Agricultural Extension Messages Using Video on Portable Devices Increase Knowledge about Seed Selection and Seed Storage & Handling among Smallholder Potato Farmers in Southwestern Uganda

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Abstract

To feed a growing population, agricultural productivity needs to increase dramatically. Agricultural extension information, with its public non-rival nature, is generally undersupplied and public provision remains challenging. In this research, we explore the effectiveness of alternative modes of agricultural extension information delivery. We test if simple agricultural extension video messages delivered through Android tables increase knowledge of recommended practices in seed selection and seed storage & handling among a sample of potato farmers in southwestern Uganda. Using a field experiment with ex-ante matching in a factorial design, we find that showing agricultural extension videos significantly affects farmers' knowledge. However, our results suggest impact pathways that go beyond simply replicating what was shown in the video. Video messages may also trigger a process of abstraction, where farmers apply insights gained in one context in a different context. Or, video messages may activate knowledge farmers already posses but, for some reason, do not use.

Keywords: extension, video, seed selection, storage and handling, knowledge, potato, Uganda.

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Introduction

To feed a growing population, agricultural production needs to increase dramatically. Globally, population is projected to increase to more than 9 billion by 2050. In order to meet the demand for increasingly calorie intense and complex diets, overall food production would need to increase by some 70 percent between 2005/07 and 2050 (FAO, 2009). However, this needs to be accomplished against a background of greater competition for land, water and energy and in the context of a changing climate. Therefore, sustainable intensification, where more food is obtained from the same area of land while reducing environmental impacts through the use of modern inputs and improved technologies and practices, is imperative (Tilman et al., 2011; Garnett et al., 2013). Indeed, in Asia, the use of modern inputs and techniques on a large scale led to a substantial increase of yields in a relatively short period of time (Mueller et al., 2012). Conversely, yield gaps, expressed as the difference between actual yields and attainable yields, remain large in many parts of the world, and especially in Sub-Saharan Africa. Closing these gaps in under-yielding locations through the use of modern inputs and improved technologies is expected to boost production, increase food security and reduce poverty (Godfray et al., 2010).

Use of modern inputs such as inorganic fertilizer or adoption of recommended farming practices such as row planting is generally low in developing countries. There are different reasons why smallholder farmers shun agricultural intensification investments. It may be that the agricultural technology is simply not profitable, hence non-adoption is a rational response on the part of the farmer. However, more careful investigation suggests substantial heterogeneity, where some farmers adopt certain practices while others do not. Such selective adoption is indicative of market imperfections (de Janvry, Fafchamps, and Sadoulet, 1991), land and labour market inefficiencies, credit constraints, missing insurance markets and poor infrastructure (Jack, 2013). In poor, remote communities, information market inefficiencies are often blamed for underadoption: If an individual does not know that a technology exists, does not know about its benefits or does not know how to use it effectively, then the technology will not be adopted. Since information is a public, non-rival good, governments across the developing world have started providing extension services on a large scale. However, they have done so with mixed success. While most studies have reported positive impacts of extension services, the effects are far from general (Taye, 2013), and cost effectiveness, limited scaleability and accountability are frequently cited as issues (Anderson and Feder, 2007). Information and Communication Technologies (ICTs) have been advanced as a promising way to improve agricultural extension services (Aker, 2011). However, to date, most use of ICTs in development has been in the provision of financial services through mobile phones (Duncombe and Boateng, 2009), while the potential for agricultural extension has been studied less.

This research contributes to the literature on innovations in agricultural extension services by testing if showing simple and short videos is a viable alternative to more elaborate, and hence more costly, extension practices. More specifically, we investigate if simple informational interventions succeed at increasing knowledge among smallholder farmers. To do so, we set up an experiment among Irish potato farmers in the Kigezi subregion in southwestern Uganda, where low seed quality is an important reason for low yields. While providing access to basic pathogen free foundation seed should remain a key policy priority, current seed systems are too weak to have a significant impact in the short to medium run. Therefore, in a context where farmers rely heavily on recycling of own seed as planting material for the next season, seed selection, and storage & handling of seeds are the main pathways to improve quality. Our interventions therefore focus on Positive Seed Selection (PSS), which refers to only keeping the best potatoes as seed material (Schulte-Geldermann, Gildemacher, and Struik, 2012), and Potato Seed Storage & Handling (PSSH), which entails advice on how to best store seed potatoes between harvest and planting for the next season.

Our experiment adheres to the highest standards in terms of transparency. For instance, a pre-analysis plan that details what sampling methods would be used, what specifications would be run and what outcome variables would be used was developed before the interventions took place. The experiment was also registered at the American Economic Association's registry for randomized controlled trials (Van Campenhout, Vandevelde, and Van Asten, 2016). Finally, the entire project, including all data, computer code and documents are under revision control using git and mirrored on an online repository (https://bitbucket.org/bjvca/potseedrct). This means all material can be downloaded to rerun the analysis and track changes to the project over time, resulting in a level of transparency that is exceptional in social sciences.

Materials and Methods

Experimental Units

We base ourselves on baseline data that was collected from potato farmers in three districts (Kisoro, Kanungu and Kabale) in southwestern Uganda for the 2013/14 agricultural season. These districts are very important for potato production, together accounting for about 47 percent of total potato production in Uganda (UBOS, 2010). With the assistance of the Uganda Bureau of Statistics, we randomly selected 35 enumeration areas. Within each enumeration area, we then listed all households and determined whether they were growing potatoes. From these lists, potato farmers were randomly selected to be interviewed on a range of socio-economic variables. For our experiment, we selected 248 farmers from this baseline (see next section).

IRB approval for the experiment was obtained from the International Food Policy Research Institute's Institutional Review Board (IRB #00007490 FWA #00005121) on February 2nd, 2016 (IRB Approval Number 2016-12-DSGD-M . We also obtained consent of each farmer that was selected to participate in the study.

Experimental Design

These farmers were then randomly allocated to one of four treatment arms of a 2x2 full factorial design. In particular, about half of the farmers were subjected to the first treatment (referred to as PSS, see next section). Also, about half of the farmers was subjected to the second treatment (referred to as PSSH). However, half of this last subset overlaps with half of the farmers that were treated with PSS. As such, a quarter of farmers received both PSS and PSSH treatments, and about one quarter of farmers received no treatment at all.

We use a matched bloc design, where we match farmers that are similar along a range of characteristics, as it is argued that, in small samples, designs based on matching and stratification can significantly improve on statistical power (Bruhn and McKenzie, 2009). In particular, we randomly select a farmer and then match this farmer to another farmer that is closest to this farmer on the basis of a set of characteristics (see below), by minimizing the square root of the sum of squared standardized differences of the measures for these characteristics. This is repeated three times and the resulting group of four farmers is given a bloc number and removed from the sample. This is repeated until all farmers are matched in groups of four and the desired sample size is obtained. Finally, within each bloc, we randomly allocate the four treatments ("Control", "PSS", "PSSH", "PSS+PSSH") to the four farmers. As our sample size is 248 observations, this results in 62 blocs.

We have matched on ten variables. We include three variables related to household demographics that are standard in empirical specifications of agricultural household models (Singh, Squire, and Strauss, 1986). Household size is an important measure of human capital, particularly in the smallholder agricultural settings with imperfect labor markets (Benjamin, 1992). The age of the household head is included to capture experience and life-cycle effects. We also match on gender of household head, as previous knowledge about modern agricultural techniques and inputs may differ by sex (Doss and Morris, 2000). We also include the area of potato grown, as well as a variable that indicates whether the household received extension on potatoes in the past, the logarithm of potato yields and the logarithm of welfare per capita. We also account for travel distance to closest farm input stockist or farm supply store and access to credit. Finally, to reduce spillover effects, we maximize the geographical distance between the four farmers within each group.

Inference

The matched design of our experiment is likely to introduce dependence among outcome variables within blocs, so we need to account for clustering during inference (Bruhn and McKenzie, 2009). As the typical approach to deal with this, using cluster robust standard errors, is known to be biased in small samples, we use randomization inference (RI) (Young, 2015). Instead of relying on a theoretical distribution, RI involves comparing the test statistic to the distribution of the test statistic under each possible allocation of treatments. In particular, within each bloc of four matched farmers, we compute the outcome (eg. proportion of correct answers) for all 6 possible permutations of two treatments (as the four treatment arms in the factorial design correspond to two pure treatments). For 62 blocs, this leads to a total of 6^62, so instead of actually computing all combinations, we base inference on a random sub-sample of 100,000 permutations for the means tests.

Not accounting for the method of randomization may result in overly conservative standard errors and a significant reduction in power (Bruhn and McKenzie, 2009). Therefore, in addition to accounting for clustering through the use of randomization inference, we also run regression models where we include fixed effects at the bloc level. Note that in each bloc $b = \{b_1, ..., b_{62}\}$, we have four treatments that were randomly assigned. For the main treatments, each bloc always has two treated and two control observations $t = \{c_1, c_2, r_1, r_2\}$. We estimate average treatment effects (β) by regressing the outcome variable (y) on the treatment indicator T where $T = 1\; if\; t = \{r_1, r_2\}$ and zero otherwise and on fixed effects for the blocs (δ_b):

$$y_{t,b} = \alpha + \delta_b + \beta T_{t,b} + \varepsilon_{t,b} \tag{1}$$

where α is a contant and $\varepsilon_{t,b}$ is an error term.

Treatments

The interventions rely on two basic information treatments. Simply providing information has been found to be very effective in a range of applications. For example, Jensen (2010) observes returns to education are perceived much lower than what they actually are and finds that students that were given information on the higher measured returns completed on average 0.20–0.35 more years of school over the next four years. Dupas (2011) finds that providing teenagers with information about relative risk of HIV infection by partner's age significantly impacts sexual behaviour. In the context of agricultural extension, Cole and Fernando (2016) find that delivering timely, relevant, and actionable information and advice to farmers reduces knowledge gaps and increases productivity.

The information treatments will take the form of video messages that are shown to farmers on Android tablets. Video, combining both visual and verbal communication methods, also has been found promising in providing low literacy populations with skills, information and knowledge on complex technical knowledge (David and Asamoah, 2011; Zossou et al., 2009; Van Mele, Wanvoeke, and Zossou, 2010). Steady progress in mobile display video equipment and increasing mobile phone penetration and internet connectivity in rural areas means distributing video content becomes easier and cheaper. In addition to increasing knowledge directly, video has also been found to induce behavioural changes in poor countries. While some of this behavioural change is a consequence of the newly acquired knowledge, research by

Bernard et al. (2015) suggests that videos featuring role models can also induce behavioural change by affecting the motivation and aspirations of farmers.

The first treatment consists of a video that provides information on Positive Seed Selection (PSS), which can be found on the internet[1]. In this video, a potato farmer from the area introduces himself and explains that he has experimented over the years to find out that good quality planting material is key to becoming a successful farmer (0:00-1:25). The benefits of good quality seed are illustrated by contrasting healthy fields, plants and tubers to diseased ones (1:25-2:35). The farmer also explains how he used to do it wrongly, pulling out the strongest plants first to eat or sell, and hence was left with small and malformed tubers for planting. He explains how this quickly leads to seed degeneration (2:35-3:19). Next, the concept of Positive Seed Selection is introduced (3:19-4:26). In particular, the farmer explains how, at time of flowering, the tallest plants with at least four stems should be pegged for follow-up. Pegs should be removed when plants get diseased or when they grow slowly (4:26-5:05). At time of harvest, pegged plants should be harvested first (5:05-5:16). Only egg sized tubers should be retained for planting material (5:16-5:27). Tubers should look healthy, without cuts or bruises, and it is advised to only keep tubers with at least four eyes (5:27-5:43). The video ends by recapitulating the most important components of Positive Seed Selection. (5:43-7:02). We have produced videos in both Rufumbira and Rukiga, the two languages spoken in the study area.

The second treatment comprises of showing a video that provides information on Proper Seed Storage & Handling (PSSH), for which the Rufumbira version can also be found on the internet[2]. The first part, where a farmer introduces himself as a successful potato grower from the region and illustrates the benefits of good quality seeding material by contrasting healthy fields, plants and tubers to diseased ones is similar to the part used in the PSS treatment (0:00-2:08). The farmer also explains how he used to do it incorrectly, storing potatoes in sacks or storing them together with other crops in places that are too dark and inadequately ventilated (2:08-3:24). The farmer then explains what Proper Seed Selection & Handling is about. He first underscores potatoes should be spread out on racks, or on dried grass on the floor (3:24-4:03). Second, potato seeds should be stored in a separate room, away from animals and humans (4:03-4:11). Third, seed potatoes should be stored in a well ventilated place in diffuse lighting conditions and checked regularly for rotten tubers (4:11-5:07). Finally, the farmer advises the use of a cheap organophosphate insecticide for seed preservation and underscores the importance of cleaning all tools used during seed production to avoid contamination (5:07-5:45). As in the previous video, the video ends by summarizing the most important aspects of Proper Seed Storage & Handling (5:45-7:05). For this video, a Rukiga version was also produced. The choice of which techniques and information to highlight in both treatments was based on extensive interviews with potato growing experts (seed producers, extension officials, agronomists) in the area and on the results of the analysis of previously

[1]https://www.dropbox.com/s/7o5zcrlr1hvw3m7/moviePSS.mp4?dl=0
[2]https://www.dropbox.com/s/bg0ks15uomr70m9/moviePSSH.mp4?dl=0

collected data among potato farmers.

[[[It is important to note that the treatment consists of being shown a video on an android device at the individual level and farmers did not receive anything beyond the information. As such, the focus of this experiment is not so much on the merits of using android tablets, but rather on the effectiveness of providing information using video messages. Therefore, a valid argument may be that it would be much more cost-effective to gather a group of farmers in front of a tv or projector. We opted for individual screenings for at least two reasons. First, it is difficult to control group dynamics, and learning in a group may be quite different from learning individually. Secondly, gathering a group of people at a public place in a village is bound to attract considerable attention. This may attract other farmers, some of which may be selected as control, and it would be very difficult to turn them away. To reduce the likelihood of contamination, we thus decided to show the videos in the private homes of the farmers, which is likely to attract much less attention. Showing video's in a group setting would necessitate an encouragement design, requiring a larger sample size (Hirano et al., 2000).]]]

Outcomes

We test if the videos reduce knowledge gaps of potato farmers by subjecting farmers to a short quiz. In particular, we ask farmers six multiple choice questions. All subjects, including control farmers, were presented with all six questions. In particular, enumerators visited farmers at their homes and started by explaining the study and asking for consent. Upon receiving consent, some basic data was gathered, mainly to make sure the right farmer was interviewed and confirm contact information. The quiz was taken immediately after being shown the video. Then, depending on what treatment group the farmer was in, the video was shown. Immediately after administering the treatment, the quiz was done. Each question has three answers, which are read out to the farmer, and only one is correct. The farmer is then instructed to indicate what he or she thinks is the correct answer. Two of the six questions are related to topics that were discussed in the PSS treatment. As such, it is expected that farmers who were subjected to the PSS treatment would do better in answering these questions correctly. Another two questions are related to topics covered in the PSSH treatment and it is expected that farmers who were provided information in the PSSH treatment would be able to answer these questions correctly. We also included two questions that were related to PSS and PSSH but were not explicitly covered in the treatment videos. We hypothesize that the incidence of correct answers to these two "control" questions would not be different for treated compared to untreated farmers.

The two questions that test knowledge provided by the PSS treatment related to which plants to peg (correct answer: largest plants in the field that look healthy, incorrect alternatives: average sized plants in the field that look healthy; smallest plants in the field that look healthy) and the size of the tuber to select as planting material (correct: egg-size, incorrect: the larger the better; the smallest ones you can find). The answers will be referred to in the analysis below by variable names *sel1* and *sel2* respectively. To test the effectiveness of the PSSH treatment, the first question relates to which lighting conditions seed potatoes should be stored in (correct: in indirect (diffuse) light, incorrect: in direct sunlight; in a dark place). The second question asks how seed potatoes should be stored (correct: spread out on racks or on dried grass on the floor, incorrect: in bags that have been thoroughly cleaned; in airtight containers or buckets with a closing lid). The answers to these questions are recorded in variables called *store1* and *store2* respectively.

For the questions that relate to topics not explicitly covered in either PSS of PSSH videos, the first question simply asks respondents to indicate which of three statements is correct. The first option, that immediately after harvest, you should thoroughly wash potato seeds using detergent before putting the in storage, is incorrect. The second option, which is also incorrect, stated that immediately after harvest, you should thoroughly wash potato seeds using clean water before putting the in storage. The correct answer is the third option, that you should never wash potato seeds before putting them in storage. While this knowledge is not explicitly covered in the PSSH video, it is related to Proper Seed Storage & Handling. We will refer to this question using the variable *gen1*. The second question asks if farmers know where fields for seed potato production should be located. The correct option here is that they should be located in the highlands in isolated areas. Incorrect options are lowlands with plenty of water; and a garden close to the house or in densely populated areas. While this knowledge is not explicitly covered in the PSS video, it can be categorized under Positive Seed Selection knowledge. We will refer to this question using variable *gen2*. All this information is summarized in Table 1.

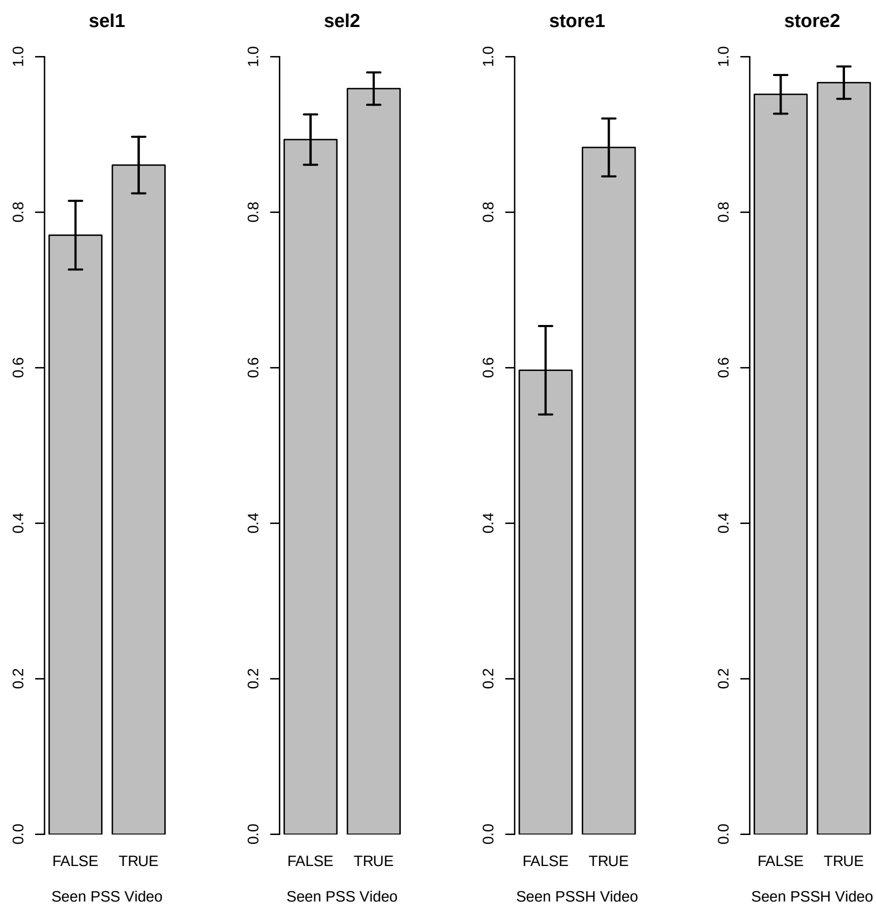
Table 1: **Effect of PSS and PSSH treatments on knowledge.**

code	question	answer (correct one underlined)		
sel1	Which plants should you peg for seed selection?	The largest plants in the field that look healthy	The smallest plant in the field that look healthy	Average sized plants that look healthy
sel2	What size should a potato seed tuber be?	The larger the better	Size of an egg	The smallest ones you find
store1	Where do you store your seed potatoes?	In direct sunlight	In a dark place	In indirect light (diffuse light)
store2	How should you store your seed potatoes?	In bags that have been thoroughly cleaned with JIK	Spread out on racks or on dried grass on the floor	In airtight containers or buckets with a closing lid
gen1	Which of the following statements is correct?	Immediately after harvest, you should thoroughly wash potato seeds before putting them in storage using JIK	Immediately after harvest, you should thoroughly wash potato seeds before putting in storage using clean water	You should never wash potat seeds before putting them in storage
gen2	When picking a field for positive seed selection...	Pick a garden that is in highlands and in isolated areas	Pick lowlands with plenty of water	Pick a garden close to your h or in densely populated area

Results

We find that showing extension videos on Positive Seed Selection to farmers increases knowledge related to seed selection that was covered in the video. The first bar chart in Fig 1 shows the proportion of farmers that know the largest, healthy looking plants need to be pegged for follow-up for seed selection (*sel1*). The figure reveals that about 77 percent of farmers that were not shown the PSS video were able to indicate the correct option in the multiple choice question. For farmers that did get to see the video on positive seed selection, this proportion increases to 86 percent. The increase is statistically significant (one-sided RI, p=.041). Similarly, the second bar chart in Fig 1 reveals that the proportion of farmers that know egg sized tubers are best seeding material was 89 percent among those that were not subjected to the PSS treatment, while it is 96 percent among those that did see the video. Again, the increase in knowledge is statistically significant (one-sided RI, p=.042).

Figure 1: **Effect of PSS and PSSH treatment on knowledge covered in videos.**



We also find that showing videos on the importance of Potato Seed Storage & Handling, and how to properly do this increases knowledge about recommended storage and handling practices that was covered in the video. As indicated by the third bar chart in Fig 1, only about 60 percent of participants that have not been exposed to the PSSH treatment know that seed potatoes need to be stored in diffuse light (*store1*). This proportion increases to 88 percent among farmers that have seen the video on PSSH. The increase in the proportion is statistically significant (one-sided RI, $p<.001$). Finally, we find that 95 percent of farmers that were not shown the PSSH video know that seed potatoes should be spread out on racks (*store2*). This percentage increases to 97 percent among farmers that did see the PSSH video, but the increase is not significant (one-sided RI, $p=.372$). However, to reduce the influence of outcomes with limited variation, we specified in our pre-analysis plan that variables for which 95 percent of observations are the same value would be discarded.

We also find that being shown any video has the potential to increase knowledge beyond what is explicitly covered in the video. For example, the first bar chart in Fig 2 shows that farmers that were subjected to the PSS treatment were also significantly more likely to know seed potatoes should not be washed before being stored (one-sided RI, $p<.001$). The second bar chart shows that the same treatment also significantly increases the likelihood that a farmer knows fields for planting materials should ideally be located in highlands, away from human settlements (one-sided RI, $p=.006$). The third bar chart shows farmers exposed to the PSSH treatment are also more likely to know seed potatoes should not be washed before being stored (one-sided RI, $p=.032$), while the fourth shows they also know fields for planting materials should ideally be located in highlands (one-sided RI, $p<.001$). This effect is also present when we compare outcomes on knowledge related to one treatment between groups based on the other treatment: farmers that were exposed to PSS score significantly better on *store1* and *store2* than those that were not and farmers that were exposed to PSSH score significantly better on *sel1* and *sel2*.

To account for the clustering due to our matched bloc design, we also run regressions using a within bloc specification (see equation 1). The estimates of the average treatment effects can be found in Table 2 and are consistent with the findings in the figures. For instance, we see that the PSS treatment induces an increase of 9 percentage points in the proportion of farmers that answers correctly on the first seed selection knowledge question. This is exactly what we found in the simple means comparisons above, but the standard error is slightly higher, leading to a p-value of .05. The effect of PSS on the second question related to seed selection is also estimated at 7 percentage points, and this time the inclusion of bloc fixed effects reduces the standard error. Also consistent with the means tests, the PSSH treatment has a large and significant effect on knowledge related to storage as measured by the first question, while the effect on the second question is not significant (probably due to limited variation in the outcome variable).

Again consistent with the figures, we find that showing a video does not only increase knowledge related to what is featured in the video, but there seems to be a more general knowledge effect. For example, we find an increase in the proportion of farmers that answer correctly on the questions that were not explicitly covered (*gen1*

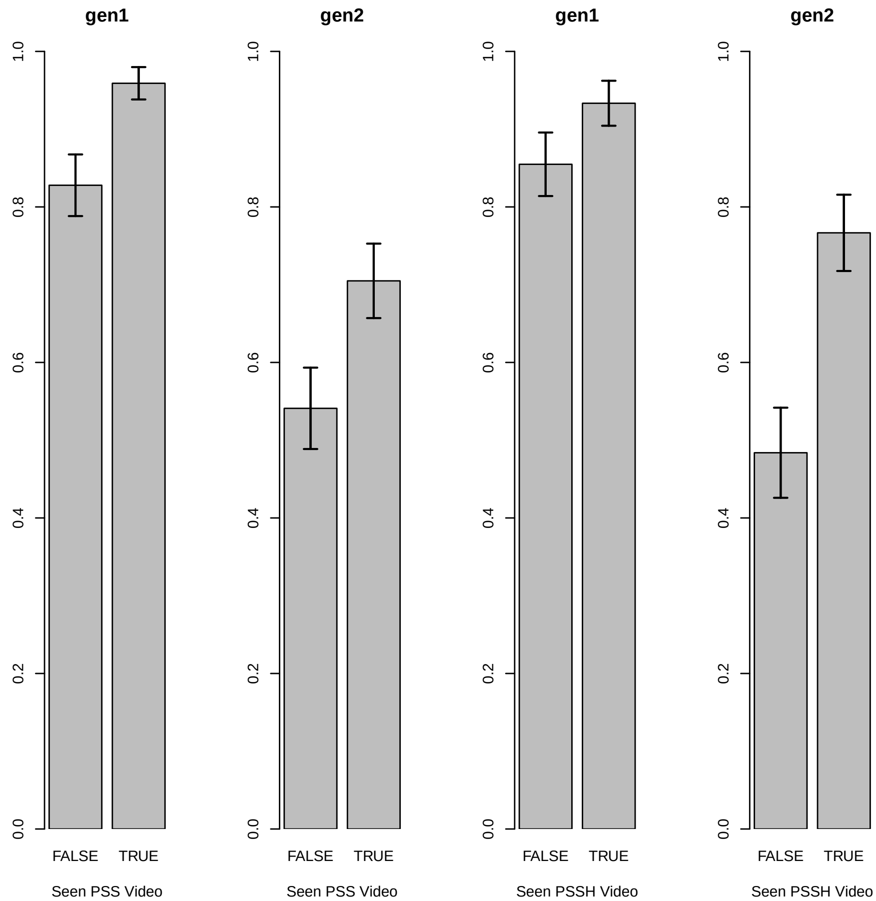


Figure 2: **Effect of PSS and PSSH treatment on knowledge not explicitly covered in videos.**

Table 2: **Effect of PSS and PSSH treatments on knowledge.**

	sel1	sel2	store1	store2	gen1	gen2
PSS	0.09	0.07	0.28	0.02	0.13	0.17
	[0.050]	[0.012]	[0.000]	[0.165]	[0.000]	[0.002]
PSSH	0.07	0.08	0.29	0.02	0.08	0.28
	[0.091]	[0.003]	[0.000]	[0.163]	[0.010]	[0.000]

Table notes: one-sided p-values are in square brackets and are based on randomization inference, with a random sample of 10,000 permutations used.

and *gen2*) as a result of being shown any of the videos. Also, we see that farmers that have been shown the video that explains Positive Seed Selection score higher on *store1*. Similarly, the likelihood of correctly answering *sel1* and *sel2* increases by

7 and 8 percentage points respectively as a consequence of having been shown the Seed Storage & Handling video.

The results in Table 2 may mask heterogeneity in the average treatment effect. In particular, we suspect that farmers with little prior knowledge about PSS and/or PSSH are more likely to benefit from the information that is contained in the videos. To test this hypothesis, we use information collected during the baseline. We check if farmers reported to be aware of the importance of using clean and disease free planting materials and use this information in a regression to control for previous knowledge related to Positive Seed Selection. In addition, we check if farmers knew seeds should be stored on dried grass in the shade and use this to control for previous knowledge related to Proper Seed Storage & Handling in the regression. This is done in the regression framework of equation (1) by interacting both of these variables with the treatment indicators. Results are summarized in Table 3. As our study was not designed to identify heterogeneous treatment effects, and our sample size is likely to be too small, we will confine our attention to the variables that display most variation (*sel1*, *store1* and *gen2*).

The first column in Table 3 shows that controlling for prior knowledge substantially increases the treatment effect for the PSS treatment on *sel1*. Among farmers that are not aware of the importance of using clean and disease free planting materials and do not know seed potatoes need to be stored on dried grass in the shade, the coefficient estimate is higher than in the case where they do have prior knowledge (0.31 compared to 0.09). The second column shows a similar response of storage related knowledge to the PSSH video. Here, the treatment effect increases from 0.29 to 0.36 among farmers that report to have no prior knowledge pertaining to potato seed quality. Contrary to what we found in Table 2, showing the PSS video does not seem to affect knowledge on seed selection that was not explicitly covered in the video among farmers that have no prior knowledge on the importance of seed quality. However, column 4 to 6 suggests that even after controlling for previous knowledge, a particular treatment may still increase knowledge about a subject not explicitly covered in the video.

Discussion

We find that showing simple agricultural extension videos to individual potato farmers on portable devices significantly increases knowledge related to seed selection and seed storage & handling among potato farmers. In particular, showing a video that explains Positive Seed Selection increases the likelihood that farmers know about the methods explained in the video. Similarly, showing a video that demonstrates Proper Seed Storage & Handling increases the likelihood that farmers know about the information explained in the video. This finding suggests that agricultural extension videos are an effective tool for accurate transmission of homogeneous information from a technical source to a low literacy population, for instance when a technical

Table 3: **Effect of PSS and PSSH treatments on knowledge controlling for previous knowledge.**

	sel1	store1	gen2	gen2	sel1	store1
PSS	0.31		0.13			0.36
	[0.017]		[0.203]			[0.011]
PSSH		0.36		0.32	0.24	
		[0.011]		[0.022]	[0.055]	
knowPSS	0.09	-0.04	0.05	-0.10	0.08	0.06
	[0.217]	[0.778]	[0.120]	[0.773]	[0.288]	[0.249]
knowPSSH	0.12	0.00	-0.23	-0.08	0.09	-0.07
	[0.055]	[0.138]	[0.743]	[0.141]	[0.104]	[0.376]
knowPSS*PSS	-0.12		-0.14			-0.07
	[0.832]		[0.831]			[0.689]
knowPSSH*PSS	-0.17		0.17			-0.05
	[0.862]		[0.176]			[0.622]
knowPSS*PSSH		0.05		0.05	-0.11	
		[0.358]		[0.377]	[0.808]	
knowPSSH*PSSH		-0.15		-0.08	-0.13	
		[0.821]		[0.671]	[0.800]	
nobs	235	235	235	235	235	235
Adj-R-squared	0.026	0.064	-0.023	0.045	0.069	0.0114
F-statistic	1.094	1.244	0.919	1.168	1.264	1.041
p-value F	0.320	0.134	0.646	0.213	0.118	0.410

Table notes: one-sided p-values are based on randomization inference, with a random sample of 10,000 permutations used. All regressions include 61 bloc fixed effects.

expert or high quality trainer is not available or too expensive.

In addition to a direct effect, we also find that showing a video displaying methods related to a particular aspect of potato growing increases knowledge more in general. For instance, showing a video about Positive Seed Selection methods increases knowledge related to seed selection but not explicitly shown in the video, such as where the field for seed production should be located. Similarly, showing a video about Proper Seed Storage & Handling also increases knowledge related to storage and handling not covered in the video, such as the importance of keeping potatoes dry. Even more, we find that showing a video on one topic, for instance on Seed Selection, increases knowledge in another topic, such as Seed Storage & Handling.

There are different reasons for such indirect effects. First, it may be due to poor design of our treatments. It may be that we unintentionally give information in one treatment that gives the farmer clues about knowledge we explicitly show in the other treatment (and thus associate to the other treatment). For example, when it is explained in the PSS video that tubers should look healthy and one should only keep tubers with at least four eyes (5:27-5:43), the farmer in the video is shown to be selecting from potatoes that are stored on racks in diffuse light. This may give farmers clues about Proper Storage & Handling, increasing their likelihood of picking the correct option for the question which was intended to measure the information given on PSSH (*store2*).

Second, the above may suggest farmers go beyond simply repeating what is shown in videos, and engage, to some degree, in a process of abstraction (learning concepts from examples) where they apply insights gained in one context in a different context. For example, recommending potato seeds to be stored away from other crops, animals and humans, such as is done in the PSSH treatment (4:03-4:11), may inform farmers about the abstract concepts of hygiene and separation in the context of seed potatoes. This in turn might prompt farmers to pick the answer from *gen2* most in line with those concepts, namely that the potato seed field should ideally be in a remote place high in the mountains. In cognitive psychology, this type of learning is known as schema abstraction, which posits that knowledge represents an abstraction of different memory traces, each representing a specific experience in our lives (Hintzman, 1986). In this sense, our videos can be interpreted as an experience that teaches farmers something about relevant concepts in their profession.

Third, and perhaps most interestingly, it may be possible that farmers already possess some of the information needed to identify the correct alternative in the multiple choice questions, but that a video is needed to trigger the farmer to actually use this information when confronted with the multiple choice questions. For instance, it may be that a farmer is aware of the recommended practice (through having received extension services in the past for instance), but bases his or her actual response on what the customary practice is. Being shown a video, where a fellow farmer talks about the virtues of a range of modern techniques, may serve as a visual and auditory cue for the information the farmer already possesses. This finding is consistent with knowledge about the cognitive capacities of human beings (Tulving, 1972). In particular, it suggests the usefulness of video messages to trigger associative recognition and cued recall, which involves retrieval of memory or recognition of previously encountered events, objects, or people with the help of cues and associations (Tulving and Pearlstone, 1966; Mandler, 1980). Alternatively, being shown a video may confirm the knowledge the farmer has, making him or her more confident to use it. As such, a simple reminder may both validate information a farmer has but has not applied, or may serve to make it more salient. This is consistent with the finding that receiving information from a trusted source positively affects take up of rainfall insurance among smallholders in India (Cole et al., 2013) .

Our findings suggest that videos are likely to become an indispensable part of the agricultural extension toolkit. It suggests that specific videos aimed at transferring narrow technical information are effective. In addition, video messages that show more general information, such as the importance of nutrient management or general hygiene to combat pests and diseases may even be more important. Such videos may provide visual and auditory stimuli that lead to cognitive processes of schema abstraction and cued recall. The act of recalling instead of studying creates new and longer lasting connections between concepts (Carrier and Pashler, 1992). In addition, our research suggests that videos should be context specific featuring model farmers to maximize the potential of videos to leverage knowledge farmers already possess, but may not be confident enough to use.

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