB is that a person's intention to perform a certain behaviour has an impact on the actual performance of the behaviour. Ajzen (1991) states that "the stronger the intention to engage in a behavior, the more likely should be its performance" (p.181). This suggests a strong relationship between intentions and behaviour, where a change of intentions also results in a change of behaviour (Ajzen, 2012). Intentions in turn are influenced by three main factors: attitudes towards the behaviour, subjective norms and perceived control over the behaviour (see Figure 1). These three parts factor into predicting intentions to varying degrees, depending on the kind of behaviour and situation (Ajzen, 1991). However, control over the behaviour can also directly influence the performance, so that it acts as a moderator for the relationship

between intentions and behaviour (Ajzen, 2012). Thereby, the perceived behavioural control is often of more interest than the actual control and, if the perceptions are realistic, perceived control can be used as a substitute for actual control (Ajzen, 1991) (figure 1).

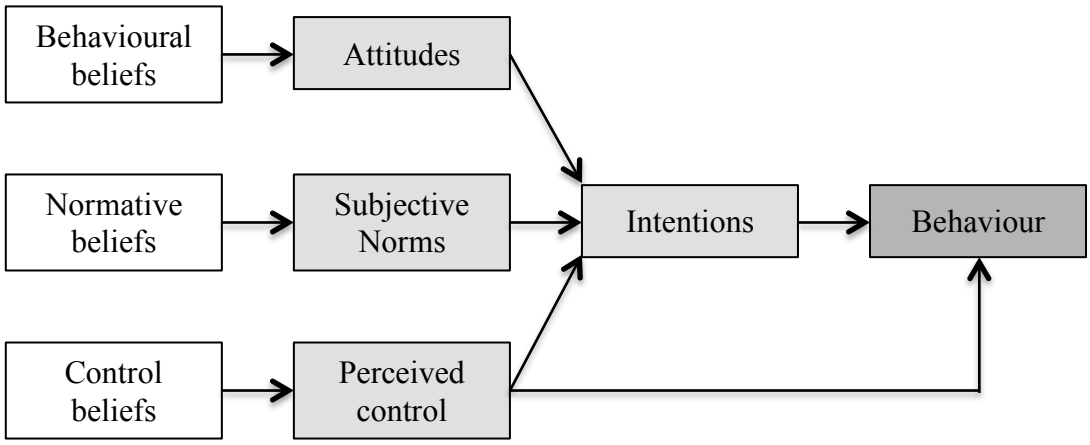

Figure 1: The theory of planned behaviour (after Ajzen, 1991)

Attitudes, subjective norms and perceptions of control are determined by different underlying beliefs. These beliefs are the salient beliefs that are readily accessible and appear to be relevant to the given behaviour (Ajzen, 2012). Behavioural beliefs influence attitudes by associating the behaviour with certain attributes that can either be positively or negatively connoted (Ajzen, 1991). Thereby, behaviours that follow a positive association are favoured over those that evoke undesirable consequences. Normative beliefs determine perceived social pressure or subjective norms that are based on "the expectations of important referents" (Ajzen, 2012, p.443). Compared to behavioural beliefs, hereby the person's perception of the approval or disapproval from referent groups in relation to performing the behaviour is of importance. Lastly, control beliefs are concerned with the person's available resources and opportunities. The more a person believes that they can perform a certain behaviour, the greater should be their perceived control over the behaviour (Ajzen, 1991). All three of these beliefs are unobservable as they are deeply ingrained in a persons' natural way of behaving, influenced by attitudes, subjective norms and perceptions of control.

Limitations and Problems

Since the theory deals with the very intangible concept of human behaviour, criticism regarding measurements and the sufficiency of the TPB has arisen over time. Measuring attitudes, perceptions or intentions can create problems in terms of predictive validity, as correlations between intentions and behaviour often vary considerably (Ajzen, 2011). A reason for that can be changing beliefs due to intervening events that can in turn lead to changing intentions (Ajzen, 2011). Similarly, issues regarding the accessibility of beliefs might create problems with the validity of the questionnaire measures. This is a general problem of questionnaire studies though, as the measures for the questions can make certain beliefs salient that otherwise might not have been accessible (Fishbein & Ajzen, 2010). Additionally, the researcher has to be aware of the possibility of a consistency bias. This means that participants might adjust their answers consistently among the different factors of the TPB, thus creating overestimates of correlations (Fishbein & Ajzen, 2010). However, according to Fishbein and Ajzen (2010), studies showed only small differences between thematic and random versions of questionnaires, thus leading to the assumption that there is only "little evidence for a bias on the part of respondents to make their answers internally consistent" (p.318).

Furthermore, studies often point out that the variables of the TPB are not sufficient to completely predict intentions and behaviour (Ajzen, 2011). One suggested additional variable that would be of interest for this study is the role of past behaviour as a predictor for future behaviour. Previous studies have found strong correlations between past and future behaviour that suggest that past behaviour contributes to predicting future behaviour (see Conner & Armitage, 1998; Ouellette & Wood, 1998; Rhodes & Courneya, 2003; Forward, 2009). For that, however, a stable context where the behaviour remains unchanged and thus allows for the development of habits appears to

be essential. Ouellette and Wood (1998) state that in this case, conscious thoughts are not necessary as habitual performance becomes automatic. When including past behaviour as an additional factor to the TPB, the researcher should also take the influence of past behaviour on predicting intentions into consideration. Ajzen (2011) suggests that determining a causal relationship between past behaviour and a person's intentions would be difficult. Instead, he argues that past behaviour should rather be seen as a "reflection of all factors that determine the behaviour of interest" (Ajzen, 1991, p.203).

Another point that is often criticised and needs to be taken into account is the easily made misconception that the TPB implies a too rational, impassionate and unbiased actor. Since the TPB assumes that behaviour is based on available information, it follows a reasoned action approach. Clarification is necessary on how the available information is assessed. The TPB at no point assumes that a person's information results from rational or unbiased beliefs (Ajzen, 2011). Instead, the beliefs that constitute attitudes and perceptions are heavily influenced by inaccurate, incomplete and biased information and therefore do not necessarily reflect reality (Ajzen, 2012). Only in the sense that these beliefs consistently underlie attitudes, subjective norms and perceptions of control can the TPB be seen as following reason and planning (Ajzen, 2012).

Application to this Study

For this study, the TPB shall help access scientists' beliefs towards science communication and thus determine how these salient beliefs influence attitudes, subjective norms and perceptions of control as well as their intentions and actual behaviour. The TPB is used as a basis to predict what leads to the scientists' engagement in science communication activities. Previous studies in this area from

science communication research will help in specifying different variables that are used to access the salient beliefs and will be presented as a model in the following.

2.3.2 Dependent Variable

Following the TPB, the dependent variable describes the given behaviour, in this case the *engagement in science communication activities*. Science communication activities are understood as different activities that improve the awareness, knowledge and understanding of science in the general public (Burns et al., 2003; van Dijck, 2003). This includes for example engaging directly with the public through dialogues or indirectly through the media, following both one-way and two-way communication approaches (Bucchi, 2008). On the surface, the activities aim at bridging the gap between science and society, however, raising awareness for research findings and scientific results through engagement is certainly also motivated by prospects of receiving funding for further research. As the study follows a cross-sectional design, engagement is only measured once by asking respondents to assess the number of times they have engaged in a certain activity. Hence, past behaviour is included in the general assessment of engagement. As former studies have suggested that past behaviour might be in line with the formation of habits, the results will be examined to see whether tendencies in this area can be found.

Furthermore, the TPB presumes that engagement is influenced by intentions, which in turn are influenced by attitudes, subjective norms and perceived behavioural control. Therefore *intention to engage* can be seen as an intermediary variable. For one it will be treated as a dependent variable in regard to the predictive effects of attitudes, subjective norms and perceived control on intentions. On the other hand though, intentions will be examined together with attitudes, subjective norms and behavioural control regarding their combined contribution towards predicting engagement. In this case, intentions are

not a dependent variable, but a variable that influences the effect of the other independent variables in terms of predicting engagement.

2.3.3 Independent Variable I: Attitudes towards Science Communication Activities

Previous research suggests that positive attitudes towards partaking in science communication activities determine the likelihood of also engaging (Poliakoff & Webb, 2007; Dudo, 2012). This may be influenced by the *importance* that the scientists place on engaging (Besley et al., 2012). Additionally, scientists are driven by rewards (Dunwoody et al., 2009, Poliakoff & Webb, 2007), such as the incentive that engaging in science communication activities could bring more money to their department (Royal Society, 2006). This is why *perceived rewards for engagement* are said to determine attitudes. These assumptions result in the following hypotheses:

H1a: Scientists with a positive attitude towards science communication activities have a high intention to engage in those activities.

H1b: Scientists with a positive attitude towards science communication activities are more likely to actually engage in those activities.

2.3.4 Independent Variable II: Subjective Norms

Subjective norms such as approval from colleagues or friends and family are deemed to influence the intention to engage in science communication activities. Colleagues are thereby seen as the more important reference group and the *perceived behaviour of colleagues* is seen as a driving factor on the influence. Previous studies show that scientists who believe their colleagues to be participating in science communication activities are more likely to engage themselves (Poliakoff & Webb, 2007; Dudo, 2012). Furthermore, *norms within the scientific community* influence the approval from colleagues. Weigold (2001) states that scientific colleagues may act derogatory towards their peers, as they believe that "science is best shared through peer-reviewed

publications" (p.173). This is supported by a survey from the Royal Society that showed that 20% of the participants agreed that scientists who engage in science communication activities are less well regarded by other scientists and that it is not seen as a central part of academic life (Royal Society, 2006). This leads to the following hypothesis:

H2a: Scientists who have approval from reference groups such as colleagues or family and friends that science communication is valuable/good have a high intention to engage in science communication activities.

H2b: Scientists who have approval from reference groups such as colleagues or family and friends that science communication is valuable/good are more likely to actually engage in those activities.

2.3.5 Independent Variable III: Perceived Behavioural Control

Several studies show that scientists who believe to have the skills and ability needed to engage in science communication activities are more likely to engage (Dunwoody et al., 2009; Poliakoff & Webb, 2007). The perceived control is influenced by several different factors. Firstly, *perceived ease or difficulty of engaging* can be seen as an influencing factor that determines perceived control (Dunwoody et al., 2009). Additionally environmental restraints such as time and money as well as the perceived suitability of the research can be seen as a restricting factor (Royal Society, 2006; Pansegrau et al., 2011, Dudo, 2012). This is backed up by obligations to inform the public about important topics (Pansegrau et al., 2011; Dunwoody et al., 2009), which is why *perceptions of obligations and restraints* are seen as an influencing factor. Another factor that may influence the perceived control to engage is *communication autonomy*, as scientists who have the support from the head of their department are more likely to engage (Royal Society, 2006; Dudo, 2012). Lastly, *perceived fears of consequences* that science communication activities might have are assumed to influence perceived

control. This includes, on the one hand, fears that the media distorts scientific information and on the other hand that "rewards of a media career can compromise a scientist's integrity" (Weigold, 2001, p.173). Considering all these variables, the following hypotheses are formed:

H3a: Scientists who perceive their control as high have a high intention to engage in science communication activities.

H3b: Scientists who perceive their control as high have are more likely to actually engage in science communication activities.

2.3.6 Control Variables

Additionally to the three main parts of the model, several control variables will be introduced. These include socio-demographic variables such as *age* and *gender* as well as the *area of research*. This is deemed important as studies show that answers can vary depending on subject-specific differences (Pansegrau et al., 2011). Furthermore, *status* is considered as a variable that determines the engagement in science communication activities (Dudo, 2012; Dunwoody et al., 2009). It can be assumed that differences can be also found due to age-related reasons. For one this might be due to the simple fact that older researchers had more time to engage. On the other hand, it could also be expected that younger researchers might be more open towards new forms of communication. On the basis of these considerations, the following model was developed (figure 2).

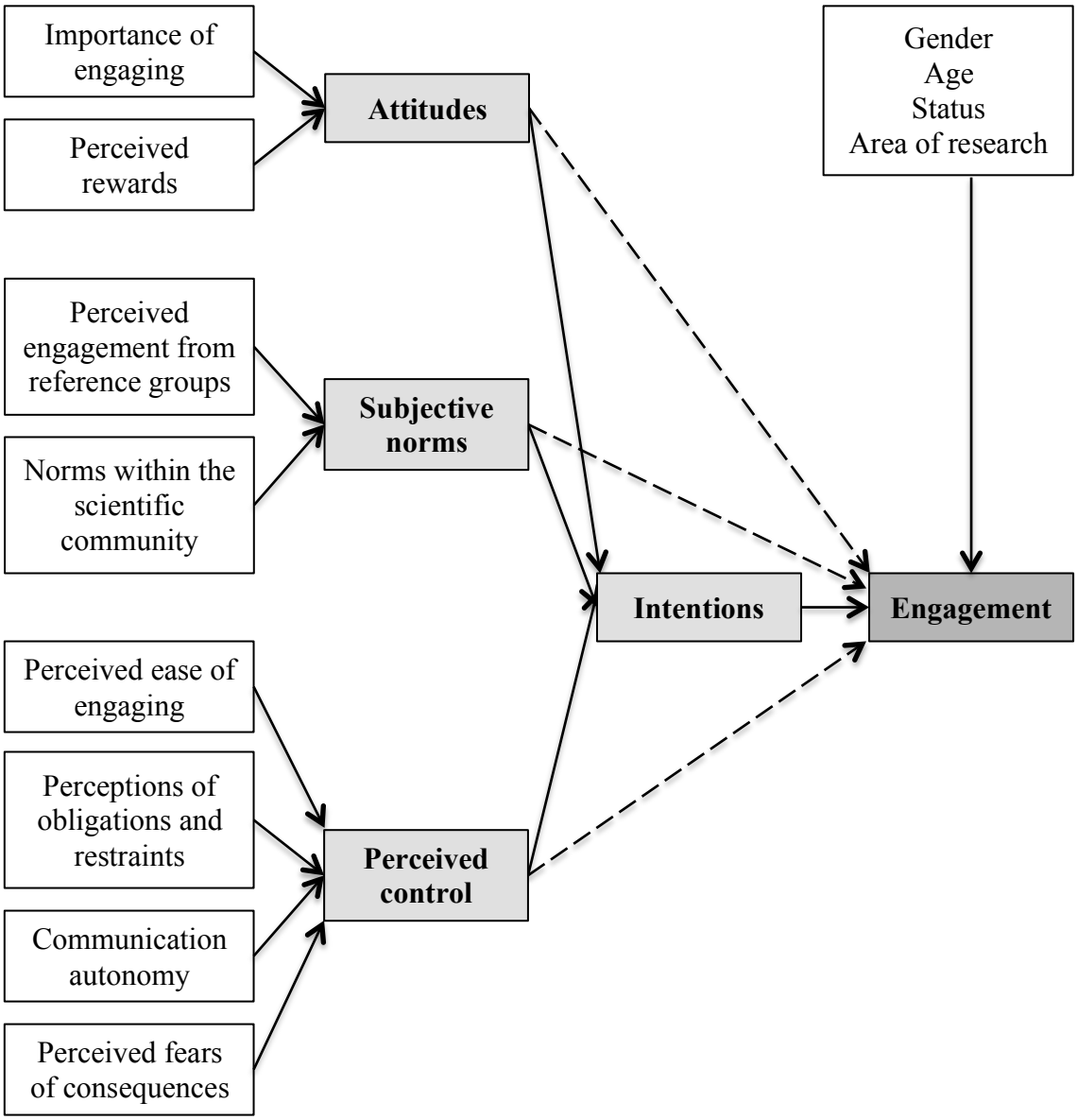

Figure 2: Model of the study

Given the theoretical framework, it should be possible to determine the factors that are most important in predicting both intentions and engagement. It could be expected that especially the perceived control plays an important part as it might restrict the scientists most in performing the behaviour. However, countering these factors might also be easier than for example changing attitudes, as they might be more accessible for the institutions. Possible steps to increase the perceived control could originate from the communications departments of the respective research institutions.

3 Research Design and Methods

The following part focuses on the research approach and will thus define the philosophical worldview and methodological approach followed while conducting the study. It will furthermore outline the specific research design that includes data collection, analysis and interpretation as well as limitations of the study and ethical considerations.

3.1 Research Approach

In social research, researchers use different approaches to examine, investigate and understand social phenomena such as qualitative, quantitative or mixed methods approaches. As this study uses the TPB as a theoretical framework, it follows a quantitative research approach that is based on a postpositivist worldview. Postpositivism arose after positivism and challenged the positivist beliefs that absolute truth exists (Phillips & Burbules, 2000). Instead, Phillips and Burbules (2000) stress that knowledge is conjectural and that the "acceptance of possible imperfection and fallibility of evidence is one of the central tenets of postpositivism […]" (p.39). In contrast to positivism where a concrete reality exists, postpositivism is based on ontological assumptions of critical realism where reality does exist but is determined by imperfections (Mertens, 2015). Thus, research is based on claims that are refined or abandoned over time. Important thereby is, that at the time these claims were made, they were warranted even if they turned out to be fallible in the end (Phillips & Burbules, 2000).

The epistemological assumptions that underlie this approach are thus based on an objectivist modified perspective where "knowledge cannot be absolutely true and is, instead, only an approximation of reality" (Gelo, 2012, p.120). Postpositivists acknowledge that their background knowledge influences the research, but still strive

for objectivity in the sense that they try to avoid letting their biases have an effect on their results (Mertens, 2015). Rather, knowledge relies on evidence that is gathered through observation and measurements and out of which relevant claims can be made (Creswell, 2014). According to Phillips and Burbules (2000), postpositivist researchers are not looking for the 'absolute truth', but instead seek true beliefs on different matters. Depending on what the researched problem is, this can both mean that the researcher investigates whether a statement is true or whether an individual believes a statement to be true regardless whether it is true or not. As this study strives to ascertain attitudes and perceptions of scientists regarding their engagement in science communication activities, the aim is to formulate true statements regarding their beliefs. If these beliefs are true or not is not of importance as long as the scientists believe them to be true. To gain relevant evidence, the underlying methodology of the study is based on survey research and therefore follows a non-experimental design.

Another point that has to be discussed is measures of rigour such as reliability, validity and generalizability as a way to reduce bias. Reliability in quantitative research is defined as the "extent to which research produces the same result when replicated" (Bloor & Wood, 2006, p.147). Important is, that findings cannot only be repeated but also reproduced, as it is a measure of precision, accuracy and stability (Wrench et al., 2013). To test the reliability and stability of the research scales that were administered during the data collection process, a test-retest reliability approach can be taken (Bryman, 2016). Thereby, the same constructs are measured on more than one occasion (Wrench et al., 2013). The applicability of this approach might be problematic in cross-sectional studies. Therefore, another reliability test that is often used in social research for multiple-indicator measures is the Cronbach's alpha reliability test (Bryman, 2016). To improve the reliability while constructing the research design and more specifically the instrument with which the data will be collected, certain measures can be taken such

as constructing unambiguous items and instructions to avoid misinterpretation (Wrench et al., 2013).

Furthermore, the concept of validity is extremely important as it aims at showing the accuracy of the intended measurements (Bloor & Wood, 2006). Constructs are examined regarding whether they measure what they are meant to measure (Wrench et al., 2013). Through establishing face validity for example, an external person examines if the items appear to reflect the intended measurement (Bryman, 2016). Additionally, construct or factorial validity is based on correlations between the respective items in multiple-indicator measures through statistical methods such as factor analysis (Wrench et al., 2013). Using this technique though, the researcher has to be aware that it only shows if something is not measuring the items (Wrench et al., 2013). Important to note is also that a measure cannot be valid if it is not reliable (Bryman, 2016). If a multiple-indicator construct for example is not internally reliable, it cannot be valid as it might be measuring several different things (Bryman, 2016).

Lastly, a major concept in quantitative research is generalizability. It can be defined as the "extent to which the findings of a study can apply to a wider population" (Bloor & Wood, 2006, p.93). Results are thereby representative for the whole population and in some cases can be transferred to other studies without loosing their truth. However, generalizing to other studies needs to be treated with caution as various factors might influence the actual generalizability beyond the population that was examined in the study (Bryman, 2016). Following these assumptions of a quantitative research approach, the next part will elaborate on the research method and survey design of the study.

3.2 Research Method

The study is designed to test factors that determine the engagement of scientists in science communication activities. The researcher will collect evidence on attitudes, perceptions and opinions of a sample of scientists in Germany using self-administered Internet-based questionnaires. The aim is to gain an overview of reasons for participation in science communication activities by generalizing the findings to the whole population, which will be defined in the following part (Fowler, 2009). In line with the theoretical framework of the TPB, a survey was determined as the best procedure for data collection as a great number of the population can be reached through a survey. However, the researcher needs to take into account that it is difficult to control different aspects such as who answers the questions or that all questions are answered (Bryman, 2016). The survey will be cross-sectional, as the data will be collected once in a time span of five weeks. When doing the data analysis, it needs to be taken into account that cross-sectional designs allow mainly for examining associations and relationships between different variables (Bryman, 2016). As the data is collected only once, it is difficult to establish causal directions (Wrench et al., 2013). Bryman (2016) argues, that in cross-sectional designs, the researcher often has to "draw on common sense or theoretical ideas to infer the likely temporal precedence of variables" (p.163).

Since it can be assumed that virtually all researchers should have access to the Internet, e-mails with a link to the survey were deemed as the best way of distribution, as they provide access to widely dispersed samples and the respondents have enough time to give thought-out answers (Fowler, 2009). Using an Internet-based survey has the advantage of easily and cost-efficiently distributing a large number of questionnaires in a short span of time as well as having direct access to the results of the survey (Fowler, 2009; Bryman, 2016). However, one disadvantage is that Internet-based surveys often

struggle with low response rates that might distort the generalizability of the data (Bryman, 2016). Thus, different steps are taken to improve response rates. These include for example sending out the initial email through the institutes own distribution list to create a stronger obligation of answering as well as sending several follow up emails to non-respondents (Nulty, 2008).

3.2.1 Population and Sample

The population that will be sampled for the study consists of all scientists at non-university research institutions in Germany. The scientific landscape in Germany is mainly build on the four big science societies (Max Planck Society, Fraunhofer Society, Helmholtz Association and Leibniz Association). Each society and most of the times the individual institutes are responsible for their communication activities, with very limited guidelines from funding institutions. These institutions are focused solely on research activities, whereas universities or universities of applied sciences are more focused on educational purposes. Furthermore, it can be expected that a university has to have a communications department in order to attract new students and that these departments are also responsible for communicating about findings and results from research activities. Even though research is also done at universities, the employees' responsibilities are not focused solely on research projects but divided between academic and scientific work. It would thus be difficult to compare the engagement of researchers at universities with the engagement of researchers at non-university institutions. Therefore, it was decided to not include universities and universities of applied sciences as part of the population, but only include scientists that belong to a research institute of one of the following institutions into the study population:

Max Planck Society	83 institutes	13,276 scientific employees (as of 2016)
Fraunhofer Society	85 institutes	8,416 scientific employees (as of 2014)

Helmholtz Association	17 institutes	17,914 scientific employees (as of 2014)
Leibniz Association	91 institutes	9,303 scientific employees (as of 2016)
Federal Institutions	44 institutes	3,983 scientific employees (as of 2014)

Table 1: Overview of non-university research institutions

Estimated after a report from the Federal Statistical Office from 2014 and indications from some of the institutions, this entails approximately 53,892 scientific employees (Statistisches Bundesamt, 2016; Max Planck Society, 2016; Leibniz Association, 2016). However, it is difficult to determine an exact number of scientists in Germany and even less compile a complete list of all scientists.

Therefore, the sampling design for the study follows a multi-stage cluster sampling approach. Multi-stage cluster sampling is especially applicable when dealing with a population that can be grouped (Fowler, 2009). In the case of this study, in the first stage of sampling, the scientists are clustered into the respective research institutes they belong to, thus compiling a list of 320 institutes. To ensure a true representation and better generalizability of the population in the sample and to reduce sampling error, the sample was stratified after a specific characteristic (Wrench et al., 2013). For this study, the population was stratified after the area of research, thus dividing it into the following three different research areas:

Humanities and social sciences	69 institutes	21.56% of population
Life sciences	102 institutes	31.88% of population
Natural sciences and engineering	149 institutes	46.56% of population

Table 2: Overview of strata

A sample of 20 institutes was randomly selected from the stratified clusters proportionally to the population. 20 institutes were deemed as sufficient as it has been shown that at some point the precision of the collected data will not noticeably increase

anymore when increasing the sample (Bryman, 2016). Thus, 4 institutes from humanities and social sciences, 7 institutes from life sciences and 9 institutes from natural sciences and engineering were randomly drawn in the first stage of the sampling approach. These institutes were contacted in the next stage and the questionnaires were send out to all scientific employees at each sampled institute.

Before drawing the final sample, the institutes were examined regarding their size in terms of the number of scientists working there. For that, four samples with respectively 20 institutes were drawn and each institute was reviewed. The examination resulted in a wide range of size with some institutes having less than 100 employed scientists while at others more than 500 scientists work. However, when looking closely at the individual strata's scores for mean and median it showed that life sciences as well as natural sciences and engineering have similar scores while in humanities and social sciences the institutes' scores are approximately half in size (table 3).

Sample number	Mean	Median
Sample 1	187	166
Humanities and social sciences	87	81
Life sciences	201	189
Natural sciences and engineering	232	220
Sample 2	249	196
Humanities and social sciences	136	144
Life sciences	286	230
Natural sciences and engineering	270	202
Sample 3	277	200
Humanities and social sciences	96	76
Life sciences	485	428

Natural sciences and engineering	224	241
Sample 4	230	235
Humanities and social sciences	107	85
Life sciences	293	236
Natural sciences and engineering	246	237
Total	235	201
Humanities and social sciences	106	85
Life sciences	308	236
Natural sciences and engineering	245	220

Table 3: Examination of institutes' size

Since there seems to be quite some consistency within the individual strata with only a couple of outliers, the size of the institutes is expected to not overly influence the results of the study. Sample 4 was chosen as the final sample for the study as the mean and median scores were closest to the total mean and median scores of all four samples.

3.2.2 Survey Instrument and Protocol

The questionnaire was created and distributed using the survey tool Sunet Survey. Sunet (Swedish University computer network) is part of the Swedish Research Council and is widely used by Swedish universities and institutions (Vetenskapsrådet, 2016; Sunet, 2017). The tool was chosen as it is the standard survey tool used at Lund University and meets the necessary technical requirements for the analysis of the data. The survey construction allows for a personalized layout and design of the questions as well as introductory texts and thank-you messages. After completing the data collection, the tool generates results and it is possible to export the data into a spread-sheet for further analysis in SPSS.

The questionnaire was specifically designed for this study. The questions were based on similar previous studies (Royal Society, 2006; Poliakoff & Webb, 2007; Dunwoody et

al., 2009; Pansegrau et al., 2011; Besley et al., 2012; Dudo, 2012) as well as on a guide on how to construct a theory of planned behaviour questionnaire (Fishbein & Ajzen, 2010). Especially the studies by Poliakoff & Webb (2007) and Dudo (2012) were deemed as important guides for establishing the questionnaire as their framework also follows the theory of planned behaviour. Additionally, when comparing the different items that were inquired about, a lot of similar reasons could be found throughout the various studies. As the questionnaire was thus far untested, scores for validity and reliability have to be newly established to ensure that the questions measure the content they are supposed to measure and that responses are consistent, which was why a pilot study was conducted.

The questionnaire included 33 questions and was divided into six sections: engagement, attitudes, norms, control, intentions and general information. The first page the respondents saw when opening the survey was an introductory text that stated the purpose and length of the survey as well as the utilisation of the data (appendix 1). Participants were notified that by participating in the study, they gave their informed consent. Furthermore, participants had the option to not answer questions. The introduction was followed by an explanation of science communication activities to ensure that all participants were on the same level of knowledge. Afterwards, instructions on how to answer the questionnaire were given followed by the six sections. After completing the survey, a thank-you message was displayed with information on where results of the study can be obtained.

The scales that were used to measure the different questions included continuous scales (4-point or 5-point Likert-scales and 5-point bipolar adjective scales) as well as categorical scales (yes/no questions). It was decided to mainly use 5-point scales as it was shown that these obtain the best quality and validity of the data as more scaling

categories lead to a higher variation in the interpretation of the scales (Revilla et al., 2014). To reduce acquiescence response bias, some questions were designed in a way that multiple items measured the same question with half of them asking in a positive and the other half in an opposing way (Holbrook, 2008). Additionally, reversed scales were partly used in order to alternate positive and negative items. One thing that has to be taken into account hereby is that the researcher has to be careful in wording the items as participants could misinterpret negatively formulated items (Sauro & Lewis, 2011). Additionally, before the data analysis can be conducted, these scales have to be reversed again to avoid coding errors (Sauro & Lewis, 2011).

3.2.3 Pilot Study

To test the usability of the questionnaire as well as establish scores of validity and reliability, a pilot study was conducted. The main aim was to determine improvements regarding lengths, comprehensibility of both the instructions and the questions as well as the chronological order of the questions. The study was active from 6 March to 15 March 2017 and distributed among 115 scientists. 27 scientists answered the survey, which leads to a response rate of 23.5%. General feedback revealed that the length of the questionnaire was perceived as too lengthy. While looking at the data and doing a first preliminary data analysis, a special focus was put on questions that would be dispensable and it became apparent that some of the questions were redundant. It was decided to exclude these questions from the questionnaire for the actual study. Furthermore, one battery of questions regarding the encouragement from reference groups with a 5-point agree-disagree scale showed very high responses on the ‘neither’ option. This suggested that respondents either might not have been sure how the different reference groups would react to their engagement or that they did not place too much importance on what others thought about their engagement. For the study, a response in either the agree- or the disagree-direction would have been preferable to

better estimate whether reference groups have an impact on intentions or engagement. Therefore, the scaling was changed from a 5-point scale to a 4-point scale in order to elicit a response in one of the directions.

3.2.4 Variables in the Study

The variables were measured using the following constructs: attitudes, norms, control, engagement, intentions and general information.

Attitudes were measured with four different multiple-items questions: How important do you feel it is that you directly are engaging in the following activities? How important do you think it is that you directly engage the public on the following? Engaging in science communication activities is (bipolar adjective scales). Engaging in science communication activities will (different external rewards).

Subjective norms were measured with six different questions: Most of the following people approve/support/oppose of my engaging in science communication activities. Do other members of your institution engage in science communication activities? How many of the five colleagues you know best engage in science communication activities? Scientists who engage in science communication activities (different answers).

Perceived behavioural control was measured with eight multiple-items constructs: Do you find it easy or difficult to engage in the following science communication activities? It is important to engage in science communication activities because (different moral obligations). Do you agree or disagree with the following statements (different environmental restraints)? I need to seek approval from someone in my institution before (different communication activities). Do you agree or disagree with the following statements (perceived suitability of own research)? If I engaged in science communication activities, I would fear that (different fears).

Engagement was measured with the following question: How often have you engaged in the following science communication activities?

Intentions were measured with the following two questions: I intend to engage in science communication activities in the next 12 months. It is likely that I will engage in science communication activities in the next 12 months.

To acquire some general information for the *control variables*, questions regarding gender, age, area of research, status, academic degree, number of publications and the existence of a communications department in the respondent's institution were asked.

In order to ensure the validity of the different variables, the wording was carefully chosen. As the questions were created based on previous studies that showed no signs of issues in regards to measuring what the variables were intended to measure, it can be expected that the variables will show adequate accuracy of the intended measurements. The results of the pilot study support this, as a preliminary analysis affirmed that the variables reflected the intended measurement.

3.2.5 Statistical Data Analysis

The data was analysed using the software SPSS. Several standard statistical analyses were performed. To obtain an overview of the given data, univariate analyses of the respective variables were carried out including examinations of distribution, central tendencies as well as measures of dispersions. Before conducting the bivariate and multivariate analysis, the data was tested for reliability using Cronbach's alpha and reduced using factor analysis. For a first examination of relationships between the individual independent variables and the dependent variables, bivariate analyses were conducted. Hereby the focus was put on measures of association such as correlations. To test the hypotheses and the combined effects the independent variables have on the dependent variables, hierarchical multiple regression analyses were carried out, to

control for the effects of intentions as well as to consider differences that might arise due to the socio-demographic variables.

3.3 Ethical Considerations

Since the research involves human subjects in the form of the respondents to the questionnaire, some ethical principles regarding the conduct of the research have to be discussed.

It is of importance to inform respondents on who is involved in the research as well as what the purpose of the research is to avoid deception (Creswell, 2014). Issues regarding confidentiality and voluntary participation need to be addressed so that respondents know what to expect from taking part in the survey (Fowler, 2009). To ensure that respondents are informed, an introductory text is displayed at the beginning of the survey with information that participation is voluntarily and that all collected data will be treated with confidentiality. To ensure that respondents cannot be identified, the data collection is anonymous and aggregated.

Furthermore, while analysing the collected data, the researcher has to "avoid going native" as Creswell (2014, p.99) puts it. This means that data should not be disregarded simply because it does not confirm hypotheses. The researcher needs to be aware that leaving out data leads to underreported or distorted analyses and interpretations.

3.4 Problems and Difficulties

One major difficulty that arose was the acquisition of a respectable number of research institutions in which the questionnaire was supposed to be distributed. Originally, the aim was to have 20 institutions as the sample. However, after contacting the original 20 institutions, only eight institutions agreed to participate in the study. In addition, 23 further institutions were contacted, from which seven agreed to send out the questionnaire, thus acquiring a sample of 15 institutions instead of 20. The

representation of the three different strata was still attained, with three institutions in the area of humanities and social sciences, five in the area of life sciences and seven in the area of natural sciences and engineering. As a consequence of this acquisition difficulty, the generalizability of the results might not be as accurate as desired.

4 Results and Analysis

The data was gathered from 22 March 2017 to 26 April 2017, thus leaving a time frame of five weeks. The questionnaire was distributed at 15 research institutions in Germany among 3,097 researchers. 137 respondents completed the survey, which results in a response rate of 4.42%. As this response rate is even lower than what can normally be expected from Internet-based surveys, the generalizability of the results is questionably. It would be difficult to actually generalize to the whole population of all scientists at non-university research institutions in Germany as only a fraction of the population participated in the survey. It cannot be said with certainty that the outcome would have been the same if more respondents had answered the survey. When looking at the socio-demographics however, there appears to be no reason to suspect a strongly biased distribution. The results of this study can therefore still be seen as an interesting and informative contribution for which the generalizability is treated with caution.

In a first step, the data was screened in SPSS for noticeable missing cases. One case was removed from the data file, as the respondent did not fill in any of the answers. To establish values for reliability, internal reliability tests using the Cronbach alpha coefficient were conducted and will be reported throughout the analysis.

4.1 Socio-demographic Distribution of the Sample

Before looking at the different items that were used to measure the dependent and independent variables, an overview of the socio-demographic distribution will be given. Most of the respondents were male (59.0%), while 41.0% were female. The average age of the sample is approximately 37 years (mean=36.81, median=35). The histogram in figure 3 as well as the values for skewness (.966) and kurtosis (.614) show that the distribution of age is moderately skewed to the right and platykurtic.

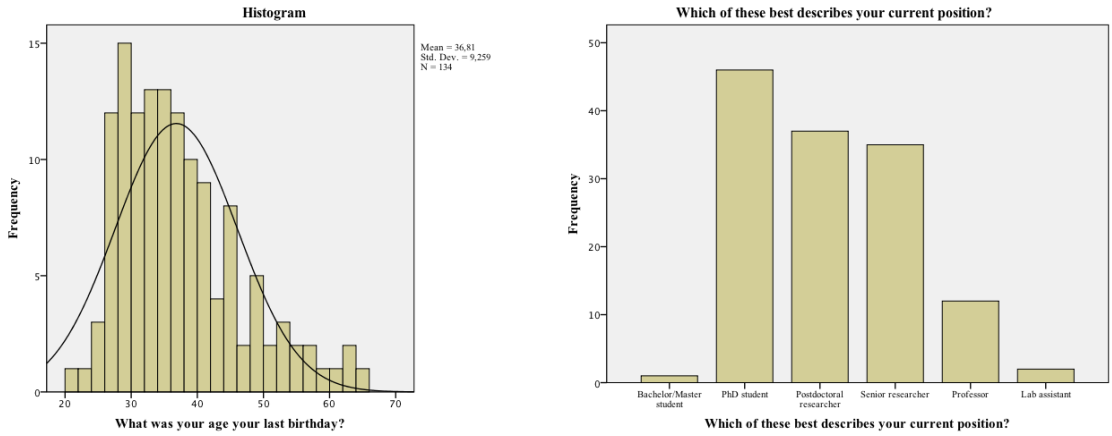

Figure 3: Distribution of the variables 'age' and 'status'

The distribution regarding the status of the respective researchers matches the age distribution (figure 3). Approximately one third of the respondents stated that they are PhD students (34.6%), which corresponds with one third of the sample being 31 or younger. Another third of the respondents indicated to be senior researchers (26.3%) or professors (9.0%).

As table 4 shows, the distribution of the area of research in the sample differs from the comparable estimated distribution in the population. Even though the sample was stratified to ensure a better representation, the area of natural sciences and engineering is overrepresented, while the area of life sciences is underrepresented.

	Distribution in the population	Distribution in the sample
Humanities and social sciences	21.56%	16.4%
Life sciences	31.88%	16.4%
Natural sciences and engineering	46.56%	67.1%

Table 4: Distribution of the variable 'area of research'

A possible reason for this could be that the line between life sciences and natural sciences is rather blurred, thus leading the scientists to differently assess their area of research than the way the population was stratified. Fields such as biochemistry for example could both be seen as life sciences or natural sciences and engineering.

When asked whether their institution has a communications department, almost all scientists (95.6%) affirmed this, with only three respondents not knowing (2.2%) and three respondents answering no (2.2%).

4.2 Univariate Analysis

To give a first overview of the collected data, a univariate analysis was done that includes a presentation of distribution, central tendencies and dispersion of the different variables. As most variables were measured using multiple-item constructs, several factor analyses were conducted in order to reduce the data. The following is a summary of the univariate and factor analyses. Extensive figures and tables can be found in appendix 2.

4.2.1 Dependent Variables

The dependent variable 'engagement in science communication activities' was measured using 14 different activities. When looking at the first distribution of these 14 items in table 5, some interesting tendencies can be noticed.

Frequencies: Engagement[a]						
How often have you engaged in the following science communication activities?	1[b]	2	3	4	5	Missing
Explaining your research to friends and family	1,5	5,9	11,8	14,7	66,2	0,0
Talking to journalists	47,1	24,3	13,2	6,6	8,8	0,0
Talking to politicians and policy makers	55,9	28,7	5,1	2,2	8,1	0,0
Giving interviews	50,0	26,5	14,7	5,1	2,2	1,5
Appearing on a TV/radio programme	58,1	26,4	8,8	1,5	2,9	2,2
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	71,3	9,6	4,4	2,9	11,8	0,0

Giving lectures or talks for adults	24,3	20,6	19,9	11,8	22,8	0,7
Giving lectures or talks for children	66,9	14,7	9,6	2,2	5,1	1,5
Participating in a public dialogue event	64,0	23,5	6,6	2,2	2,9	0,7
Participating in exhibitions at museums	77,2	14,7	4,4	0,0	2,9	0,7
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)	22,1	33,8	30,1	7,4	5,9	0,7
Writing press releases	53,7	20,6	14,0	3,7	5,9	2,2
Creating content for your institutions website	36,0	24,3	20,6	4,4	14,7	0,0
Creating content for your own website	58,8	11,0	12,5	5,1	12,5	0,0

a. Values in per cent.
b. Scale: 1=None, 2=1-2 times, 3=3-5 times, 4=6-10 times, 5=More than 10 times.

Table 5: Frequencies of the different items measuring engagement

Almost every respondent (98.5%) at least once explained their research to friends and family, with two thirds (66.2%) having done this more than ten times. However, for the majority of the other items, the mean response was between ‘none’ and ‘1-2 times’. This corresponds to previous studies, where the majority of respondents answered between ‘none’ and ‘1-2 times’ as well (Royal Society, 2006; Pansegrau et al., 2011). Figure 4 shows the distribution of the item ‘writing press releases’ exemplary for 10 out of 14 of the items. In this case, the mean is 1.85, with approximately three quarters having answered ‘none’ (54.9%) or ‘1-2 times’ (21.1%).

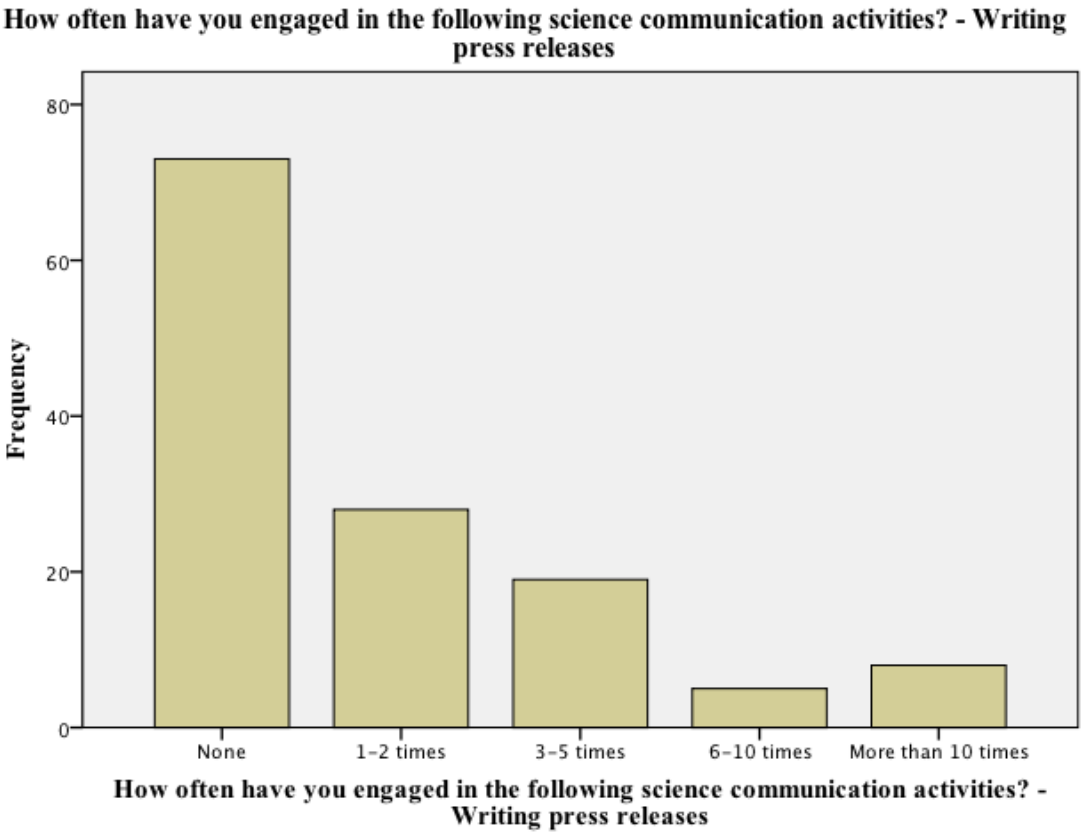

Figure 4: Distribution of the item 'writing press releases'

Differences from this distribution can be observed in the items 'participating in events at your organisation', 'giving lectures or talks for adults' and 'creating content for your own website'. Almost two thirds (63.9%) of the respondents indicated that they had participated in events at their organisation between 1-5 times, with only 22.1% indicating that they never participated. A reason for this could be that participating in open day events at their own organisation is obligatory for the scientists, thus leading to them having participated at least once. Engagement for giving lectures or talks for adults was also quite high with the average of respondents answering '3-5 times' (mean=2.88, median=3). Three quarters (75.6%) stated that they gave lectures or talks at least once, with 23.0% having done this more than 10 times. This high engagement might be explained as presenting their research results at conferences is a substantial part of publishing in journals and gaining recognition for their work.

When looking at all items, one overall tendency can be observed. For 12 out of the 14 items, it is noticeable that the amount of respondents having answered 'more than 10 times' was higher than the amount of responses for '6-10 times'. This suggests the existence of a threshold, after which the scientists start engaging more. When looking at the gathered data, this threshold seems to be after 5 times. Once they reach this threshold in their engagement in science communication activities, it appears to be done more regularly. To eliminate the possibility that this phenomenon is due to age-related differences, namely that older researchers engaged more simply because they had more opportunities, the data was split into four different age groups that were grouped after the three quartiles. With few exceptions, this overall tendency could still be observed, thus leading to the assumption, that other reasons are responsible. One explanation for this could be that it does not require that much effort to engage once or twice, but for more participation, more effort needs to be extended. At some point though it does not make a difference anymore if the scientists engage 10 or 15 times as they already took the time to engage. It might be that the engagement transitioned from occasional participation to being part of the scientist's habitual work routine. However, to better explain this phenomenon, more research is needed.

To reduce the data for further analysis, a factor analysis of the 14 items that were used to measure engagement was conducted. To ensure that all 14 items were suitable to be included in the factor analysis, an internal reliability test was done. The items showed good internal consistency, with a Cronbach's alpha of .856. The factor analysis showed a KMO of .842 and a significant Bartlett's Test of Sphericity ($p<.0005$), which confirmed that the chosen items were useful to be included in the factor analysis. The total variance explained table (appendix 2b) showed that there are four components with an eigenvalue greater than 1, which explain 63.389% of the total variance. The pattern matrix shows variables that are connected, which results in four components in this

case. However, as the third component only loaded on two items, the analysis was repeated extracting a 3-factor solution. The 3-factor solution explained 56.163% of the variance. The pattern matrix (table 6) showed that the majority of items loaded quite strongly on two components.

Pattern Matrix[a]			
How often have you engaged in the following science communication activities?	Component 1	2	3
Explaining your research to friends and family		,554	
Talking to journalists	,689	,305	
Talking to politicians and policy makers	,787		
Giving interviews	,664		
Appearing on a TV/radio programme	,590		
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)			,879
Giving lectures or talks for adults	,629		
Giving lectures or talks for children		,845	
Participating in a public dialogue event	,689		
Participating in exhibitions at museums		,523	
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)		,653	
Writing press releases	,727		
Creating content for your institutions website	,716		
Creating content for your own website			,625

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Table 6: Pattern matrix of factor analysis for 'engagement in science communication activities'

When looking at the first two components of the pattern matrix, it becomes clear that it is necessary to distinguish between different kinds of engagement. Items such as

'talking to journalists', 'giving lectures or talks for adults' or 'writing press releases' can be seen as regular activities that are done as part of PR work. Therefore, the eight items that loaded on the first component in the factor analysis were summarised in a summative index to measure *engagement in classic PR activities*. A closer look at the second component revealed items that involve some kind of direct interaction with non-experts. This component was thus summarised in a second index to measure *direct engagement with lay public*. The further analyses will determine whether attitudes, subjective norms and perceived control have the same effect on both kinds of engagement or whether the effect differs.

Another variable that will be examined regarding the influence attitudes, subjective norms and perceived control have on it are intentions to engage. Two items were used to measure intentions (table 7).

Frequencies: Intention to engage[a]						
	1[b]	2	3	4	5	Missing
I intend to engage in the next 12 months.	42,6	35,3	14,7	4,4	2,9	0,0
It is likely that I will engage in the next 12 months.	42,6	37,5	13,2	4,4	1,5	0,7

a. Values in per cent.
b. Scale: 1=Agree completely, 2=Agree somewhat, 3=Neither, 4=Disagree somewhat, 5=Disagree completely.

Table 7: Frequencies of the different items for 'intention to engage'

An internal reliability test resulted in a Cronbach alpha coefficient of .907, which shows excellent internal consistency and suggests that both items can be summarised in one index. A bivariate analysis of the two items supported this as it showed a high positive significant correlation (Pearson's $r=.834$, $p<.0005$). Therefore, it was decided to combine both items into one index to measure *intention to engage*. An analysis of the distribution, central tendencies and dispersion showed that the average response can be

put in relation to the former value 'agree somewhat' (mean=3.741, median=4) and that approximately three quarters (73.3%) of the respondents have the intention to engage in science communication activities in the future.

When looking at the relationship between intention to engage and the two different kinds of engagement (engagement in classic PR activities and direct engagement with lay public), it can be seen that scientists who have a high intention to engage also have a high actual engagement, both in classic PR activities (Pearson's r=.441, p<.0005) and directly with the lay public (Pearson's r=.317, p<.0005) (table 8). This supports the assumptions of the TPB that there is a relationship between intentions and engagement. To what extend intentions can be used to predict engagement in relation with the other independent variables will be determined in the multivariate analysis.

Correlations

		Intention to engage	Engagement in classic PR activities	Direct engagement with lay public
Intention to engage	Pearson Correlation	1	**,441****	**,317****
	Sig. (2-tailed)		,000	,000
	N	135	125	131
Engagement in classic PR activities	Pearson Correlation	**,441****	1	**,527****
	Sig. (2-tailed)	,000		,000
	N	125	132	122
Direct engagement with lay public	Pearson Correlation	**,317****	**,527****	1
	Sig. (2-tailed)	,000	,000	
	N	131	122	126

**. Correlation is significant at the 0.01 level (2-tailed).

Table 8: Correlations for the dependent variables

The next part will examine the different constructs that were used to measure attitudes, subjective norms and perceived control. The analysis will reduce the data and highlight the variables that appear to be of the most importance and that will be included in the subsequent bivariate analysis.

4.2.2 Independent Variable I: Attitudes towards Science Communication Activities

To determine the salient beliefs that underlie attitudes, two main variables were used: importance of engaging and perceived rewards. Both were measured with multiple-items constructs, which was why factor analysis was done respectively to ascertain connections between the various items and to reduce the data. In the following, the results and the extracted factors will be presented briefly. Extensive figures and tables can be found in appendix 2c.

The importance that the scientists attached to a variety of different activities and topics was measured using 23 items (table 9). These ranged from the importance of giving interviews or participating in a public dialogue event to the importance of engaging on the relevance, benefits or implications of their research. Generally, it can be said that the respondents consider engaging in different activities or on different topics rather important than unimportant.

Frequencies: Importance of engaging[a]

How important do you feel it is that you directly are engaging in the following activities?	1[b]	2	3	4	5	Missing
Explaining your research to friends and family	30,1	52,6	9,6	7,4	0,0	0,7
Talking to journalists	22,1	48,5	17,6	10,3	1,5	0,0
Talking to politicians and policy makers	37,5	39,7	16,9	5,1	0,7	0,0
Giving interviews	15,4	40,4	33,8	7,4	2,2	0,7

Appearing on a TV/radio programme	11,0	34,6	31,6	16,9	5,1	0,7
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	6,6	36,0	25,7	22,1	9,6	0,0
Giving lectures or talks for adults	30,1	55,9	12,5	0,7	0,7	0,0
Giving lectures or talks for children	29,4	46,3	13,2	5,1	5,9	0,0
Participating in a public dialogue event	21,3	42,6	26,5	8,1	0,7	0,7
Participating in exhibitions at museums	5,9	36,8	34,6	10,3	11,0	1,5
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)	36,8	42,6	17,6	2,2	0,7	0,0
Writing press releases	22,1	45,6	18,4	11,0	2,9	0,0
Creating content for your institutions website	21,3	52,2	16,2	5,9	3,7	0,7
Creating content for your own website	16,9	30,9	23,5	14,0	13,2	1,5
How important do you think it is that you directly engage the public on the following?	1[b]	2	3	4	5	Missing
Scientific findings of your research	23,5	58,1	13,2	5,1	0,0	0,0
Scientific findings of a broad research area	54,4	40,4	3,7	1,5	0,0	0,0
Policy and regulatory issues	27,2	39,7	23,5	8,8	0,7	0,0
Relevance of your research to everyday life	25,7	43,4	19,1	9,6	1,5	0,7
Potential benefits of your research for the public	34,6	51,5	11,0	2,9	0,0	0,0
Ethical implications of your research findings	27,2	33,8	26,5	11,0	1,5	0,0
Enjoyment of doing research	25,0	35,3	28,7	10,3	0,7	0,0

Raise awareness for a scientific topic	47,1	44,1	6,6	2,2	0,0	0,0
Raise awareness for career options	12,5	44,1	25,7	12,5	5,1	0,0

a. Values in per cent.
b. Scale: 1=Extremely important, 2=Somewhat important, 3=Neither, 4=Somewhat unimportant, 5=Extremely unimportant.

Table 9: Frequencies for the variable 'importance of engaging'

An internal reliability test of all 23 items resulted in a Cronbach's alpha of .892, which indicates good internal consistency of the scales und suggests that a factor analysis would be of use to reduce the data. The factor analysis resulted in a KMO of .801 and a significant Bartlett's Test of Sphericity (p<.0005), which further supported this. A first look at the total variance explained table (appendix 2c) showed six components that had an eigenvalue greater than 1, explaining 63.559% of the total variance. The pattern matrix, however, showed that several of the items of the last two components loaded twice. It was therefore decided to redo the factor analysis and extract a 4-factor solution. The item 'creating content for your institutions website' was excluded from the analysis as it loaded very poorly on the communalities table. When looking at the pattern matrix of the 4-factor solution (table 10), it seems that the scientists place varying importance on different kinds of activities or topics.

Pattern Matrix[a]: Importance of engaging				
How important do you feel it is that you directly are engaging in the following activities or engage the public on the following?	Component			
	1	2	3	4
Explaining your research to friends and family		,709		
Talking to journalists	,747			
Talking to politicians and policy makers	,536			
Giving interviews	,825			

Appearing on a TV/radio programme	,854			
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	,541			
Giving lectures or talks for adults				-,518
Giving lectures or talks for children				-,726
Participating in a public dialogue event	,334			-,568
Participating in exhibitions at museums	,540			-,399
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)				-,676
Writing press releases	,346			-,300
Creating content for your own website	,593			
Scientific findings of your research		,426	,317	,331
Scientific findings of a broad research area		,415		
Policy and regulatory issues	,322		,511	
Relevance of your research to everyday life			,800	
Potential benefits of your research for the public			,785	
Ethical implications of your research findings			,654	
Enjoyment of doing research		,746		
Raise awareness for a scientific topic		,694		
Raise awareness for career options			,494	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 11 iterations.

Table 10: Pattern matrix for the variable 'importance of engaging'

The distinction between engagement in classic PR activities and direct engagement with lay public is reflected here as well, as the first component can be summarised in an

index measuring *importance of engaging in classic PR activities* while the fourth component can be combined into the index *importance of directly engaging with lay public*. Additionally, two further components can be identified. The items that loaded on the second component include for example the importance of explaining your research to friends and family or the importance of raising awareness for a scientific topic and were therefore summarised in the index *importance of personal enjoyment of engaging*. The last distinction that became apparent was the *importance of engaging on relevance and implications of research*, as items such as importance of engaging on policy and regulatory issues or importance of engaging on the ethical implications of the research loaded on this component.

Secondly, perceived rewards were also supposed to play an important role in determining attitudes. Both rewards that originate from feelings such as enjoyment or interest as well as more external rewards that include for example obtaining help in gaining research funding or developing the research through engagement were measured (table 11).

Frequencies: Perceived rewards[a]						
Engaging in science communication activities is	1[b]	2	3	4	5	Missing
Enjoyable – unenjoyable	17,6	57,4	20,6	3,7	0,7	0,0
Beneficial – harmful	25,0	65,4	4,4	3,7	1,5	0,0
Interesting – boring	21,3	59,6	14,0	5,1	0,0	0,0
Valuable – worthless	32,4	55,9	6,6	3,7	1,5	0,0
Rewarding – unrewarding	11,8	54,4	17,6	11,8	3,7	0,7
Engaging in science communication activities will	1[c]	2	3	4	5	Missing
Benefit my career	16,2	48,5	19,1	11,0	5,1	0,0

Help me gain research funding	12,5	37,5	19,1	24,3	6,6	0,0
Help me developing my research	9,6	28,7	27,9	24,3	8,1	1,5
Help me make contacts for my research	21,3	33,8	15,4	25,0	3,7	0,7
Enhance my personal reputation among my peers	15,4	37,5	20,6	19,1	6,6	0,7
Enhance my personal reputation among the public	18,4	54,4	16,2	8,8	2,2	0,0

a. Values in per cent.
b. Scale: 1=Extremely (positive adjective), 2=Somewhat (positive adjective), 3=Neither, 4=Somewhat (negative adjective), 5=Extremely (negative adjective).
c. Scale: 1=Extremely likely, 2=Somewhat likely, 3=Neither, 4=Somewhat unlikely, 5=Extremely unlikely.

Table 11: Frequencies for the variable 'perceived rewards'

To see if responses to internal and external rewards intersected, a factor analysis of the 11 items was done. The internal reliability test resulted in good internal consistency with a Cronbach's alpha of .765. A KMO of .741 and a significant Bartlett's Test of Sphericity ($p<.0005$) showed that the chosen items were useful to be included in the factor analysis. However, the items 'rewarding – unrewarding' and 'enhance my personal reputation among the public' loaded very poorly on the communalities table and were thus excluded from the analysis. The new analysis showed three components with an eigenvalue greater than 1 and that explained 67.687% of the total variance. When looking at the pattern matrix (table 12), it became clear that internal and external rewards did not intersect.

Pattern Matrix[a]: Perceived rewards			
	Component		
Engaging in science communication activities is and will	1	2	3
Enjoyable		,875	
Beneficial			,792

Interesting		,887	
Valuable			,764
Benefit my career	,722		
Help me gain research funding	,806		
Help me developing my research	,734		
Help me make contacts for my research	,831		
Enhance my personal reputation among my peers	,790		

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Table 12: Pattern matrix for the variable 'perceived rewards'

The five items that loaded on the first component all describe benefits or rewards that engaging would bring from the outside. Therefore, these items were included in a summative index measuring *external rewards*. The other two components were both made up of items measuring feelings of enjoyment or benefits that engaging would bring. However, both components only loaded on two items respectively and it was thus decided to not extract them.

4.2.3 Independent Variable II: Subjective Norms

The second main section dealt with subjective norms and its various underlying beliefs. On the one hand, the focus was put on encouragement from reference groups and how many people in the surrounding environment engage, on the other hand prevalent norms within the scientific community were measured. The following will give an overview of the distribution of the different items and will use factor analysis to reduce the data.

Firstly, encouragement was measured with approval, support and opposition of engaging in regard to five different reference groups: family, friends, colleagues, peers in the same area of research and peers in a different area of research. The items from 'opposition' had to be recoded so that the meaning of the scale was in line with

approval and support. Most respondents indicated that family and friends as well as colleagues and peers encouraged them to engage. A factor analysis was done to determine if there were differences between the respective reference groups. The internal reliability test showed good internal consistency with a Cronbach's alpha of .886. A factor analysis of the three constructs resulted in a KMO of .772 and a significant Bartlett's Test of Sphericity ($p<.0005$). Three components had an eigenvalue greater than 1 and therefore explained 71.099% of the total variance. When looking at the pattern matrix (table 13) two major distinctions become apparent. All items that loaded on the first component referred to colleagues or peers while all items on the second component involved family and friends. This distinction is unsurprising as it reflects the separation of the professional work environment from the personal life. Summative indices were created respectively for the first two components to measure *encouragement from colleagues and peers* as well as *encouragement from family and friends*.

Pattern Matrix[a]: Encouragement from reference groups

Most of the following people approve/support/oppose of my engaging in science communication activities.	Component 1	2	3
Family		,769	
Friends		,790	
Colleagues	,792		
Peers in the same area of research	,798		
Peers in a different area of research	,727		
Family		,812	
Friends		,823	
Colleagues	,795		
Peers in the same area of research	,870		

Peers in a different area of research	,824		
Family			,892
Friends			,920
Colleagues	,583		,462
Peers in the same area of research	,552		,516
Peers in a different area of research	,570		,475

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Table 13: Pattern matrix for the variable 'encouragement from reference groups'

Furthermore, respondents were asked about the engagement of colleagues. Almost everyone (95.6%) affirmed that at least 1 of the 5 colleagues they know best engages in science communication activities (table 14). Around 38% even stated that 4 or 5 of the colleagues they know best engage. This suggests that almost all respondents know someone in their professional environment who engages.

Frequencies: Number of colleagues who engage[a]							
	0	1	2	3	4	5	Missing
How many of the colleagues you know best engage in science communication activities?	4,4	13,2	31,6	12,5	17,6	20,6	0,0

a. Values in per cent.

Table 14: Frequencies for the variable 'number of colleagues who engage'

The third variable that was used to measure subjective norms enquired about prevalent norms within the scientific community (table 15). This included items such as 'scientists are not well regarded by their peers' or 'scientists have a good reputation among their peers'. It can be seen that more than half of the respondents disagreed that scientists who engage are not well regarded or looked down on by their peers.

Frequencies: Norms within the scientific community[a]						
Scientists who engage in science communication activities	1[b]	2	3	4	5	Missing
Are not well regarded by their peers	0,7	19,1	19,1	33,1	27,2	0,7
Have a good reputation among their peers	18,4	36,0	33,1	11,0	1,5	0,0
Are looked down on by their peers	3,7	11,0	25,0	28,7	31,6	0,0
Improve the general image of scientists	36,0	45,6	14,0	3,7	0,7	0,0

a. Values in per cent.
b. Scale: 1=Agree completely, 2=Agree somewhat, 3=Neither, 4=Disagree somewhat, 5=Disagree completely.

Table 15: Frequencies for the variable 'norms within the scientific community'

Two of the items had to be recoded so that the scales matched the other two. An internal reliability test of the four items resulted in a Cronbach's alpha of .736, which is acceptable. When leaving out 'scientists improve the general image of scientists' however, the Cronbach alpha coefficient rose to .822. Therefore, these first three items were combined in a summative index to measure *norms within the scientific community*.

4.2.4 Independent Variable III: Perceived Control

The third main concept of the TPB is concerned with perceived behavioural control. Different beliefs regarding control such as difficulty to engage or obligations and restrictions as well as fears were measured and will be presented in the following. Factor analyses were conducted as well and the resulting variables will be briefly summarised.

Respondents were asked whether they perceived engaging in nine different kinds of activities as easy or difficult (table 16). Responses varied quite strongly depending on the activity. Explaining their research to the adult public for example was an activity

that more than half (57.4%) of the respondents found at least somewhat easy. Talking to journalists on the other hand was perceived as difficult by 45.6% of the respondents.

Frequencies: Ease of engagement[a]						
Do you find it easy or difficult to engage in the following science communication activities?	1[b]	2	3	4	5	Missing
Getting generally involved in science communication activities	11,8	44,9	19,9	22,8	0,0	0,0
Explaining your research to the adult public	10,3	47,1	11,0	27,9	2,9	0,7
Explaining your research to children	5,1	30,1	23,5	29,4	9,6	2,2
Talking to journalists	0,7	19,9	30,9	36,8	8,8	2,9
Talking to politicians and policy makers	0,0	14,7	22,1	39,0	22,1	2,2
Giving interviews	4,4	12,5	39,0	30,1	11,8	2,2
Appearing on a TV/ radio programme	1,5	9,6	27,9	35,3	22,8	2,9
Write content for your institutions website	13,2	44,9	26,5	12,5	0,7	2,2
Write content for social media channel	10,3	28,7	40,4	15,4	2,9	2,2

a. Values in per cent.
b. Scale: 1 = Extremely easy, 2 = Somewhat easy, 3 = Neither, 4 = Somewhat difficult, 5 = Extremely difficult

Table 16: Frequencies for the variable 'ease of engagement'

To determine if the items could be divided into several kinds of ease, a factor analysis was done. An internal reliability test showed acceptable internal consistency with a Cronbach's alpha of .764. The factor analysis showed a KMO of .740 and a significant Bartlett's Test of Sphericity ($p<.0005$). Three components became apparent that explained 67.691% of the total variance. As can be seen in the pattern matrix (table 17), the first one included mainly items that pertained to an activity involving verbal

engagement such as talking to journalists or giving interviews. These items were combined in a summative index to measure *ease to engage verbally*. The other two components both loaded only on three items respectively with one of the items appearing on both components. It was therefore decided to not extract these two components.

Pattern Matrix[a]: Ease of engagement			
Do you find it easy or difficult to engage in the following science communication activities?	Component 1	2	3
Getting generally involved in science communication activities		,375	,469
Explaining your research to the adult public			,796
Explaining your research to children			,883
Talking to journalists	,812		
Talking to politicians and policy makers	,627		
Giving interviews	,940		
Appearing on a TV/ radio programme	,870		
Write content for your institutions website		,807	
Write content for social media channel		,809	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 17: Pattern matrix for the variable 'ease of engagement'

Another variable that was used to measure perceived control was perceptions of obligations and restrictions. This included 15 items such as 'I have a duty to share my research findings with the general public', 'I have enough financial support to engage in science communication activities' or 'my research is too complex to explain to the general public' (table 18). The responses varied a great deal, which can be attributed to the wide topical range of the items.

Frequencies: Perceptions of obligations and restrictions[a]						
Do you agree or disagree with the following statements?	1[b]	2	3	4	5	Missing
Taxpayers' money funds my research	50,0	34,6	6,6	5,9	2,9	0,0
Individuals can benefit from my research	19,1	35,3	26,5	15,4	2,2	1,5
I have a duty to share my research findings with the general public	42,6	39,7	8,8	6,6	2,2	0,0
I have a moral duty to engage about social and ethical implications of my research	25,7	32,4	21,3	12,5	7,4	0,7
I have enough time to engage in science communication activities	1,5	22,8	10,3	44,9	20,6	0,0
I have enough financial support to engage in science communication activities	8,1	18,4	17,6	30,1	25,7	0,0
It is easy to get funding for engaging in science communication activities	2,2	4,4	33,8	30,1	25,7	3,7
I have enough support from my institution regarding engaging in science communication activities	14,0	39,7	18,4	19,9	6,6	1,5
I have enough training and skills to engage in science communication activities	7,4	34,6	27,2	21,3	9,6	0,0
My research is interesting to the general public	22,1	58,1	7,4	11,8	0,7	0,0
My research is too complex to explain to the general public	2,2	16,2	17,6	41,9	22,1	0,0
My research is too specialised to make much sense to the general public	3,7	17,6	19,9	37,5	21,3	0,0
My research is too controversial for science communication activities	0,7	2,9	7,4	32,4	55,9	0,7

I feel confident that I could prepare materials about my research for the general public	41,9	41,9	8,8	5,9	0,7	0,7
I feel confident that I could answer questions about my research from the general public	49,3	36,8	8,1	4,4	0,7	0,7

a. Values in per cent.
b. Scale: 1=Agree completely, 2=Agree somewhat, 3=Neither, 4=Disagree somewhat, 5=Disagree completely.

Table 18: Frequencies for the variable 'perceptions of obligations and restrictions'

A factor analysis was done to reduce the items and to determine if specific obligations or restrictions become apparent. For that, some of the items were recoded to ensure that the direction of all scales matched. An internal reliability test showed acceptable internal consistency with a Cronbach's alpha of .716. 64.991% of the total variance were explained by five components. However, when looking at the pattern matrix (table 19), it can be seen that most of the items load on the first three components.

Pattern Matrix[a]: Perceptions of obligations and restrictions					
	Component				
Do you agree or disagree with the following statements?	1	2	3	4	5
Taxpayers' money funds my research					-,773
Individuals can benefit from my research			,896		
I have a duty to share my research findings with the general public			,420		-,534
I have a moral duty to engage about social and ethical implications of my research			,774		
I have enough time to engage in science communication activities		,548		,391	
I have enough financial support to engage in science communication activities		,870			

It is easy to get funding for engaging in science communication activities		,781			
I have enough support from my institution regarding engaging in science communication activities		,769			
I have enough training and skills to engage in science communication activities		,420			,443
My research is interesting to the general public	,454				
My research is too complex to explain to the general public	,734				
My research is too specialised to make much sense to the general public	,743				
My research is too controversial for science communication activities	,709				
I feel confident that I could prepare materials about my research for the general public				,867	
I feel confident that I could answer questions about my research from the general public				,823	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 12 iterations.

Table 19: Pattern matrix for the variable 'perceptions of obligations and restrictions'

Component 1 mainly included items that determine if the research is suitable for engaging. Environmental restraints or their absence loaded strongly on component 2. The third component showed moral obligations to engage. It can be seen that different kinds of obligations and restrictions seem to exist. Therefore, summative indices were created for the first three components respectively to measure *research is suitable for engaging*, *absence of environmental restraints* and *moral obligations*.

Furthermore, communication autonomy was measured by inquiring if respondents needed to seek approval before engaging in seven different communication activities

(table 20). When looking at the different items, it can be seen that the answers differed depending on the activities. Most respondents indicated for example that they needed to seek approval to talk to journalists or to create content for their institutions website while this was not necessary for giving lectures or talks.

Frequencies: Communication autonomy[a]				
I need to seek approval from someone in my institution before	0[b]	1	2	Missing
Talking to journalists	25,7	55,9	18,4	0,0
Talking to politicians and policy makers	27,9	48,5	22,8	0,7
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	22,8	10,3	66,9	0,0
Giving lectures or talks	14,7	34,6	50,7	0,0
Participating in a public dialogue event	25,7	27,2	46,3	0,7
Creating content for your institutions website	9,6	68,4	22,1	0,0
Creating content for your own website	22,1	11,8	66,2	0,0

a. Values in per cent.
b. Scale: 0=Don't know, 1=Yes, 2=No.

Table 20: Frequencies for the variable 'communication autonomy'

To determine if the activities can be divided into different categories, a factor analysis was done. An internal reliability test resulted in acceptable internal consistency of the scales with a Cronbach's alpha of .757. A KMO of .766 and a significant Bartlett's Test of Sphericity ($p<.0005$) supported the usefulness of including the items in the factor analysis. 'Engaging in scientific discussions on social media (e.g. Twitter or Facebook)' was excluded from the analysis as it loaded quite poorly on the communalities table. The factor analysis resulted in two components with an eigenvalue greater than 1 that explained 62.822% of the total variance. When looking at the pattern matrix (table 21), it can be seen that the components were divided by the extent that the communication activities have. Items such as 'giving lectures or talks' and 'creating content for your

institutions website' do not require as much effort as items such as 'talking to journalists' and 'participating in a public dialogue event' which loaded on component 2. Two summative indices were therefore created, with the first measuring *approval for minor communication activities* and the second measuring *approval for major communication activities*.

Pattern Matrix[a]: Communication autonomy		
I need to seek approval from someone in my institution before	Component 1	2
Talking to journalists		-,843
Talking to politicians and policy makers		-,895
Giving lectures or talks	,637	
Participating in a public dialogue event	,545	-,332
Creating content for your institutions website	,585	
Creating content for your own website	,901	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Table 21: Pattern matrix for the variable 'communication autonomy'

The last variable that was used to measure perceived control is fear of consequences. Five different items such as 'the media will oversimplify my research' or 'the general public reacts critically regarding my research area' were included (table 22). It could be seen that reactions varied depending on the different items. Noticeable was that the media was regarded with more reservation than the general public.

Frequencies: Fear of consequences[a]						
If I engaged in science communication activities, I would fear that	1[c]	2	3	4	5	Missing
I would not be taken seriously by	0,7	16,2	14,0	27,9	41,2	0,0

the general public						
The media will oversimplify my research	13,2	49,3	14,7	17,6	5,1	0,0
The media will distort my research	8,8	39,0	22,8	24,3	5,1	0,0
The general public reacts critically regarding my research area	0,7	20,6	19,9	33,1	25,0	0,7
My peers react critically regarding my engaging	2,2	19,9	25,7	28,7	22,8	0,7

a. Values in per cent.
b. Scale: 1=Agree completely, 2=Agree somewhat, 3=Neither, 4=Disagree somewhat, 5=Disagree completely.

Table 22: Frequencies for the variable 'fear of consequences'

A factor analysis was done to see if this could be backed up. The internal consistency of the scale was slightly below the recommended value of .7 (Cronbach's alpha=.666), which was confirmed in the factor analysis with a KMO of .648 and a significant Bartlett's Test of Sphericity (p<.0005). When still looking at the results of the factor analysis, two components had an eigenvalue greater than 1 and explained 67.149% of the total variance. The division between fears of the media and fears of the public was also reflected in the pattern matrix (table 23) as the items that loaded on the first component were concerned with the public while the other items related to the media.

Pattern Matrix[a]: Fear of consequences		
	Component	
If I engaged in science communication activities, I would fear that	1	2
I would not be taken seriously by the general public	,787	
The media will oversimplify my research		-,902
The media will distort my research		-,871
The general public reacts critically regarding my research area	,665	

My peers react critically regarding my engaging	,816	

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 23: Pattern matrix for the variable 'fear of consequences'

Even though only two items loaded on the second component, it was decided to create a summative index for each of the components, the first measuring *fear of consequences from the public* and the second *measuring fear of consequences from the media*. A further bivariate analysis shall determine if both variables correlate with intention to engage and actual engagement and are thus relevant.

4.3 Bivariate Analysis

After respectively outlining the different variables of the study, this part now focuses on the relationships between the dependent and independent variables. By looking at measures of association such as Pearson's correlation coefficient it can already be seen, which variables might contribute more towards explaining the scientists' behaviour and which might not be as important after all (table 24).

Correlations

		Intention to engage	Engagement in classic PR activities	Direct engagement with lay public
Importance of engaging in classic PR activities	Pearson Correlation	**,209***	**,209***	,169
	Sig. (2-tailed)	,016	,020	,057
	N	131	123	128
Importance of personal enjoyment of engaging	Pearson Correlation	**,171***	,157	**,227****
	Sig. (2-tailed)	,049	,080	,009
	N	134	125	131
Importance of	Pearson Correlation	,127	,006	-,017

engaging on relevance and implications of research	Sig. (2-tailed)	,145	,951	,845
	N	134	125	131
Importance of directly engaging with lay public	Pearson Correlation	,095	,009	**,272****
	Sig. (2-tailed)	,280	,924	,002
	N	132	123	129
External rewards	Pearson Correlation	,122	-,089	**-,252****
	Sig. (2-tailed)	,165	,323	,004
	N	131	124	128
Encouragement from colleagues and peers	Pearson Correlation	**,235****	,100	,054
	Sig. (2-tailed)	,009	,290	,557
	N	122	114	120
Encouragement from family and friends	Pearson Correlation	**,246****	,092	**,277****
	Sig. (2-tailed)	,005	,310	,001
	N	132	123	129
Number of colleagues who engage	Pearson Correlation	**-,367****	**-,302****	-,117
	Sig. (2-tailed)	,000	,001	,183
	N	135	126	132
Norms within the scientific community	Pearson Correlation	,150	,073	-,108
	Sig. (2-tailed)	,084	,421	,220
	N	134	125	131
Difficulty to engage verbally	Pearson Correlation	**,269****	**,334****	**,200***
	Sig. (2-tailed)	,002	,000	,025
	N	129	121	126
Research is suitable for engaging	Pearson Correlation	**,225****	**,226***	**,240****
	Sig. (2-tailed)	,009	,011	,006
	N	134	125	131

Absence of environmental restraints	Pearson Correlation	**,270****	,106	-,046
	Sig. (2-tailed)	,002	,249	,608
	N	128	121	125
Moral obligations	Pearson Correlation	**,335****	,141	**,216***
	Sig. (2-tailed)	,000	,118	,014
	N	132	124	129
Approval for minor communication activities	Pearson Correlation	**-,188***	**-,355****	**-,212***
	Sig. (2-tailed)	,029	,000	,015
	N	135	126	132
Approval for major communication activities	Pearson Correlation	**-,175***	**-,377****	-,160
	Sig. (2-tailed)	,044	,000	,068
	N	133	124	130
Fear of consequences from the public	Pearson Correlation	-,163	**-,350****	**-,244****
	Sig. (2-tailed)	,061	,000	,005
	N	133	124	130
Fear of consequences from the media	Pearson Correlation	,109	,027	-,073
	Sig. (2-tailed)	,207	,764	,405
	N	135	126	132
Gender	Pearson Correlation	,045	,097	-,071
	Sig. (2-tailed)	,609	,281	,420
	N	133	125	130
Age	Pearson Correlation	-,158	**-,569****	**-,359****
	Sig. (2-tailed)	,069	,000	,000
	N	133	125	130

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 24: Correlations between the dependent and independent variables

From the 17 variables that emerged from the univariate analysis, only three variables (importance of engaging on relevance and implications of research, norms within the scientific community and fear of consequences from the media) showed no significant correlation with either intention to engage or with actual engagement. Most surprisingly of these three is that 'norms within the scientific community' does not appear to be of importance in regard to intention and engagement. As the distribution showed a mean response that tended rather in the direction of respondents agreeing that scientists who engage have a good reputation and are not looked down on by their peers, a significant relationship with intention and engagement was expected. Considering that both encouragement from colleagues and peers as well as the number of colleagues who engage show a significant correlation with intention or engagement in classic PR activities, one explanation could be that respondents attached more importance to how others acted as opposed to what others thought of them.

Of no surprise were most of the other correlations. Respondents who believed different kinds of engaging important also tended to have a higher intention to engage or higher actual engagement in classic PR activities or direct engagement with lay public. Similarly, respondents who found it easy to engage or perceived their research to be suitable for engaging had higher intentions or engaged more and accordingly respondents who needed to seek approval for engaging or feared consequences from the public had lower intentions and engaged less.

Noticeable, though, is that a small significant negative correlation (Pearson's r=-.252, p=.004) can be found between external rewards and direct engagement with lay public. This suggests that respondents who do not think it likely that engaging in science communication activities will for example benefit their career or help them gain research funding actually engage more with the lay public. A reason for this might be

that the scientists consider direct engagement not as a way to acquire new funding, but instead see it as an opportunity to create awareness and understanding for their research.

From the control variables, gender did not correlate significantly or very highly with either intention or engagement. Age, however, showed a high significant negative correlation with engagement. This implies that the older the respondents were, the more they engaged. A reason why age correlates significantly with engagement but not with intention could be explained due to the actual amount of years that older respondents had more. They simply had more time and opportunities to engage. Intentions, however, do not seem to be influenced by this, which might be because other variables play a more important role in predicting intentions. The further analysis will give more information on this.

In summary, it can be said that of the 17 independent variables that emerged from the first analysis, 14 showed significant correlations with intention to engage, engagement in classic PR activities or direct engagement with lay public. These 14 variables were then further analysed regarding their combined predictive effect.

4.4 Multivariate Analysis

The last part of the analysis included a multivariate analysis. Thereby, the model was tested with the 14 independent variables that showed significant correlations with either intention to engage, engagement in classic PR activities or direct engagement with lay public during the bivariate analysis. The aim was to examine which of these independent variables predicts intention to engage or engagement in science communication activities best. The following presents the results of the hierarchical multiple regression analyses for each of the dependent variables.

4.4.1 Multiple Regression Analysis for Intention to Engage

Before looking at the effect of the different variables on predicting the intention to engage, the results of the multiple regression analysis were examined regarding multicollinearity, outliers, normality, linearity, homoscedasticity and independence of residuals to control that specific assumptions about the data were not violated (appendix 3a). Both the correlations and the coefficients table showed no signs of multicollinearity and no outliers could be found in the casewise diagnostics table. The assumptions of normality, linearity and homoscedasticity were not violated as the normal P-P plot showed a reasonably straight line and no clear or systematic pattern was discernable in the scatterplot's distribution of the residuals.

When looking at how well the 14 variables predicted intention to engage, the model summary (table 25, model 1) showed an R square of .341, which indicates that the model explains 34.1% of the variance. As the sample was rather small, the adjusted R square of 25.2% (.252) depicts a more accurate representation of the true population value. The ANOVA table (table 26) showed a significant result (p<.0005) (Tabachnick & Fidell, 2013). After controlling for the effect of the socio-demographics gender and age, the added variance was negligible (R square change=.006) and not statistically significant (Sig. F change=.622), thus suggesting that gender and age do not have an effect on predicting intention to engage and supporting the results from the bivariate analysis that showed no significant correlations between either gender or age and intention.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
1	,584[a]	,341	,252	1,59884	,341	,000
2	,589[b]	,347	,244	1,60758	,006	,622

a. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities

b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Gender, Age

c. Dependent Variable: Intention to engage

Table 25: Model summary of hierarchical multiple regression analysis for 'intention to engage'

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	136,532	14	9,752	3,815	,000[b]
	Residual	263,299	103	2,556		
	Total	399,831	117			
2	Regression	138,814	16	8,676	3,357	,000[c]
	Residual	261,017	101	2,584		
	Total	399,831	117			

a. Dependent Variable: Intention to engage
b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities
c. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Gender, Age

Table 26: ANOVA of hierarchical multiple regression analysis for 'intention to engage'

To determine which of the independent variables was the best predictor of intentions, the beta values in the coefficients table (table 27) were examined. Of the 14 variables, number of colleagues who engage had the highest beta value (β=-.243) followed by moral obligations (β=.245). Noticeable is that these two were the only variables that made a unique significant contribution (p<.005) towards explaining intentions. Neither different kinds of importance of engaging nor external rewards seemed to play an important role in predicting intentions. Instead, variables that measured perceived control such as ease to engage verbally or the absence of environmental restraints additionally contributed to the prediction of intentions.

Coefficients[a]

Model		Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)		,150	,881		
	Importance of engaging in classic PR activities	,042	,370	,712	,506	1,975

	Importance of personal enjoyment of engaging	,065	,674	,502	,688	1,453
	Importance of directly engaging with lay public	-,082	-,725	,470	,504	1,984
	External rewards	-,004	-,039	,969	,625	1,599
	Encouragement from peers and colleagues	,017	,158	,874	,540	1,853
	Encouragement from family and friends	**,146**	1,598	,113	,764	1,309
	Number of colleagues who engage	**-,253**	-2,744	**,007**	,750	1,333
	Ease to engage verbally	**,153**	1,618	,109	,717	1,394
	Research is suitable for engaging	**,111**	1,193	,236	,739	1,354
	Absence of environmental restraints	**,108**	1,070	,287	,622	1,608
	Moral obligations	**,245**	2,560	**,012**	,700	1,429
	Approval for minor communication activities	-,098	-,967	,336	,624	1,602
	Approval for major communication activities	-,046	-,493	,623	,722	1,384
	Fear of consequences from the public	,043	,414	,679	,592	1,688
2	(Constant)		,410	,683		
	Importance of engaging in classic PR activities	,043	,381	,704	,506	1,978
	Importance of personal enjoyment of engaging	,052	,532	,596	,665	1,503
	Importance of directly engaging with lay public	-,071	-,622	,535	,499	2,005
	External rewards	,016	,148	,883	,578	1,730
	Encouragement from peers and colleagues	,016	,151	,881	,540	1,853

Encouragement from family and friends	**,157**	1,683	,095	,743	1,347
Number of colleagues who engage	**-,245**	-2,629	**,010**	,744	1,345
Ease to engage verbally	**,152**	1,579	,118	,695	1,439
Research is suitable for engaging	,099	1,045	,298	,721	1,388
Absence of environmental restraints	**,133**	1,225	,224	,551	1,816
Moral obligations	**,229**	2,341	**,021**	,678	1,475
Approval for minor communication activities	-,088	-,858	,393	,617	1,622
Approval for major communication activities	-,044	-,451	,653	,691	1,448
Fear of consequences from the public	,038	,358	,721	,589	1,697
Gender	-,062	-,675	,501	,775	1,291
Age	-,067	-,709	,480	,726	1,378

a. Dependent Variable: Intention to engage

Table 27: Coefficients table of hierarchical multiple regression analysis for 'intention to engage'

After controlling for the effects of gender and age (table 27, model 2), it can be seen that the number of colleagues who engage still was the best predictor of intentions (β=-.245, p=.010). As the model summary already suggested, gender and age both did not contribute significantly towards the predictability of intentions. Therefore, the effect on the other variables was minor. In this case it seems that subjective norms and especially the behaviour of colleagues as well as perceived control play the most important role in predicting intentions.

4.4.2 Multiple Regression Analysis for Engagement in Classic PR Activities

In the next step, engagement in classic PR activities was examined in terms of the overall model fit and the predictability of the different independent variables.

Additionally, intention to engage was added in the second model of the hierarchical multiple regression analysis to examine the effect it has on the predictability of the other independent variables and on predicting engagement in classic PR activities. The specific assumptions regarding normality, linearity and homoscedasticity were not violated and the analysis showed neither multicollinearity nor any outliers (appendix 3b).

The first model examined the prediction of the 14 independent variables that were also used in the previous multiple regression analysis. The model summary (table 28, model 1) showed an R square of .391, which indicates that the model explains 39.1% of the variance of engagement in classic PR activities. As the sample was rather small, the adjusted R square of 30.5% (.305) depicts a more accurate representation of the true population value. The ANOVA table (table 29) showed a significant result (p<.0005) (Tabachnick & Fidell, 2013). In the second model, intention to engage was added, which increased the variance by 4.5% (R square change=.045, Sig. F change p=.006, ANOVA p<.0005). Lastly, the effects of the socio-demographic variables gender and age were controlled for, adding another additional 14.6% (R square change=.146, Sig. F change p<.0005, ANOVA p<.0005) to the R square. Unlike in the previous multiple regression analysis, in this case gender and age do seem to have an effect in predicting the engagement in classic PR activities.

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
1	,625[a]	,391	,305	5,60802	,391	,000
2	,660[b]	,435	,349	5,42651	,045	,006
3	,762[c]	,581	,507	4,72102	,146	,000

a. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities

b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage

c. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage, Gender, Age

d. Dependent Variable: Engagement in classic PR activities

Table 28: Model summary of hierarchical multiple regression analysis for 'engagement in classic PR activities'

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1997,815	14	142,701	4,537	,000[b]
	Residual	3113,544	99	31,450		
	Total	5111,359	113			
2	Regression	2225,556	15	148,370	5,039	,000[c]
	Residual	2885,803	98	29,447		
	Total	5111,359	113			

3	Regression	2971,712	17	174,807	7,843	,000[d]
	Residual	2139,647	96	22,288		
	Total	5111,359	113			

a. Dependent Variable: Engagement in classic PR activities
b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities
c. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage
d. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage, Gender, Age

Table 29: ANOVA of hierarchical multiple regression analysis for 'engagement in classic PR activities'

To determine which of the independent variables contributes most towards predicting the engagement in classic PR activities without the influence of the effects of intentions or the socio-demographics, model 1 of the coefficients table was examined (table 30). It can be seen that number of colleagues who engage had the highest beta value (β=-.324) followed by approval for major communication activities (β=-.230). These two variables were also the only variables that made a significant unique contribution ($p<.05$) towards explaining the engagement in classic PR activities. However, other

variables still showed a contribution in predicting the dependent variable. Different kinds of importance as well as external rewards and fear of consequences for example can also be considered as important in predicting engagement.

Coefficients[a]

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		6,416	,000		
	Importance of engaging in classic PR activities	**,109**	,992	,324	,506	1,975
	Importance of personal enjoyment of engaging	,051	,539	,591	,688	1,453
	Importance of directly engaging with lay public	**-,172**	-1,560	,122	,504	1,984
	External rewards	**-,124**	-1,255	,212	,625	1,599
	Encouragement from peers and colleagues	-,024	-,224	,823	,540	1,853
	Encouragement from family and friends	-,027	-,298	,767	,764	1,309
	Number of colleagues who engage	**-,324**	-3,576	**,001**	,750	1,333
	Ease to engage verbally	**,148**	1,601	,113	,717	1,394
	Research is suitable for engaging	,000	,003	,998	,739	1,354
	Absence of environmental restraints	-,046	-,461	,646	,622	1,608
	Moral obligations	**,125**	1,338	,184	,700	1,429
	Approval for minor communication activities	**-,106**	-1,070	,287	,624	1,602
	Approval for major communication activities	**-,230**	-2,496	**,014**	,722	1,384

Fear of consequences from the public	**-,201**	-1,976	,051	,592	1,688

a. Dependent Variable: Engagement in classic PR activities

Table 30: Coefficients table for model 1 of hierarchical multiple regression analysis for 'engagement in classic PR activities'

When adding intentions to engage to the hierarchical multiple regression analysis, the beta values changed slightly (table 31). It can be seen that intentions actually play an important role in predicting the engagement in classic PR activities (β=.260). However, the number of colleagues who engage and approval for major communication activities still made a unique significant contribution towards predicting engagement. By adding intentions to the model, the beta value of fear of consequences from the public was higher (β=-.213, p=.034), thus suggesting that fears are important.

Coefficients[a]					
	Standardized Coefficients			Collinearity Statistics	
Model	Beta	t	Sig.	Tolerance	VIF
2 (Constant)		6,588	,000		
Importance of engaging in classic PR activities	,099	,923	,358	,506	1,978
Importance of personal enjoyment of engaging	,034	,371	,711	,685	1,459
Importance of directly engaging with lay public	**-,151**	-1,409	,162	,502	1,994
External rewards	**-,123**	-1,286	,201	,625	1,599
Encouragement from peers and colleagues	-,028	-,275	,784	,539	1,854
Encouragement from family and friends	-,065	-,736	,463	,746	1,341
Number of colleagues who engage	**-,258**	-2,841	**,005**	,699	1,430
Ease to engage verbally	**,109**	1,196	,234	,699	1,430

Research is suitable for engaging	-,029	-,322	,748	,729	1,373
Absence of environmental restraints	-,074	-,765	,446	,615	1,626
Moral obligations	,062	,660	,511	,658	1,520
Approval for minor communication activities	-,081	-,837	,405	,619	1,616
Approval for major communication activities	**-,218**	-2,441	**,016**	,721	1,387
Fear of consequences from the public	**-,213**	-2,154	**,034**	,591	1,691
Intention to engage	**,260**	2,781	**,006**	,659	1,519

a. Dependent Variable: Engagement in classic PR activities

Table 31: Coefficients table for model 2 of hierarchical multiple regression analysis for 'engagement in classic PR activities'

After additionally controlling for the effects of gender and age, model 3 (table 32) showed that age actually made a unique significant contribution (p<.0005). This lessened the effect of the other independent variables, as age seems to add to the predictive effect on engagement. When looking at this last model with all the variables, it can be said that next to age and intentions, the main predictors for engagement were the number of colleagues who engage, fear of consequences from the public and approval for major communication activities. Importance both of engaging in classic PR activities and of directly engaging with lay public also contributed to the prediction of engagement in classic PR activities.

Coefficients[a]					
	Standardized Coefficients			Collinearity Statistics	
Model	Beta	t	Sig.	Tolerance	VIF
3 (Constant)		8,897	,000		

Importance of engaging in classic PR activities	**,119**	1,284	,202	,505	1,981
Importance of personal enjoyment of engaging	-,050	-,614	,541	,663	1,508
Importance of directly engaging with lay public	**-,106**	-1,133	,260	,497	2,013
External rewards	,015	,174	,862	,578	1,731
Encouragement from peers and colleagues	-,032	-,358	,721	,539	1,854
Encouragement from family and friends	,014	,186	,853	,722	1,384
Number of colleagues who engage	**-,235**	-2,967	**,004**	,696	1,437
Ease to engage verbally	,055	,690	,492	,678	1,474
Research is suitable for engaging	-,093	-1,194	,236	,713	1,403
Absence of environmental restraints	-,070	-,779	,438	,543	1,843
Moral obligations	,014	,173	,863	,643	1,555
Approval for minor communication activities	-,060	-,709	,480	,612	1,633
Approval for major communication activities	**-,143**	-1,793	,076	,689	1,451
Fear of consequences from the public	**-,215**	-2,499	**,014**	,589	1,699
Intention to engage	**,229**	2,799	**,006**	,653	1,532
Gender	-,011	-,149	,882	,771	1,297
Age	**-,449**	-5,774	**,000**	,722	1,385

a. Dependent Variable: Engagement in classic PR activities

Table 32: Coefficients table for model 3 of hierarchical multiple regression analysis for 'engagement in classic PR activities'

4.4.3 Multiple Regression Analysis for Direct Engagement with Lay Public

The last variable that was examined in terms of the predictability of the different independent variables was direct engagement with the lay public. The analysis followed the same process as the analysis for engagement in classic PR activities. A hierarchical multiple regression analysis was conducted to examine the effects the independent variables as well as intentions and the socio-demographics gender and age have on the prediction of direct engagement with lay public. The specific assumptions regarding normality, linearity and homoscedasticity were not violated and the analysis showed neither multicollinearity nor any outliers (appendix 3c).

Compared to the first model in the previous multiple regression analysis for engagement in classic PR activities, the model summary here showed a lower R square of .288, which indicates that this model with the 14 independent variables explains 28.8% of the variance of direct engagement with lay public (table 33, model 1). The adjusted R square explains 19.1% (.191) of the total variance. The ANOVA table (table 34) showed a significant result (p=.001) (Tabachnick & Fidell, 2013). These differences in the explained variance also strengthen the decision to divide engagement in two different kinds of engagement as it can be seen that the independent variables have different predictive effects on each kind of engagement. When adding intention to engage in the second model, the variance increased by 2.3% (R square change=.023, Sig. F change p=.067, ANOVA p<.0005). This effect is rather small and does not show a significant change, which suggests that in this case intentions to engage do not particularly contribute towards predicting direct engagement with lay public. Gender and age have a very small effect on predicting direct engagement, adding another 5.2% to the variance (R square change=.052, Sig. F change p=.020, ANOVA p<.0005).

Model Summary[d]						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
1	,537[a]	,288	,191	2,53419	,288	,001
2	,558[b]	,311	,210	2,50495	,023	,067
3	,603[c]	,363	,255	2,43231	,052	,020

a. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities

b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage

c. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging, Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage, Gender, Age

d. Dependent Variable: Direct engagement with lay public

Table 33: Model summary of hierarchical multiple regression analysis for direct engagement with lay public

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	267,591	14	19,114	2,976	,001[b]
	Residual	661,480	103	6,422		

	Total	929,071	117			
2	Regression	289,045	15	19,270	3,071	,000[c]
	Residual	640,027	102	6,275		
	Total	929,071	117			
3	Regression	337,457	17	19,850	3,355	,000[d]
	Residual	591,614	100	5,916		
	Total	929,071	117			

a. Dependent Variable: Direct engagement with lay public
b. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities
c. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage
d. Predictors: (Constant), Fear of consequences from the public, Number of colleagues who engage, Importance of directly engaging with lay public, Approval for major communication activities, External rewards, Ease to engage verbally, Encouragement from family and friends, Moral obligations to engage, Importance of personal enjoyment of engaging Research is suitable for communication, Approval for minor communication activities, Absence of environmental restraints, Encouragement from colleagues and peers, Importance of engaging in classic PR activities, Intention to engage, Gender, Age

Table 34: ANOVA of hierarchical multiple regression analysis for 'direct engagement with lay public'

When looking at the coefficients table for the first model (table 35), the variable that appears to be the most important is external rewards (β=-.287, p=.007), followed by moral obligations (β=.220, p=.023). These two variables were also the only ones that

made a unique significant contribution towards predicting direct engagement with lay public. Both importance of engaging in classic PR activities and importance of directly engaging with lay public contribute to the predictability as well as encouragement from family and friends and difficulty to engage.

Coefficients[a]

Model		Standardized Coefficients			Collinearity Statistics	
		Beta	t	Sig.	Tolerance	VIF
1	(Constant)		4,649	,000		
	Importance of engaging in classic PR activities	**-,174**	-1,486	,140	,506	1,975
	Importance of personal enjoyment of engaging	,090	,895	,373	,688	1,453
	Importance of directly engaging with lay public	**,154**	1,318	,191	,504	1,984
	External rewards	**-,287**	-2,731	**,007**	,625	1,599
	Encouragement from peers and colleagues	,058	,512	,610	,540	1,853
	Encouragement from family and friends	**,124**	1,304	,195	,764	1,309
	Number of colleagues who engage	**-,148**	-1,547	,125	,750	1,333
	Ease to engage verbally	**,133**	1,356	,178	,717	1,394
	Research is suitable for engaging	,055	,569	,571	,739	1,354
	Absence of environmental restraints	-,066	-,625	,534	,622	1,608
	Moral obligations	**,229**	2,301	**,023**	,700	1,429
	Approval for minor communication activities	-,046	-,441	,660	,624	1,602
	Approval for major communication activities	-,059	-,604	,547	,722	1,384

Fear of consequences from the public	-,066	-,611	,543	,592	1,688

a. Dependent Variable: Direct engagement with lay public

Table 35: Coefficients table for model 1 of multiple regression analysis for 'direct engagement with lay public'

After adding intentions to engage to the model, the coefficients table (table 36) showed only slight changes. Intention did seem to contribute to predicting direct engagement with lay public. However, external rewards were still of highest importance.

Coefficients[a]						
		Standardized Coefficients			Collinearity Statistics	
Model		Beta	t	Sig.	Tolerance	VIF
2	(Constant)		4,676	,000		
	Importance of engaging in classic PR activities	**-,181**	-1,570	,119	,506	1,978
	Importance of personal enjoyment of engaging	,077	,780	,437	,685	1,459
	Importance of directly engaging with lay public	**,170**	1,461	,147	,502	1,994
	External rewards	**-,286**	-2,756	**,007**	,625	1,599
	Encouragement from peers and colleagues	,055	,489	,626	,539	1,854
	Encouragement from family and friends	,097	1,016	,312	,746	1,341
	Number of colleagues who engage	**-,101**	-1,028	,306	,699	1,430
	Ease to engage verbally	**,105**	1,064	,290	,699	1,430
	Research is suitable for engaging	,034	,356	,723	,729	1,373
	Absence of environmental restraints	-,086	-,822	,413	,615	1,626
	Moral obligations	**,183**	1,805	,074	,658	1,520

Approval for minor communication activities	-,028	-,269	,789	,619	1,616
Approval for major communication activities	-,050	-,521	,604	,721	1,387
Fear of consequences from the public	-,074	-,693	,490	,591	1,691
Intention to engage	**,187**	1,849	,067	,659	1,519

a. Dependent Variable: Direct engagement with lay public

Table 36: Coefficients table for model 2 of hierarchical multiple regression analysis for 'direct engagement with lay public'

Even though the model summary showed that the socio-demographics only add a small percentage to the variance, they still contributed considerably to the prediction of direct engagement with lay public (table 37). Especially age seems important as it showed the highest beta value (β=-.253, p=.008). Other changes can be found in the importance of ease to engage verbally, as that has decreased after controlling for the effects of gender and age. It can be said that attitudes and particularly external rewards and importance contribute most to the prediction of direct engagement with lay public.

Coefficients[a]					
	Standardized Coefficients			Collinearity Statistics	
Model	Beta	t	Sig.	Tolerance	VIF
3 (Constant)		5,470	,000		
Importance of engaging in classic PR activities	**-,172**	-1,529	,129	,505	1,981
Importance of personal enjoyment of engaging	,031	,318	,751	,663	1,508
Importance of directly engaging with lay public	**,201**	1,774	,079	,497	2,013
External rewards	**-,210**	-2,003	**,048**	,578	1,731
Encouragement from peers and colleagues	,053	,483	,630	,539	1,854

Encouragement from family and friends	**,142**	1,510	,134	,722	1,384
Number of colleagues who engage	-,084	-,874	,384	,696	1,437
Ease to engage verbally	,089	,923	,358	,678	1,474
Research is suitable for engaging	-,005	-,049	,961	,713	1,403
Absence of environmental restraints	-,042	-,388	,699	,543	1,843
Moral obligations	**,144**	1,450	,150	,643	1,555
Approval for minor communication activities	-,006	-,058	,954	,612	1,633
Approval for major communication activities	-,023	-,238	,812	,689	1,451
Fear of consequences from the public	-,084	-,804	,424	,589	1,699
Intention to engage	**,163**	1,648	,102	,653	1,532
Gender	**-,108**	-1,194	,235	,771	1,297
Age	**-,253**	-2,696	**,008**	,722	1,385

a. Dependent Variable: Direct engagement with lay public

Table 37: Coefficients table for model 3 of hierarchical multiple regression analysis for 'direct engagement with lay public'

In summary, the multiple regression analysed showed that the different variables are of varying importance when looking at the prediction of intentions and engagement. Noticeable is that two variables that showed significant correlations in the bivariate analysis had only very little predictive effect. For one, this was importance of personal enjoyment of engaging. However, this could be explained with the fact that there were two other variables measuring importance included in the model, which seemed to be better predictors. The second variable that appeared to be rather unimportant was encouragement from colleagues and peers. This is surprising given that the number of colleagues in the direct professional environment who engage is one of the most

important predictors. As encouragement from family and friends does seem important, an explanation could be that the encouragement has more power when it comes from someone who is closer to the scientists' personal life. On a professional level, it seems to be sufficient to see your colleagues engaging. All in all, it can be said that attitudes, subjective norms and perceived control all play a role in predicting intentions and engagement, albeit to different extents.

5 Discussion

In the previous part, the gathered data was examined regarding different relationships between the independent and dependent variables to test the aforementioned hypotheses and discuss the consequent implications for science communication practice.

The analysis showed that it is necessary to make one important distinction regarding the engagement in science communication activities. Engagement is not simply only engagement, but instead can be divided into engagement in classic PR activities and direct engagement with the lay public. When looking more closely at what distinguishes these two kinds of engagement from each other, it can be seen that the direct engagement aims more at a participatory approach while the engagement in classic PR activities focuses more on an exchange of information. When looking back at the different models that are prevalent in science communication research, a distinction was also made between a one-way and two-way flow of communication (Bucchi, 2008). This distinction is reflected in the results of the analysis insofar as that engagement is in its loosest sense divided into a one-way and two-way engagement. That this distinction was necessary could also be seen when looking at the overall analysis. Depending on the kind of engagement, different factors were more or less important.

Following the approach of the TPB, attitudes, subjective norms and perceived control were first examined regarding their influence and predictive effect on intentions. Hereby, it could be seen that attitudes only play a minor role in explaining intentions. Instead, subjective norms and especially perceptions regarding the engagement of colleagues in the direct professional environment were of greater importance. The analysis showed that those scientists who know more colleagues who engage also intent to engage more themselves. Importance was placed on perceived control insofar as that moral obligations also emerged as a good predictor for intentions. Considering these

results, a closer look can be taken again at the different hypotheses concerning intentions:

H1a: Scientists with a positive attitude towards science communication activities have a high intention to engage in those activities.

H2a: Scientists who have approval from reference groups such as colleagues or family and friends that science communication is valuable/good have a high intention to engage in science communication activities.

H3a: Scientists who perceive their control as high have a high intention to engage in science communication activities.

As attitudes were only of minor importance towards predicting intentions, the null hypotheses for H1a cannot be completely refuted. Nevertheless, the bivariate analysis showed that scientists who agreed that engaging is important also had higher intentions to engage, thus supporting the alternate hypothesis H1a. It can be seen that positive attitudes indeed lead to higher intentions, however, these attitudes are not that important when other variables such as subjective norms or perceived control are controlled for.

Similar observations can be found in regards to the second hypothesis H2a. Hereby, the focus was put on approval from reference groups. The analysis showed that encouragement from family and friends was indeed important, however encouragement from colleagues and peers was hardly of importance. It can be argued though that as the number of colleagues who engage is the most important variable in predicting intentions, colleagues and peers do play a part in developing higher intentions to engage. It is therefore possible to refute the null hypothesis for H2a.

Thirdly, the previous analysis showed that various aspects are part of the perceived control. Especially moral obligations, but also the suitability of the research, the ease to engage and environmental restraints could be seen as important predictors for

intentions. The bivariate analysis of these variables also supported the hypothesis H3a that scientists who perceive their control to be high also have higher intentions to engage. Based on these results, it is possible to refute the null hypothesis for H3a.

The second major part of the TPB is the influence that intentions, but also attitudes, subjective norms and perceived control have on engagement in science communication activities. As two different kinds of engagement were examined, the differences and similarities of the predictors for both kinds of engagement will be discussed. It could be seen that intentions were of importance for both engagement in classic PR activities and direct engagement with lay public. Noticeable, though, was that the effect of intentions was considerably higher on engagement in classic PR activities than on direct engagement with the lay public. A reason for this could be due to the different nature of the engagement, as the effort to engage in classic PR activities might be lower than that of directly engaging. When looking at the other variables, it could be seen that engagement in classic PR activities was mainly predicted by the number of colleagues who engage, fears of consequences from the public and the need for approval for major communication activities. The focus hereby was thus more on subjective norms and perceived control that on attitudes, suggesting that especially fears of not being taken seriously by the public restrict the engagement. Contrary to engagement in classic PR activities, direct engagement with lay public was rather predicted by attitudes. Especially external rewards were of great importance, but the importance of engaging both in classic PR activities and directly with the lay public was also considerable. Interesting hereby is, however, that the bivariate analysis showed a significant negative correlation between external rewards and direct engagement with lay public, which would indicate that respondents who do not think it likely to receive external rewards such as gaining funding or making new contacts for their research, actually engage more with the lay public. A reason for this might be that even though external rewards

contribute most towards predicting direct engagement, the effect of the other variables such as importance of engaging or moral obligations lead the scientists to not expect any rewards for their engagement. It appears as though they do not engage simply because they expect to get something out of their engagement.

These results now make it possible to take another look at the three hypotheses concerning engagement:

H1b: Scientists with a positive attitude towards science communication activities are more likely to actually engage in those activities.

H2b: Scientists who have approval from reference groups such as colleagues or family and friends that science communication is valuable/good are more likely to actually engage in those activities.

H3b: Scientists who perceive their control as high have are more likely to actually engage in science communication activities.

As the engagement was divided, the hypotheses were evaluated respectively for engagement in classic PR activities and direct engagement with lay public. For engagement in classic PR activities, attitudes were to some extent important in predicting the engagement, however other variables were more relevant. On the contrary, attitudes contributed considerably towards predicting direct engagement with lay public. As the bivariate analysis showed that respondents who agreed of the importance of engaging also engaged more and as not expecting any rewards for their engagement could still be considered as a positive attitude, the null hypothesis for H1b can be refuted.

When looking at subjective norms and more closely at approval from reference groups, it could be observed that the number of colleagues who engage is one of the most important variables in predicting engagement in classic PR activities. Encouragement

from family and friends to a minor extent contributes towards predicting direct engagement, however it does not appear to be of great importance for the prediction of engagement in classic PR activities. Considering though that the engagement of colleagues has a strong effect, it is possible to refute the null hypothesis for H2b.

Lastly, different aspects of perceived control also seem to predict engagement. Of great importance for direct engagement were moral obligations, while fear of consequences form the public was more relevant to engagement in classic PR activities. Interestingly, environmental restraints or the perceived suitability of the research did not really contribute towards predicting engagement. The bivariate analysis supported the hypothesis H3b that high perceptions of control also lead to high engagement. However, seeing as perceived control is only important to a certain extent, the null hypothesis for H3b cannot be completely rejected.

After having established that the engagement of colleagues in the scientists' direct professional environment and moral obligations are most important in determining intentions and engagement in classic PR activities, but that attitudes play an important part in predicting direct engagement with the lay public, different implications for the practice of science communication become apparent.

As almost all of the scientists (95.6%) indicated that their institution has a communications department, this would be the place to start to improve intentions and engagement. Changing intentions and behaviour is often rather difficult and depends on a lot of different factors that are not necessarily made available through the theory of planned behaviour. However, Fishbein and Ajzen (2010) note that it is important to target the primary beliefs that underlie the model to effectively attempt to make a change.

Perceiving their colleagues to be engaging is one of the most important predictors both for intention and for engagement in classic PR communities. This would suggest that getting only a few scientists to engage could create a snowball effect that leads to more scientists engaging. However, if it was that easy, then more scientists should already be engaging. The part where the science communication departments might be able to intervene easiest is in strengthening the perceived control. By clearly communicating detailed information on what the scientists can and cannot communicate without approval, scientists who would hesitate to communicate at all could be reassured. It would also be advantageous, if scientists could easily reach the communication department to inquire in situation they are not sure about. To counteract perceived restraints or fears, workshops or trainings on various communication topics such as engaging with journalists, writing about results targeted at the general public or public speaking could be made available within the institution. The success of these measures however depends strongly on the way they are communicated to the scientists.

Attitudes would be more difficult to change. The communication departments could stress the importance that engagement would have, however that would not necessarily prompt the scientists to also perceive engagement as important. Considering that the analysis showed that even though rewards are seen as an important predictor, scientists did not believe that engagement would for example benefit their career, it is not certain that creating incentives in the form of awards would actually increase engagement. A measure to raise attitudes towards engaging might be instead to make appreciation for scientists who engage more known within the institution. This could be achieved for example through notifying all employees of communication accomplishments of their colleagues.

6 Conclusion

This thesis focused on examining key factors that lead scientists to engage in science communication activities by developing and testing a model based on the theory of planned behaviour. Attitudes, subjective norms and perceived control were examined regarding their predictive effect on intentions and engagement in science communication activities. The research question that guided all parts of the thesis was therefore:

Why do scientists engage in science communication activities?

After analysing and discussing the results of the implemented study, this question can now be answered in two ways. First of all, the analysis showed that science communication activities are not just science communication activities, but that engagement can be divided into two different parts: engagement in classic PR activities and direct engagement with the lay public. By following this distinction, a more targeted analysis could be carried out, which leads to the second answer to the research question. The TPB follows the assumptions that behaviour is influenced by intentions. The study reflected this and showed that intention did indeed contribute towards predicting the engagement both in classic PR activities and directly with the lay public. Additionally, it could be seen that other factors also play an important part in determining why scientists engage in science communication activities. The study showed that scientists who had several close colleagues who engaged also themselves engaged more in classic PR activities. Supported by moral obligations and a perceived ease to engage, the respondents' answers indicated that observing others in their direct professional environment bolstered them in their own engagement. In terms of direct engagement with the lay public, a special emphasis was put on positive attitudes and the perception that engagement with the lay public is important.

One more thing has to be taken into account when looking at the results of the survey. As the response rate was extremely low, the generalizability of the results to the whole population has to be treated with caution. The established factors however can still be seen as an indication of which are more important and which are rather irrelevant in predicting engagement both in classic PR activities and directly with the lay public. Especially for science communication practitioners these factors now offer a suggestion of where changes could begin to get more scientists involved in science communication.

Following this study, further research could go into two directions. For one, it would be interesting to further explore the composition of engagement in science communication activities. One focus could hereby be placed on the different kinds of engagement to see whether only this distinction of classic PR activities and direct engagement with the lay public exists or whether engagement can be divided into additional factors. Furthermore, the analysis hinted at the existence of a certain threshold after which engagement increases again. This phenomenon would be worth exploring further to determine in what way this could be seen as habit formation and in what way habits influence the communication behaviour.

The second direction that offers opportunities for further exploration are the particular factors that emerged as most important during the analysis. A closer look could for example be taken at the work environment of the scientists to ascertain reasons why the engagement of colleagues influences the scientists' own engagement. One possible reason could be that by observing the engagement of others, the scientists are reassured that the engagement does not bear any negative consequences or takes away too much time that could otherwise be focused on their research. Similarly, the study showed that the importance that is placed on engagement has an effect on the actual engagement. The next step could be to determine reasons why importance has such a great influence

on the engagement. As importance is a very subjective feeling, interviews with scientists could possibly shed more light on the underlying reasons behind this. It would be interesting to discover if importance of engaging could be motivated by wanting to educate and enlighten the public or if the motivation is rather due to self-centred reasons such as spreading their own research findings.

In summary, it can be said that the study did indeed find different factors that can help in explaining why scientists engage in science communication activities. Still, the scientists' communication behaviour is far from being entirely uncovered and offers opportunities for further exploration to strengthen the connection between the scientific community and the general public.

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Appendices

Appendix 1: Questionnaire

Dear Participant,

You are being invited to participate in a brief online research study. This study is part of my thesis for the Master programme Strategic Public Relations at Lund University in Sweden. The purpose of this research study is to examine the role of science communication in the daily work life of scientists. The aim is to identify key factors that lead to participating in science communication activities.

Completing the study will take you approximately 10-15 minutes. I would be very grateful if you choose to complete all of the survey. However, your participation is entirely voluntary and you can withdraw at any time.

Your answers in this study will remain confidential to the best of my abilities and will only serve research purposes. The data gathered from your answers may be published in academic papers. By answering this survey you indicate that you have read the above information and are giving your free and informed consent to participate in this study.

If you have any questions or concerns regarding this research study, please feel free to contact me at katharina.kramer.2161@student.lu.se.

Thank you for your participation!

Katharina Kramer, Lund University, Department of Strategic Communication

Explanation of science communication activities

This survey is concerned with questions regarding your participation, perceptions and opinions of science communication activities. Science communication activities are understood as different activities that improve the awareness, knowledge and understanding of science in the general public. This includes for example engaging directly with the public through dialogues or indirectly through the media.

Engagement in science communication activities

Please answer each of the following questions by ticking the box that best describes your participation. Some of the questions may appear to be similar, but they do address somewhat different activities. Please read each question carefully.

1. How often have you engaged in the following science communication activities?					
	None	1-2 times	3-5 times	6-10 times	More than 10 times
Explaining your research to friends and family					
Talking to journalists					
Talking to politicians and policy makers					
Giving interviews					
Appearing on a TV/ radio programme					
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)					
Giving lectures/ talks for adults					
Giving lectures/ talks for children					
Participating in a public dialogue event					
Participating in exhibitions at museums					
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)					
Writing press releases					
Creating content for your institutions website					
Creating content for your own website					

Attitudes

Please answer each of the following questions by ticking the box that best describes your beliefs. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

2. How important do you feel it is that you directly are engaging in the following activities?					
	Extremely important	Somewhat important	Neither	Somewhat unimportant	Extremely unimportant
Explaining your research to friends and family					
Talking to journalists					
Talking to politicians and policy makers					
Giving interviews					
Appearing on a TV/ radio programme					
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)					
Giving lectures/ talks for adults					
Giving lectures/ talks for children					
Participating in a public dialogue event					
Participating in exhibitions at museums					

Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)					
Writing press releases					
Creating content for your institutions website					
Creating content for your own website					

3. How important do you think it is that you directly engage the public on the following?					
	Extremely important	Somewhat important	Neither	Somewhat unimportant	Extremely unimportant
Scientific findings of your research					
Scientific findings of a broad research area					
Policy and regulatory issues					
Relevance of your research to everyday life					
Potential benefits of your research for the public					

Ethical implications of your research findings					
Enjoyment of doing research					
Raise awareness for a scientific topic					
Raise awareness for career options					

4. Engaging in science communication activities is						
	Extremely	Somewhat	Neither	Somewhat	Extremely	
Enjoyable						Unenjoy-able
Harmful						Benefic-ial
Interesting						Boring
Worthless						Valuable
Unrewar-ding						Rewar-ding

5. Engaging in science communication activities will					
	Extremely likely	Somewhat likely	Neither	Somewhat unlikely	Extremely unlikely
Benefit my career					
Help me gain research funding					
Help me developing my research					
Help me make contacts for my research					
Enhance my personal reputation among my peers					
Enhance my personal reputation among the public					

Norms

Please answer each of the following questions by ticking the box that best describes your perceptions. Some of the questions may appear to be similar, but they do address somewhat different perceptions. Please read each question carefully.

6. Most of the following people approve of my engaging in science communication activities.				
	Disagree completely	Disagree somewhat	Agree somewhat	Agree completely
Family				
Friends				
Colleagues				
Peers in the same area of research				
Peers in a different area of research				

7. Most of the following people support my engaging in science communication activities.				
	Disagree completely	Disagree somewhat	Agree somewhat	Agree completely
Family				
Friends				
Colleagues				
Peers in the same area of research				
Peers in a different area of research				

8. Most of the following people oppose my engaging in science communication activities.				
	Disagree completely	Disagree somewhat	Agree somewhat	Agree completely
Family				
Friends				
Colleagues				
Peers in the same area of research				
Peers in a different area of research				

9. Do other members of your institution engage in science communication activities?				
Yes, most of them	Yes, some of them	Yes, one or two of them	None of them	Don't know

10. How many of the five colleagues you know best engage in science communication activities?					
0	1	2	3	4	5

11. Scientists who engage in science communication activities					
	Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely
Are not well regarded by their peers					
Have a good reputation among their peers					
Are looked down on by their peers					
Improve the general image of scientists					

Control

Please answer each of the following questions by ticking the box that best describes your perceptions. Some of the questions may appear to be similar, but they do address somewhat different perceptions. Please read each question carefully.

12. Do you find it easy or difficult to engage in the following science communication activities?					
	Extremely easy	Somewhat easy	Neither	Somewhat difficult	Extremely difficult
Getting generally involved in science communication activities					
Explaining your research to the adult public					
Explaining your research to children					
Talking to journalists					
Talking to politicians and policy makers					
Giving interviews					
Appearing on a TV/ radio programme					
Write content for your institutions website					
Write content for social media channel					

13. It is important to engage in science communication activities because					
	Disagree completely	Disagree somewhat	Neither	Agree somewhat	Agree completely
Taxpayers' money funds my research					
Individuals can benefit from my research					
I have a duty to share my research findings with the general public					

I have a moral duty to engage about social and ethical implications of my research					

14. Do you agree or disagree with the following statements?					
	Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely
I have enough time to engage in science communication activities					
I have enough financial support to engage in science communication activities					
It is easy to get funding for engaging in science communication activities					
I have enough support from my institution regarding engaging in science communication activities					
I have enough training and skills to engage in science communication activities					

15. Have you ever had formal training in communication skills?	
Yes	
No	

16. If yes, at what target group was the training aimed?	
Students	
Scientists	
Journalists	
General public: adults	
General public: children	

17. I need to seek approval from someone in my institution before			
	Yes	No	Don't know
Talking to journalists			
Talking to politicians and policy makers			
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)			
Giving lectures/ talks			
Participating in a public dialogue event			
Creating content for your institutions website			
Creating content for your own website			

18. Do you agree or disagree with the following statements?					
	Disagree completely	Disagree somewhat	Neither	Agree somewhat	Agree completely
My research is interesting to the general public					
My research is too complex to explain to the general public					
My research is too specialised to make much sense to the general public					
My research is too controversial for science communication activities.					
I feel confident that I could prepare materials about my research for the general public					

I feel confident that I could answer questions about my research from the general public					

19. If I engaged in science communication activities, I would fear that					
	Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely
I would not be taken seriously by the general public					
The media will oversimplify my research					
The media will distort my research					
The general public reacts critically regarding my research area					
My peers react critically regarding my engaging					

Engagement in science communication activities

Please answer each of the following questions by ticking the box that best describes your intentions. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

20. I intend to engage in science communication activities in the next 12 months.				
Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely

21. It is likely that I will engage in science communication activities in the next 12 months.				
Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely

22. How much time would you like to spend on engaging in science communication activities?					
	Agree completely	Agree somewhat	Neither	Disagree somewhat	Disagree completely
I would like to spend more time.					
I am content with the amount of time I spend on this now.					
I would like to spend less time.					

General information

Please answer each of the following questions by ticking the box that best describes your position. Please read each question carefully.

23. Are you	
Male	
Female	

24. What was your age your last birthday?

25. Which of these best describes your area of research?	
Humanities	
Social sciences	
Life sciences	
Natural sciences	
Engineering	
Other (please specify)	

26. Which of these best describes your current position?	
Bachelor/Master student	
PhD student	
Postdoctoral researcher	
Senior researcher	
Professor	
Lab assistant	

27. What is your highest academic degree?	
Graduate (Bachelor, Master or equivalent)	
Doctorate	
Habilitation/ postdoctoral qualification	

28. What is your approximate number of research publications?	
Fewer than 10	
10 – 40	
40 – 70	
70 – 100	
More than 100	

29. Is there an official communications and PR department at your institution?	
Yes	
No	
Don't know	

Thank you message

Dear Participant,

Thank you for taking the time to participate in my survey. I am very appreciative of the time you have taken to assist in my Master thesis and I truly value the information you have provided. If you would like to receive the survey results, please contact me at katharina.kramer.2161@student.lu.se.

Kind regards,

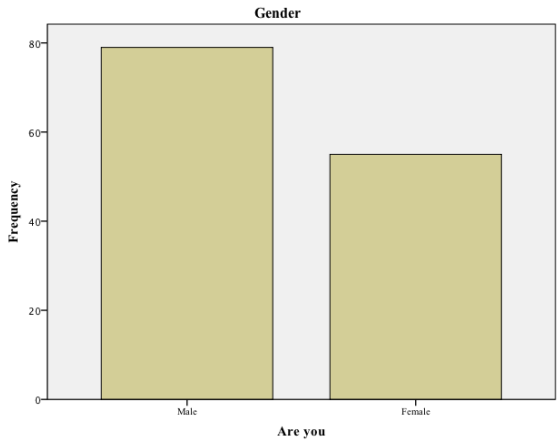
Katharina Kramer

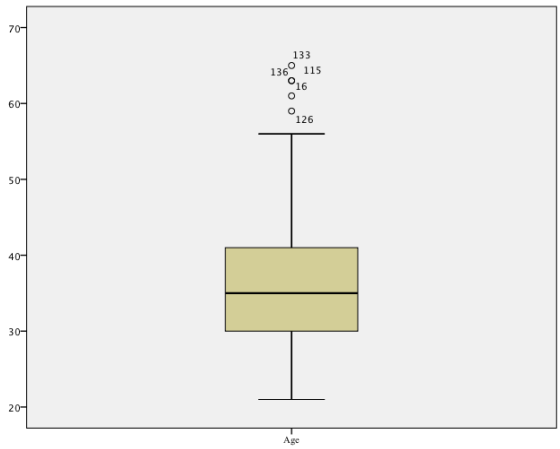
Lund University, Department of Strategic Communication

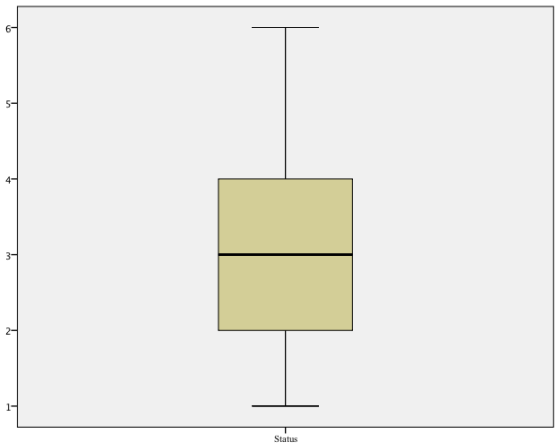
Appendix 2: Supplementary Figures and Tables from Univariate Analysis

2a. Descriptives socio-demographic variables

Descriptives					
		Gender	Age	Status	Area of research
N	Valid	134	134	133	134
	Missing	2	2	3	2
Mean		1,41	36,81	3,13	3,59
Std. Error of Mean		,043	,800	,092	,089
Median		1,00	35,00	3,00	4,00
Mode		1	29a	2	4
Std. Deviation		,494	9,259	1,062	1,028
Variance		,244	85,732	1,127	1,056
Range		1	44	5	4
Skewness		,368	,966	,473	-,920
Kurtosis		-1,893	,614	-,583	,364



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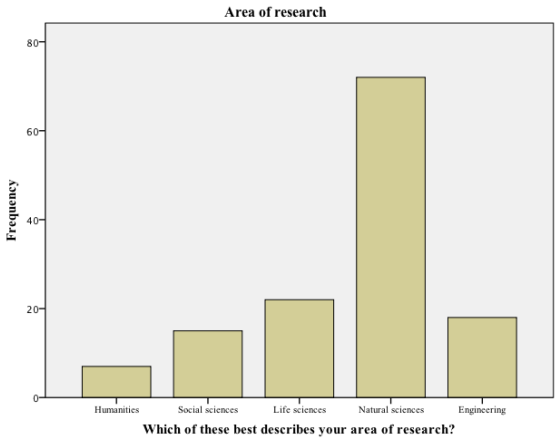
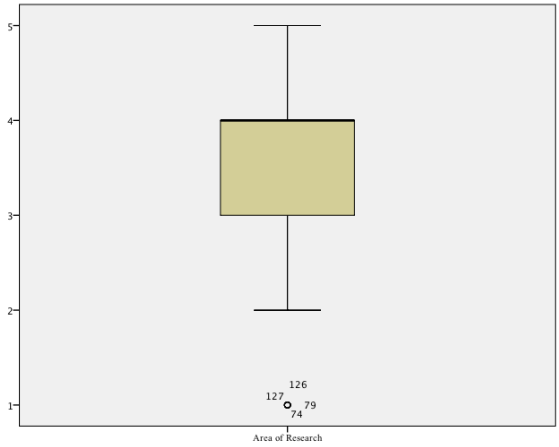
5
4
3
2
1
Status


Area of research
80
60
40
20
0
Frequency
Humanities
Social sciences
Life sciences
Natural sciences
Engineering
Which of these best describes your area of research?


5
4
3
2
1
126
127
79
74
Area of Research

2b. Factor analysis and descriptives: dependent variables

Communalities: Engagement		
	Initial	Extraction
Explaining your research to friends and family	1,000	,648
Talking to journalists	1,000	,830
Talking to politicians and policy makers	1,000	,656
Giving interviews	1,000	,816
Appearing on a TV/radio programme	1,000	,668
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	1,000	,781
Giving lectures or talks for adults	1,000	,399
Giving lectures or talks for children	1,000	,653
Participating in a public dialogue event	1,000	,527
Participating in exhibitions at museums	1,000	,473
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)	1,000	,589
Writing press releases	1,000	,611
Creating content for your institutions website	1,000	,678
Creating content for your own website	1,000	,545

Extraction Method: Principal Component Analysis.

The total variance explained tables show only the components with an eigenvalue greater than 1.

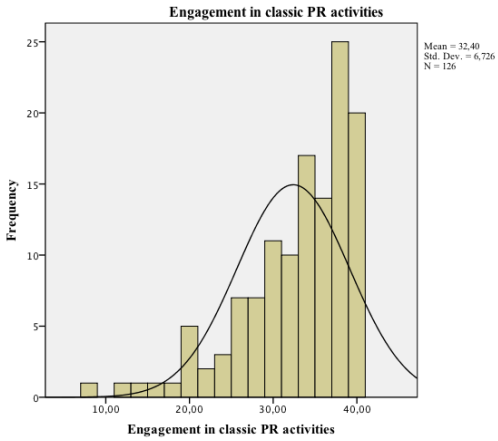
Total Variance Explained: Engagement							
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5,386	38,472	38,472	5,386	38,472	38,472	4,183
2	1,274	9,099	47,571	1,274	9,099	47,571	3,181
3	1,203	8,591	56,163	1,203	8,591	56,163	1,932
4	1,012	7,277	63,389	1,012	7,227	63,389	2,427

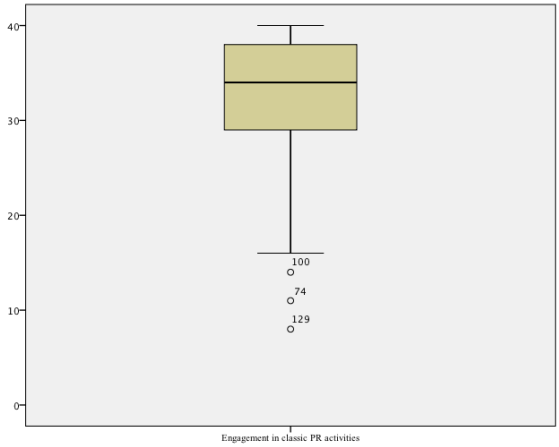
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

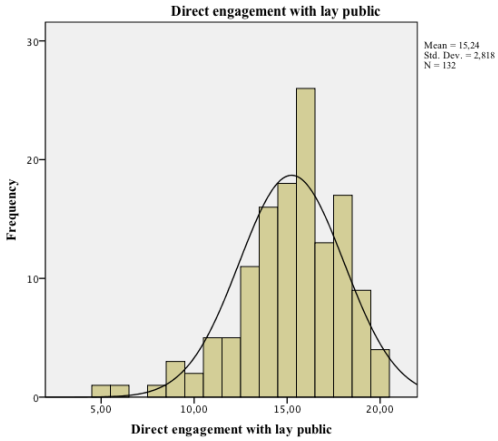
Correlations: Intention to engage			
		I intend to engage in science communication activities in the next 12 months	It is likely that I will engage in science communication activities in the next 12 months
I intend to engage in science communication activities in the next 12 months	Pearson Correlation	1	**,834****
	Sig. (2-tailed)		,000
	N	136	135
It is likely that I will engage in science communication activities in the next 12 months	Pearson Correlation	**,834****	1
	Sig. (2-tailed)	,000	
	N	135	135

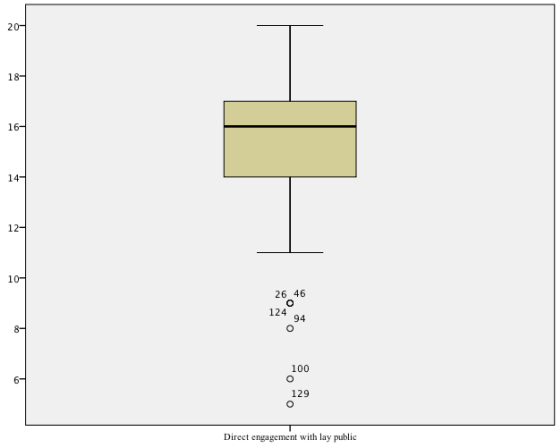
**. Correlation is significant at the 0.01 level (2-tailed).

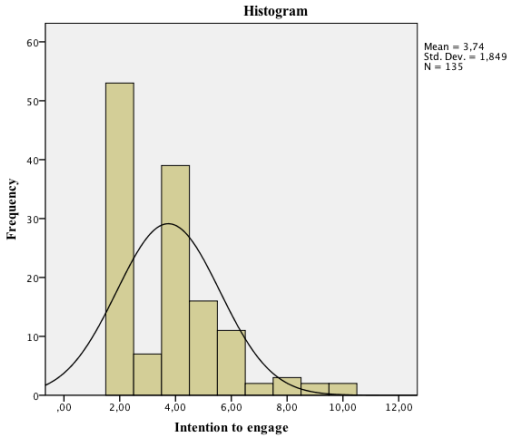
Descriptives				
		Engagement in classic PR activities	Direct engagement with lay public	Intention to engage
N	Valid	126	132	135
	Missing	10	4	1
Mean		15,6032	9,7576	3,7407
Std. Error of Mean		,59916	,24527	,15910
Median		14,0000	9,0000	4,0000
Mode		10,00	9,00	2,00
Std. Deviation		6,72557	2,81794	1,84861
Variance		45,233	7,941	3,417
Range		32,00	15,00	8,00
Skewness		1,245	,908	1,151
Kurtosis		1,370	1,311	1,362

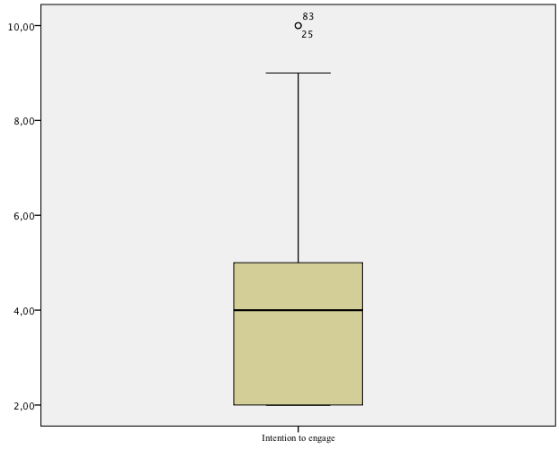

Engagement in classic PR activities
Mean = 32,40
Std. Dev. = 6,726
N = 126
Frequency
Engagement in classic PR activities


100
74
129
Engagement in classic PR activities


Direct engagement with lay public
Mean = 15,24
Std. Dev. = 2,818
N = 132
Frequency
Direct engagement with lay public


26
46
124
94
100
129
Direct engagement with lay public


Histogram
Mean = 3,74
Std. Dev. = 1,849
N = 135
Frequency
Intention to engage


83
25
Intention to engage

2c. Factor analysis and descriptives: independent variable I

Communalities: Importance of engaging	Initial	Extraction
Explaining your research to friends and family	1,000	,595
Talking to journalists	1,000	,663
Talking to politicians and policy makers	1,000	,667
Giving interviews	1,000	,738
Appearing on a TV/radio programme	1,000	,747
Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	1,000	,513
Giving lectures or talks for adults	1,000	,490
Giving lectures or talks for children	1,000	,707
Participating in a public dialogue event	1,000	,715
Participating in exhibitions at museums	1,000	,687
Participating in events at your organisation (e.g. Open Day, Long Night of the Sciences)	1,000	,539
Writing press releases	1,000	,510
Creating content for your institutions website	1,000	,720
Creating content for your own website	1,000	,502
Scientific findings of your research	1,000	,604
Scientific findings of a broad research area	1,000	,679
Policy and regulatory issues	1,000	,620
Relevance of your research to everyday life	1,000	,666
Potential benefits of your research for the public	1,000	,759
Ethical implications of your research findings	1,000	,717
Enjoyment of doing research	1,000	,648
Raise awareness for a scientific topic	1,000	,622

Raise awareness for career options	1,000	,510

Extraction Method: Principal Component Analysis.

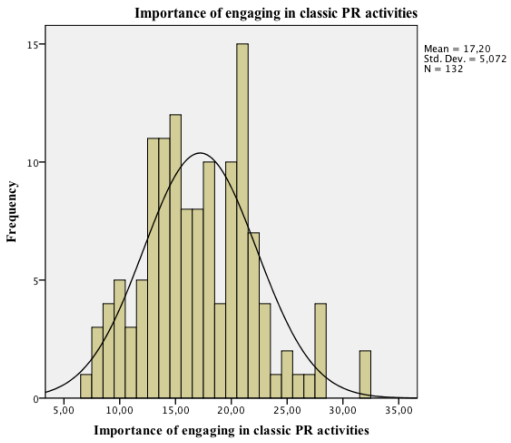
Total Variance Explained: Importance of engaging

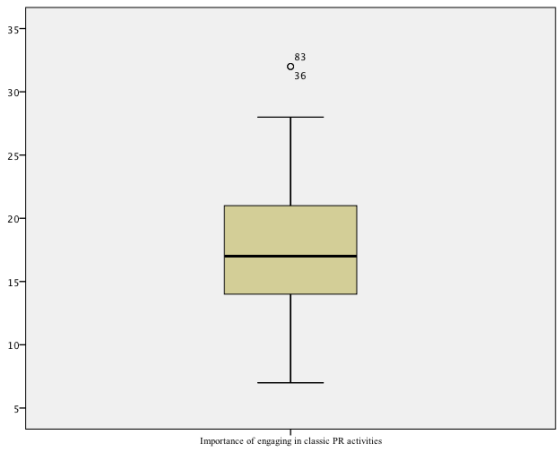
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6,837	29,725	29,725	6,837	29,725	29,725	4,026
2	2,037	8,857	38,581	2,037	8,857	38,581	2,983
3	1,880	8,173	46,755	1,880	8,173	46,755	4,322
4	1,419	6,169	52,924	1,419	6,169	52,924	2,974
5	1,277	5,552	58,476	1,277	5,552	58,476	3,123
6	1,169	5,983	63,559	1,169	5,983	63,559	2,942

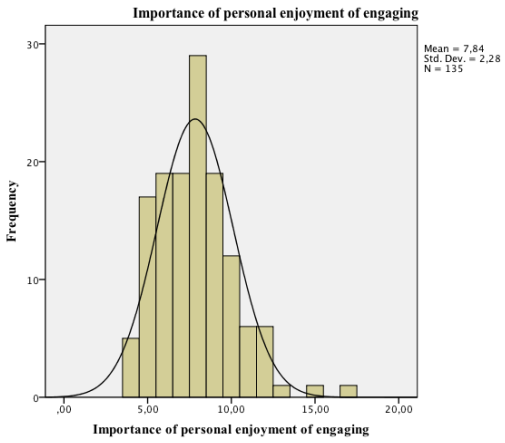
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

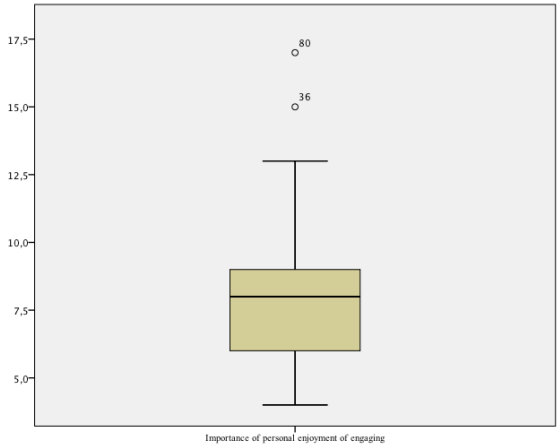
Descriptives: Importance of engaging					
		Importance of engaging in classic PR activities	Importance of personal enjoyment of engaging	Importance of engaging on relevance and implications of research	Importance of direct engagement with lay public
N	Valid	132	135	135	133
	Missing	4	1	1	3
Mean		17,2045	7,8370	10,9481	10,9023
Std. Error of Mean		,44143	,19621	,28259	,28934
Median		17,0000	8,0000	11,0000	10,0000
Mode		21,00	8,00	10,00a	8,00a
Std. Deviation		5,07161	2,27972	3,28342	3,33681
Variance		25,721	5,197	10,781	11,134
Range		25,00	13,00	15,00	16,00
Skewness		,403	,799	,380	,578
Kurtosis		,117	1,411	-,255	,037

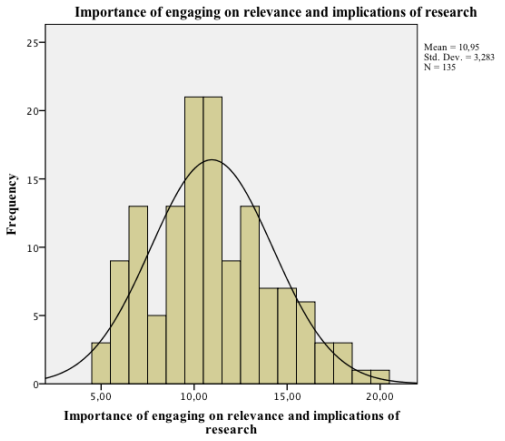
a. Multiple modes exist. The smallest value is shown.

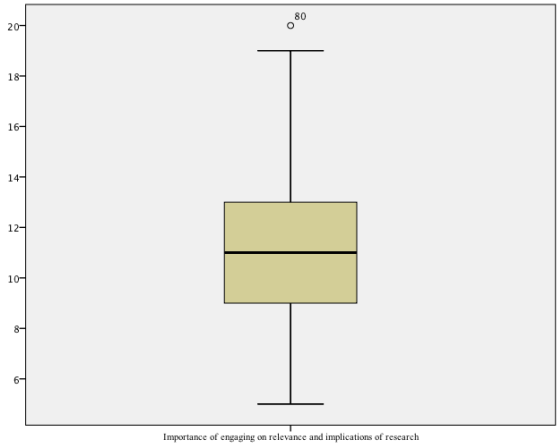


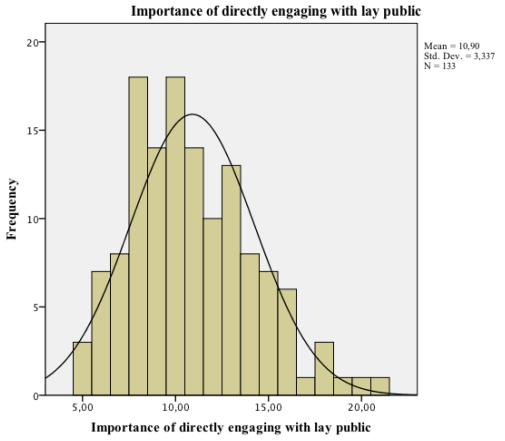


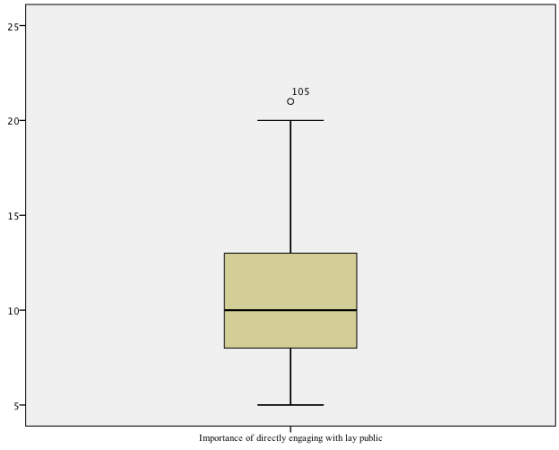












Communalities: External rewards		
	Initial	Extraction
Enjoyable – unenjoyable	1,000	,794
Beneficial – harmful	1,000	,667

Interesting – boring	1,000	,807
Valuable – worthless	1,000	,629
Benefit my career	1,000	,574
Help me gain research funding	1,000	,658
Help me developing my research	1,000	,613
Help me make contacts for my research	1,000	,687
Enhance my personal reputation among my peers	1,000	,663

Extraction Method: Principal Component Analysis.

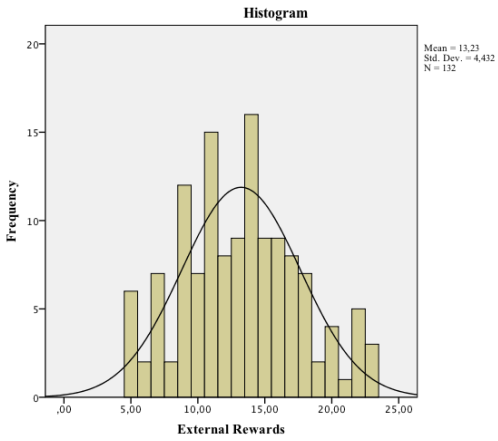
Total Variance Explained: External rewards

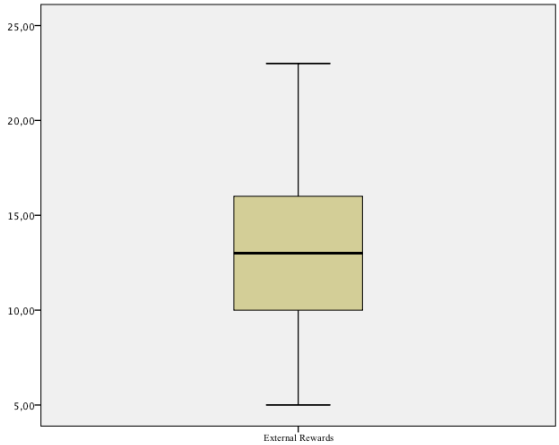
	Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
	Total	% of Variance	Cumulative %	Total
	3,165	35,171	35,171	3,100
	1,854	20,596	55,767	1,766
	1,073	11,920	67,687	1,463

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3,165	35,171	35,171
2	1,854	20,596	55,767
3	1,073	11,920	67,687

Descriptives: External rewards		
N	Valid	132
	Missing	4
Mean		13,2273
Std. Error of Mean		,38576
Median		13,0000
Mode		14,00
Std. Deviation		4,43200
Variance		19,643
Range		18,00
Skewness		,206
Kurtosis		-,438


Histogram
Mean = 13,23
Std. Dev. = 4,432
N = 132
Frequency
External Rewards


External Rewards

2d. Factor analysis and descriptives: independent variable II

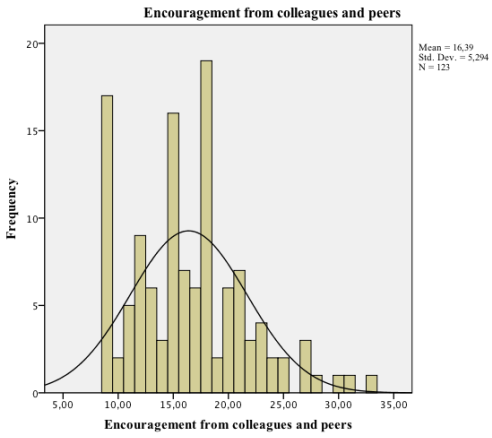
Communalities: Encouragement from reference groups		
	Initial	Extraction
Family	1,000	,654
Friends	1,000	,673
Colleagues	1,000	,665
Peers in the same area of research	1,000	,659
Peers in a different area of research	1,000	,605
Family	1,000	,704
Friends	1,000	,754
Colleagues	1,000	,648
Peers in the same area of research	1,000	,730
Peers in a different area of research	1,000	,712
Family	1,000	,817
Friends	1,000	,861
Colleagues	1,000	,705
Peers in the same area of research	1,000	,756
Peers in a different area of research	1,000	,724

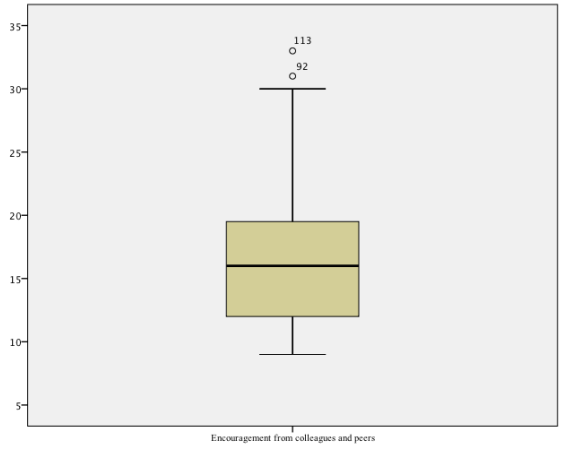
Extraction Method: Principal Component Analysis.

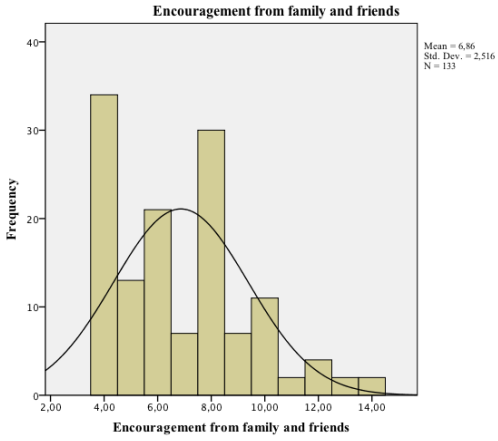
Total Variance Explained: Encouragement from reference groups							
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5,934	39,558	39,558	5,934	39,558	39,558	5,450
2	2,778	18,521	58,078	2,778	18,521	58,078	3,124
3	1,953	13,021	71,099	1,953	13,021	71,099	3,111

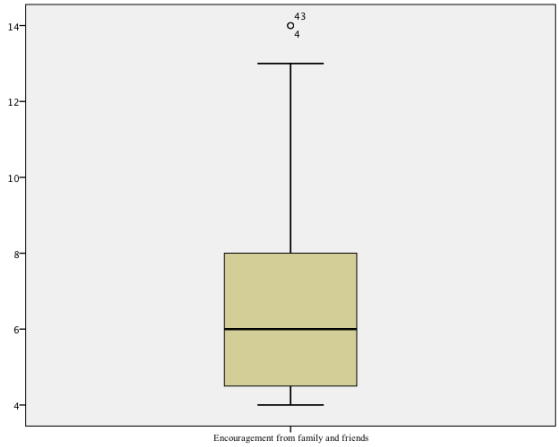
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance

Descriptives			
		Encouragement from colleagues and peers	Encouragement from family and friends
N	Valid	123	133
	Missing	13	3
Mean		16,3902	6,8647
Std. Error of Mean		,47735	,21816
Median		16,0000	6,0000
Mode		18,00	4,00
Std. Deviation		5,29403	2,51596
Variance		28,027	6,330
Range		24,00	10,00
Skewness		,621	,688
Kurtosis		,294	-,081

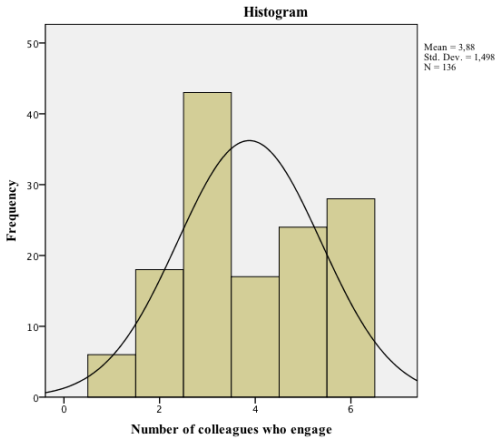


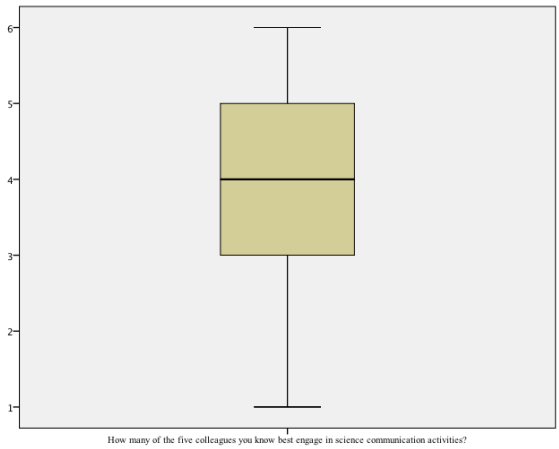




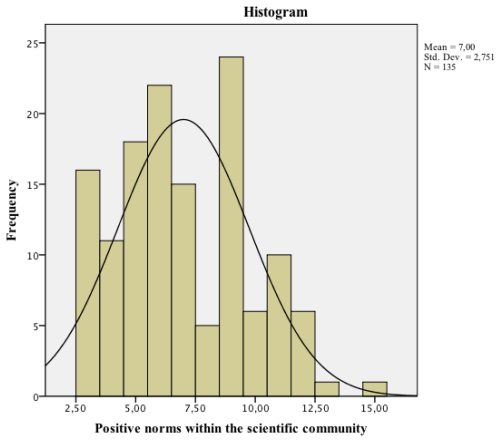


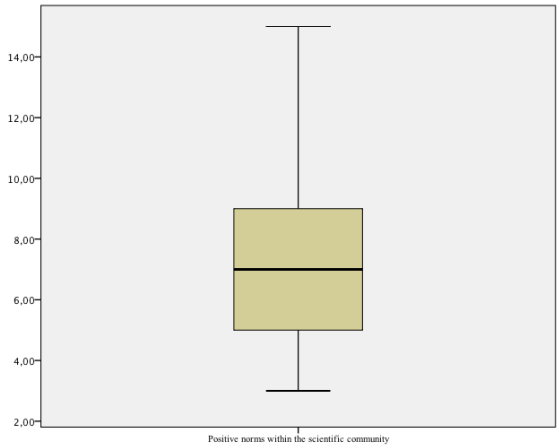
Descriptives: Number of colleagues who engage		
N	Valid	136
	Missing	0
Mean		3,88
Std. Error of Mean		,128
Median		4,00
Mode		3
Std. Deviation		1,498
Variance		2,244
Range		5
Skewness		,029
Kurtosis		-1,119





Descriptives: Norms within the scientific community		
N	Valid	135
	Missing	1
Mean		7,0000
Std. Error of Mean		,23676
Median		7,0000
Mode		9,00
Std. Deviation		2,75085
Variance		7,567
Range		12,00
Skewness		,360
Kurtosis		-,632





2e. Factor analysis and descriptives: independent variable III

Communalities: Ease of engaging		
	Initial	Extraction
Getting generally involved in science communication activities	1,000	,425
Explaining your research to the adult public	1,000	,760
Explaining your research to children	1,000	,737
Talking to journalists	1,000	,715
Talking to politicians and policy makers	1,000	,512
Giving interviews	1,000	,825
Appearing on a TV/ radio programme	1,000	,787
Write content for your institutions website	1,000	,698
Write content for social media channel	1,000	,633

Extraction Method: Principal Component Analysis.

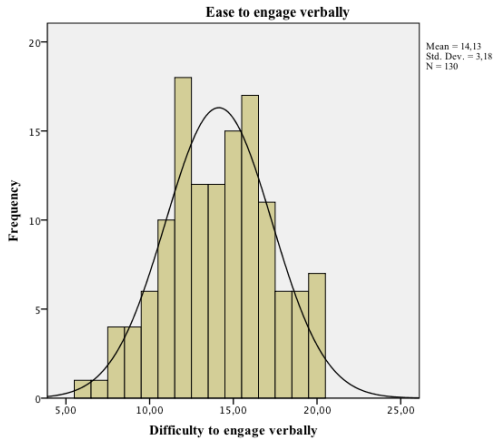
Total Variance Explained: Ease of engaging					
Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]		
% of Variance	Cumulative %	Total	Total	Cumulative %	% of Variance
37,258	37,258	3,036	3,036	37,258	37,258
16,045	53,303	1,711	1,711	53,303	16,045
14,388	67,691	2,094	2,094	67,691	14,388

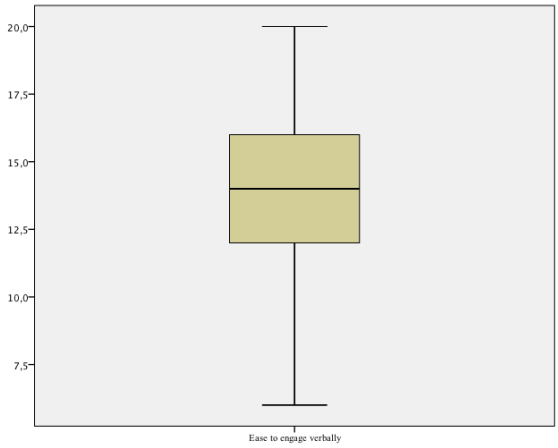
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Component	Initial Eigenvalues			Total
	Total	% of Variance	Cumulative %	
1	3,353	37,258	37,258	3,353
2	1,444	16,045	53,303	1,333
3	1,295	14,388	67,691	1,295

Descriptives: Ease to engage verbally		
N	Valid	130
	Missing	6
Mean		14,1308
Std. Error of Mean		,27893
Median		14,0000
Mode		12,00
Std. Deviation		3,18034
Variance		10,115
Range		14,00

Skewness	-,109
Kurtosis	-,494





Communalities: Perceptions of obligations and restrictions		
	Initial	Extraction
Taxpayers' money funds my research	1,000	,632
Individuals can benefit from my research	1,000	,774
I have a duty to share my research findings with the general public	1,000	,678
I have a moral duty to engage about social and ethical implications of my research	1,000	,724
I have enough time to engage in science communication activities	1,000	,608
I have enough financial support to engage in science communication activities	1,000	,782
It is easy to get funding for engaging in science communication activities	1,000	,612
I have enough support from my institution regarding engaging in science communication activities	1,000	,671
I have enough training and skills to engage in science communication activities	1,000	,469

My research is interesting to the general public	1,000	,362
My research is too complex to explain to the general public	1,000	,644
My research is too specialised to make much sense to the general public	1,000	,684
My research is too controversial for science communication activities	1,000	,536
I feel confident that I could prepare materials about my research for the general public	1,000	,805
I feel confident that I could answer questions about my research from the general public	1,000	,769

Extraction Method: Principal Component Analysis.

Total Variance Explained: Perceptions of obligations and restrictions

	Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
	Total	% of Variance	Cumulative %	Total
	3,091	20,608	20,608	2,401
	2,543	16,890	37,498	2,647
	1,992	13,282	50,780	1,856
	1,073	7,150	57,931	2,073
	1,059	1,060	64,991	1,568

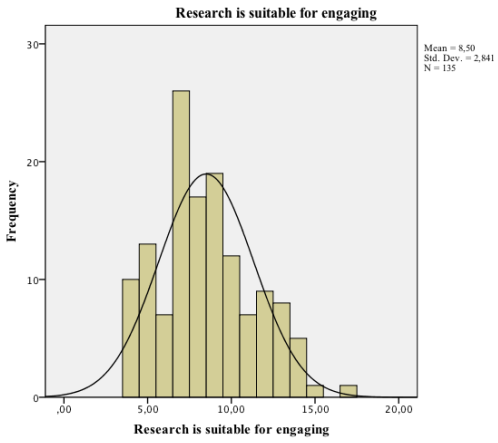
Extraction Method: Principal Component Analysis.

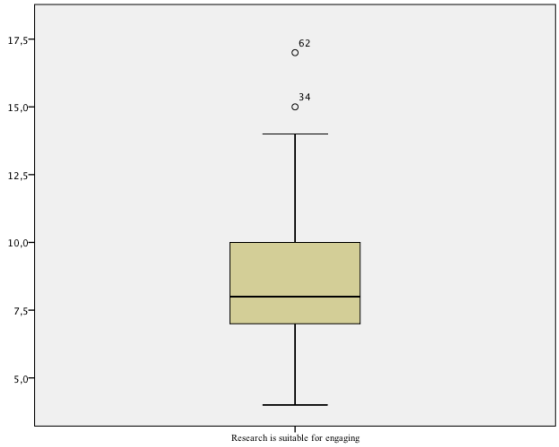
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

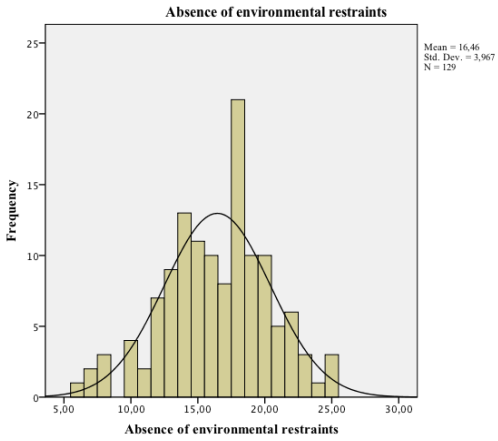
Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3,091	20,608	20,608
2	2,534	16,890	37,598
3	1,992	13,282	50,780
4	1,073	7,150	57,931
5	1,059	7,060	64,991

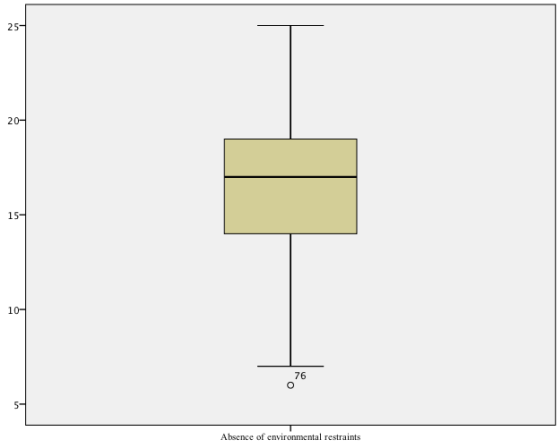
Descriptives

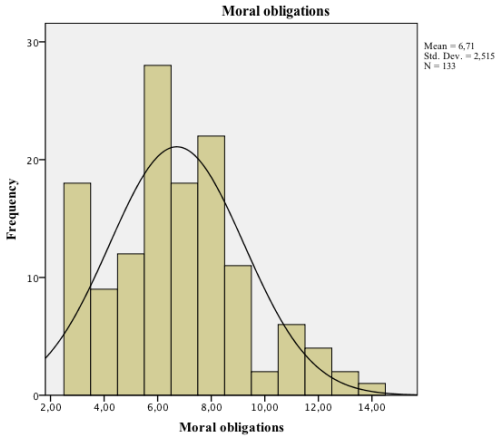
		Research is suitable for engaging	Absence of environmental restraints	Moral obligations
N	Valid	135	129	133
	Missing	1	7	3
Mean		8,4963	16,4574	6,7143
Std. Error of Mean		,24454	,34925	,21811
Median		8,0000	17,0000	6,0000
Mode		7,00	18,00	6,00
Std. Deviation		2,84126	3,96667	2,51532
Variance		8,073	15,734	6,327
Range		13,00	19,00	11,00
Skewness		,440	-,249	,494
Kurtosis		-,311	-,055	,041

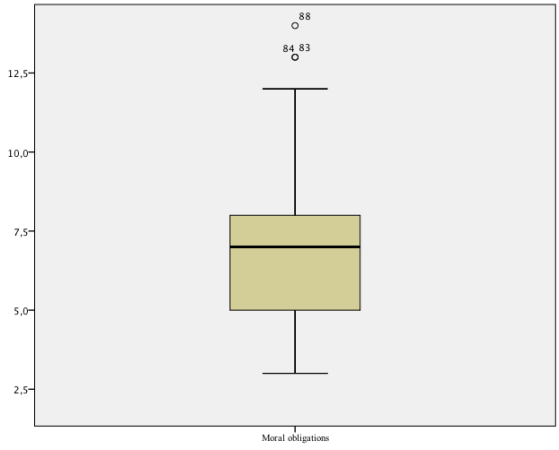












Communalities: Communication autonomy		
	Initial	Extraction
Talking to journalists	1,000	,729
Talking to politicians and policy makers	1,000	,773

Engaging in scientific discussions on social media (e.g. Twitter or Facebook)	1,000	,284
Giving lectures or talks	1,000	,525
Participating in a public dialogue event	1,000	,577
Creating content for your institutions website	1,000	,383
Creating content for your own website	1,000	,704

Extraction Method: Principal Component Analysis.

Total Variance Explained: Communication autonomy

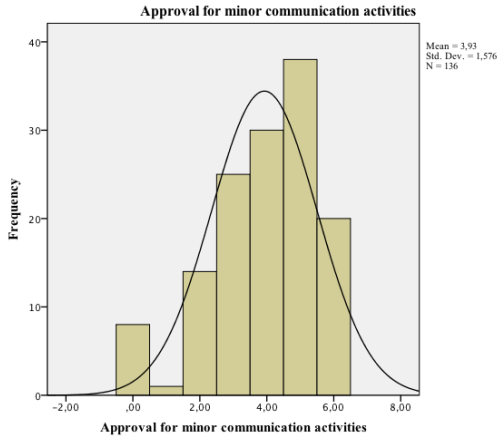
Initial Eigenvalues	Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
Cumulative %	Total	% of Variance	Cumulative %	Total
45,316	2,719	45,316	45,316	2,217
62,822	1,050	17,506	62,822	2,137

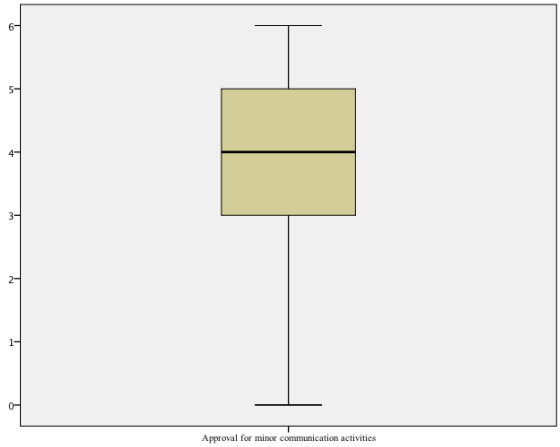
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

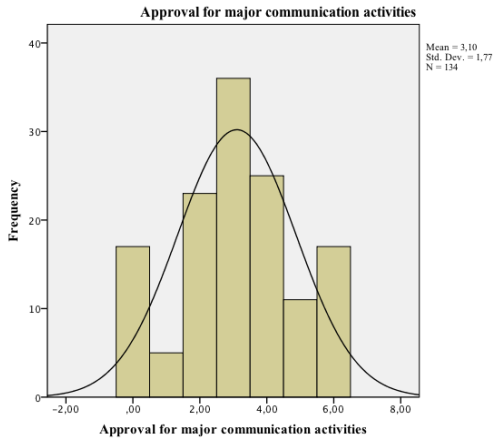
Component	Total	% of Variance
1	2,719	45,316
2	1,050	17,506

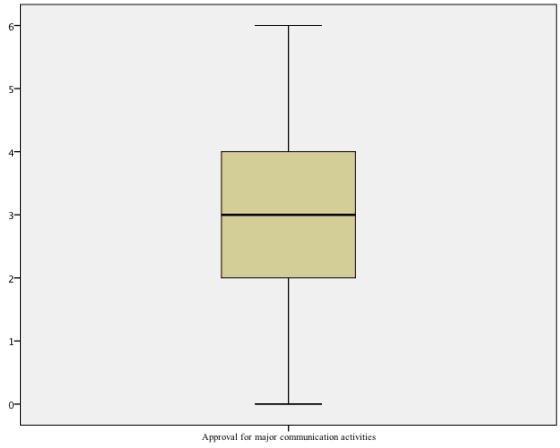
Descriptives

		Approval for minor communication activities	Approval for major communication activities
N	Valid	136	134
	Missing	0	2
Mean		3,9265	3,1045
Std. Error of Mean		,13513	,15288
Median		4,0000	3,0000
Mode		5,00	3,00
Std. Deviation		1,57589	1,76971
Variance		2,483	3,132
Range		6,00	6,00
Skewness		-,776	-,111
Kurtosis		,205	-,611









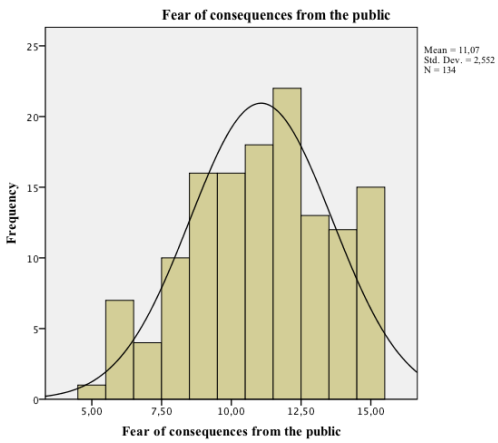
Communalities: Fear of consequences		
	Initial	Extraction
I would not be taken seriously by the general public	1,000	,619
The media will oversimplify my research	1,000	,799
The media will distort my research	1,000	,782
The general public reacts critically regarding my research area	1,000	,527
My peers react critically regarding my engaging	1,000	,630

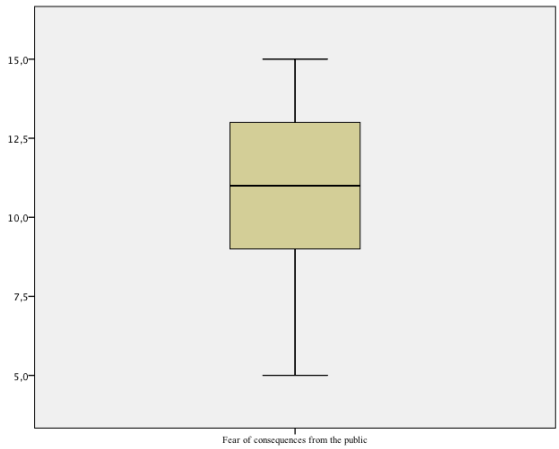
Extraction Method: Principal Component Analysis.

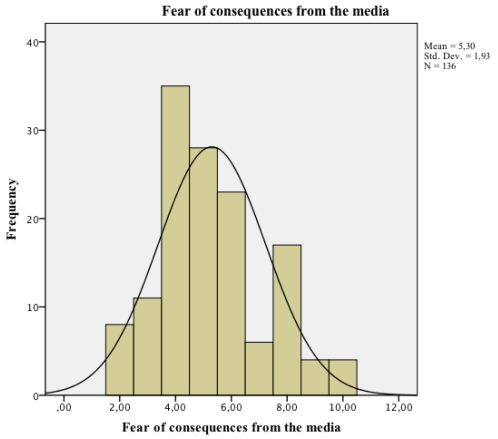
Total Variance Explained: Fear of consequences							
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation of sums of squared loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	2,150	43,002	43,002	2,150	43,002	43,002	1,857
2	1,207	24,147	67,149	1,207	24,147	67,149	1,748

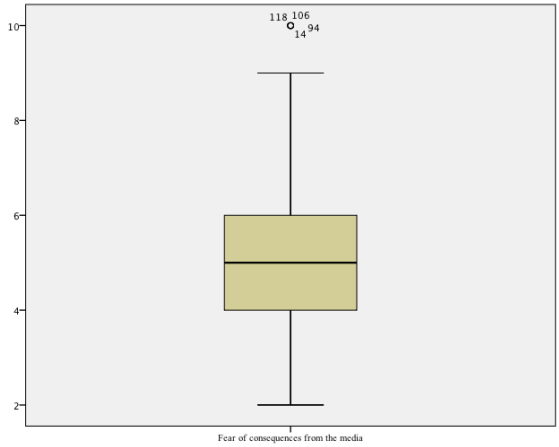
Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Descriptives			
		Fear of the public	Fear of the media
N	Valid	134	136
	Missing	2	0
Mean		11,0672	5,3015
Std. Error of Mean		,22049	,16546
Median		11,0000	5,0000
Mode		12,00	4,00
Std. Deviation		2,55230	1,92957
Variance		6,514	3,723
Range		10,00	8,00
Skewness		-,241	,511
Kurtosis		-,671	-,267



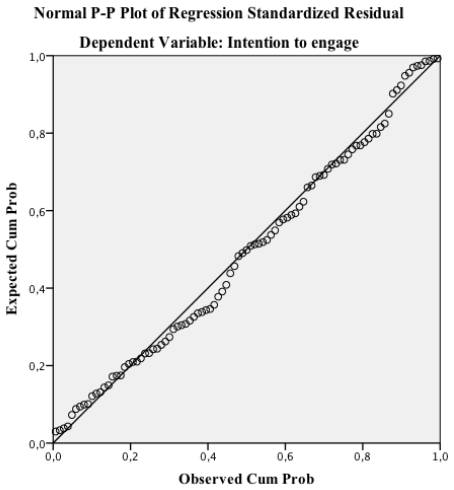


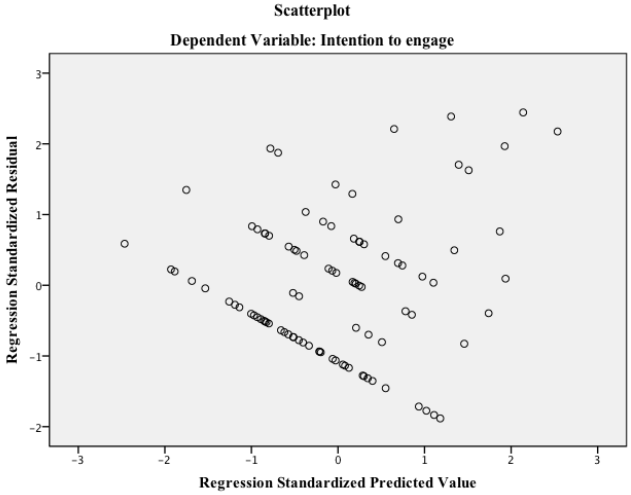




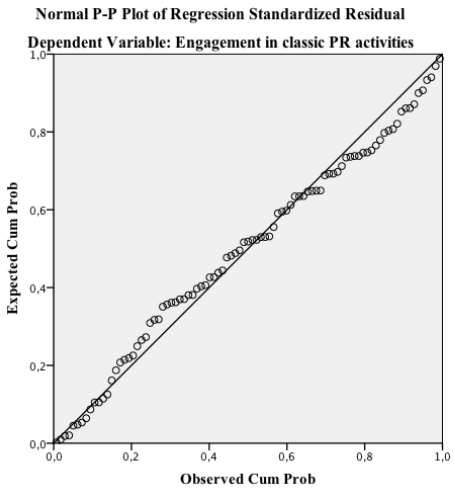
Appendix 3: Supplementary Figures and Tables from Multivariate Analysis

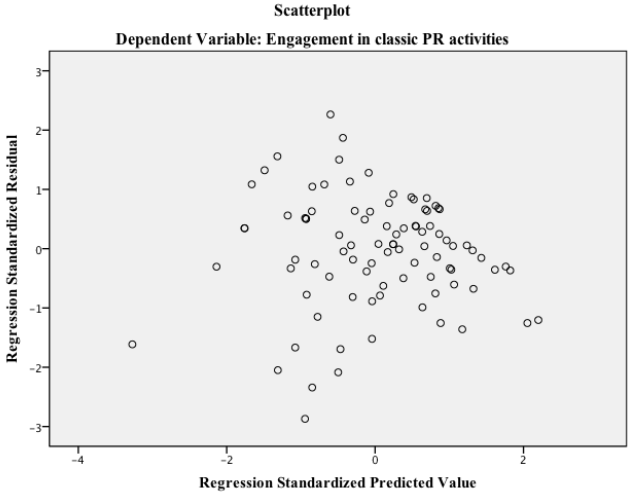
3a. Intention to engage





3b. Engagement in classic PR activities





3c. Direct engagement with lay public