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Motivated Beliefs and the Elderly's Compliance with COVID-19 Measures

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Abstract

Although the elderly are more vulnerable to COVID-19, the empirical evidence suggests that they do not behave more cautiously in the pandemic than younger individuals. This theoretical model argues that some individuals might not comply with the COVID-19 measures to reassure themselves that they are not vulnerable, and that the incentives for such self-signaling can be stronger for the elderly. The results suggest that communication strategies emphasizing the dangers of COVID-19 could backfire and reduce compliance among the elderly.

JEL: C70, D91, D82, I12, I18.

Keywords: motivated beliefs; compliance behavior; age; health; COVID-19.

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1 Introduction

Many governments have implemented COVID-19 measures to slow down the spread of the disease. Compliance with these measures reduces the risk of infection and thereby directly benefits the complying individuals themselves. Levin et al. (2020) document that COVID-19 is particularly dangerous for the elderly so that this age group benefits the most from strict compliance. Nevertheless, compliance among the elderly is far from perfect. In fact, Clark et al. (2020) find that compliance is unrelated to age. Daoust (2020) shows that the elderly behave the same as much younger individuals, while the willingness to wear a face mask even decreases in age.

This note shows that motivated beliefs can explain why the elderly do not comply better with COVID-19 measures than age groups less threatened by the disease. The argument is that compliance might reveal having a weak constitution, thereby increasing anxiety. If people receive utility from believing to be strong, there can exist a separating equilibrium in which only weak people comply with the COVID-19 measures. This separating equilibrium might exist even if everybody net benefits from compliance. Further, the pooling equilibrium with universal compliance might exist only for the young but not for the elderly. The reason is that only the elderly must reasonably interpret non-compliance as signaling a robust constitution, which destroys the equilibrium.

Formally, the prior probability of being strong determines whether an equilibrium refinement based on equilibrium dominance restricts out-of-equilibrium beliefs. Any young individual is strong with a high probability. Because her beliefs in a pooling equilibrium are favorable, she could never possibly benefit from deviating to non-compliance, not even if she is strong and interprets non-compliance as signaling a strong constitution. The equilibrium refinement has no bite, and the individual can reasonably hold any belief after observing non-compliance. However, suppose an individual is more advanced in age so that her prior probability to be strong is lower. Because her equilibrium utility in a pooling equilibrium is lower, an individual with a strong constitution might possibly benefit from deviating to non-compliance. The refinement might require non-compliance to be interpreted as signaling a strong constitution, destroying the pooling equilibrium.

Intuitively, the young enjoy a high belief utility from believing to have the average constitution of their age group. After all, young people typically have a good constitution. For the elderly, believing to have the average constitution of their age group is much less comforting. To cope with the resulting anxiety, the elderly might want to believe that they are not in danger because they have a strong constitution for someone in their age group. Gerhold (2020) indeed finds evidence for such comforting, but inconsistent beliefs: he shows that 67% of the survey respondents in the highest age group worry about COVID-19 in general, but only 9% of the same age group are afraid of being infected themselves. The present model argues that upholding such comforting beliefs might require non-compliance.

2 Model

Consider an individual who is either young or elderly and who has either a strong or a weak constitution. Let $\gamma \in \{y, e\}$ be the age group of this individual, where y stands for young, and e stands for elderly. Let $\theta \in \{s, w\}$ denote the health of the individual, where s stands for a strong, and w stands for a weak constitution. The constitution is defined in absolute terms so that two individuals in different age groups but with the same constitution have comparable health. Age only affects the prior probability with which an individual is weak or strong, as to be explained later.

Let action $a \in \{c, nc\}$ describe the individual's compliance behavior, where c stands for compliance, and nc stands for non-compliance. Compliance has some costs, for example, from wearing a face mask, but reduces the probability of attracting the disease. Falling ill has expected health consequences that depend on the constitution of the individual. Let $\pi(a, \theta)$ be the expected physical, health-related, and discounted net-utility of the individual if she has constitution $\theta \in \{s, w\}$ and engages in compliance behavior $a \in \{c, nc\}$. Because constitution is defined in absolute terms, age does not enter the individual's physical net-utilities. Let

$$\Delta\pi(\theta) = \pi(c, \theta) - \pi(nc, \theta) \tag{1}$$

denote the increase in physical health-related utility from compliant rather than non-compliant behavior of the individual with constitution $\theta \in \{s, w\}$. Assume

$$\Delta\pi(w) > \Delta\pi(s) \tag{2}$$

so that the individual has less to gain from compliance if she is strong rather than weak. By definition, the individual can better cope with falling ill if she has a strong rather than a weak constitution. The above assumption holds if compliance costs do not depend too much on the individual's constitution. To best illustrate the possible negative effect of motivated beliefs on compliance, assume

$$\Delta\pi(s) > 0 \tag{3}$$

so that the individual's physical health benefits from compliance even if she is strong. This assumption holds if the costs of compliance are small.

The self-signaling model is based on Bodner and Prelec (2003) and Bénabou and Tirole (2006, 2011), see also the excellent survey by Golmann et al. (2017). Age is an observable fact, and the individual must acknowledge belonging to a certain age group. But the constitution of an individual is less factual so that the individual might form motivated beliefs about her physical health. The model's idea is that the individual's compliance might signal something about the individual's constitution to the individual herself. Let $\mu_0(\gamma) \in]0,1[$ be the prior probability that the individual is strong. This initial probability $\mu_0(\gamma)$ depends on age $\gamma \in \{y, e\}$ where $\mu_0(y) > \mu_0(e)$ because the young have a higher prior probability of being strong than the elderly. Let $\mu_1(\gamma, a) \in [0,1]$ be the posterior probability with which an individual in the age group γ believes herself to be strong after engaging in compliance behavior $a \in \{c, nc\}$. The Bernoulli utility of the individual is

$$u\big(a, \theta, \mu_1(\gamma, a)\big) = \pi(a, \theta) + \lambda\, \mu_1(\gamma, a). \tag{4}$$

Parameter λ measures how much the individual appreciates believing herself to be strong. To focus on the most interesting case, assume that

$$\Delta\pi(w) > \lambda > \Delta\pi(s) \tag{5}$$

so that motivated beliefs are behaviorally relevant without dominanting all physical health concerns.

The analysis considers perfect Bayesian equilibria in pure strategies, separately for both age groups. A pure strategy is a function α that specifies compliance conditional on the age group and the constitution. An equilibrium strategy α^* maximizes the individual's expected utility given her equilibrium beliefs. Equilibrium beliefs μ_1^* specify the probabilities with which the individual believes herself to be strong, conditional on the individual's own compliance, and given her observable age group. For both compliance and non-compliance, the beliefs must be consistent with the prior belief and the individual's equilibrium strategy.

Finally, perfect Bayesian equilibria can seem unreasonable if they are supported only by unintuitive out-of-equilibrium beliefs. Standard equilibrium refinements for signaling games consider the responders' possibly optimal responses to the senders' out-of-equilibrium signals. These refinements are not directly applicable in the present setup because the sender is the receiver, and the receiver derives direct utility from holding a particular belief without taking any further action. At the same time, not all out-of-equilibrium beliefs are equally reasonable in a self-signaling equilibrium. If one accepts that the formation of motivated beliefs can be modeled as a self-signaling game, an individual should not believe herself to have a particular type if the observed out-of-equilibrium compliance behavior is equilibrium-dominated for this type but not for some other type. The individual's utility is strictly increasing in the probability with which she believes herself to be strong. Concerning the individual's belief utility, the best that can happen after deviating to out-of-equilibrium action a' is that she believes herself to be strong with certainty. Analogously to equilibrium dominance, the equilibrium refinements can be formally defined as follows.

Definition (Reasonable Beliefs)**.** *Consider an equilibrium in the age group $\gamma \in \{y, e\}$ with strategy α^* and beliefs μ_1^*. Suppose that for some out-of-equilibrium action a' the inequalities*

$$u(\alpha^*(\gamma, \theta), \theta, \mu_1^*(\gamma, \alpha^*(\gamma, \theta)) > u(a', \theta, 1) \tag{6}$$

and

$$u(a', \theta', 1) \geq u(\alpha^*(\gamma, \theta'), \theta', \mu_1^*(\gamma, \alpha^*(\gamma, \theta')) \tag{7}$$

hold for $\theta, \theta' \in \{w, s\}$ and $\theta \neq \theta'$. Out-of-equilibrium action a' is equilibrium-dominated for type θ but not for the other type θ'. The equilibrium is then defined to be "reasonable" if and only if $\mu_1^*(\gamma, a')$ puts all probability mass on type θ'.

3 Results

This section intuitively describes all reasonable perfect Bayesian equilibria in pure strategies; the appendix contains all formal proofs. First, there never exists a separating equilibrium in which only the strong individual complies. In such an equilibrium, the weak individual could signal to herself that she is strong by compliance and benefit her health. Therefore, it can never be optimal for the weak individual not to comply.

Second, there never exists a pooling equilibrium with universal non-compliance. In such an equilibrium, compliance would have to yield a loss in belief utility larger than the increase in physical health. However, assumption (5) states that $\Delta\pi(w) > \lambda$ so that the gain in physical health for the weak individual is larger than the largest possible loss in belief utility. The pooling equilibrium with universal non-compliance never exists. The following results show how motivated beliefs undermine compliance.

Result 1 (Separating Equilibrium)**.** *For both age groups, there exists a reasonable, perfect Bayesian equilibrium in which only the weak individual complies.*

This result has the following intuition. Non-compliance yields the largest possible loss in belief utility. The above separating equilibrium exists if and only if the physical health benefits from compliance are larger than the loss in belief utility for the weak individual, while they are smaller for the strong individual. Assumption (5) ensures this. Note that the existence of the separating equilibrium does not depend on the prior probability $\mu_0(\gamma)$ with which the individual is strong, and therefore does not depend on her age group. The paper's main result is that age affects the equilibrium existence condition for the pooling equilibrium with universal compliance.

Result 2 (Universal Compliance)**.** *Within the age group $\gamma \in \{y, e\}$ there exists a reasonable, perfect Bayesian equilibrium in which both the weak and the strong individual are compliant if and only if*

$$\mu_0(\gamma) > \frac{\lambda - \Delta\,\pi(s)}{\lambda} \tag{8}$$

so that the prior probability $\mu_0(\gamma)$ for the individual to be strong is sufficiently large. Because the prior probability $\mu_0(\gamma)$ decreases in age, universal compliance is more likely an equilibrium for the young than for the elderly.

This result has the following intuition. Because compliance benefits the health of both the strong and the weak individual, everybody complies if they do not want to form motivated beliefs. How motivated beliefs affect equilibrium existence depends on how the individual interprets a deviation to non-compliance. Suppose that after observing non-compliance, the individual believes herself to be weak or keeps her prior. Motivated beliefs then strengthen, or leave unaffected, the incentives to comply. Whether such out-of-equilibrium beliefs are reasonable depends on the prior. If the prior is rather negative, non-compliance is equilibrium-dominated only for the weak individual. The individual must then reasonably believe herself to be strong after observing non-compliance. Motivated beliefs then destroy the equilibrium. The prior beliefs are less favorable for the elderly. Therefore, a reasonable pooling equilibrium with universal compliance may exist for the young but not for the elderly.

4 Conclusion

The empirical evidence in Clark et al. (2020) and Daoust (2020) suggests that governments must develop specific communication strategies to improve the elderly's compliance with the COVID-19 measures. The present paper has implications for what might be an efficient communication strategy concerning the key variables in the model: the physical health benefits of compliance $\Delta\pi(\theta)$ and the prior probability $\mu_0(\gamma)$ with which individuals within an age group believe themselves to have a strong constitution. Obviously, explaining and emphasizing the physical health benefits $\Delta\pi(\theta)$ of compliance – for both the weak and the strong – facilitates universal compliance. More interestingly, a specific implication of the present self-signaling model is that – contrary to casual intuition – emphasizing the dangers of COVID-19 need not improve incentives for the elderly. Creating anxiety increases the need for motivated beliefs. Communicating that a large majority among the elderly are in danger could lower the prior belief $\mu_0(e)$ with which individuals in this age group believe someone like them to be strong. This note shows that a lower prior complicates the existence of the pooling equilibrium with universal compliance.

Summarizing, a good communication strategy should point out that compliance strongly decreases the infection risk, also benefiting those unlikely to die from COVID-19. Further, without downplaying the dangers, governments should not exaggerate the probability with which the elderly might be severely affected by the disease.

5 Appendix

Proof: No Crazy Separating Equilibrium

Consider the crazy separating equilibrium in which only the strong individual in age group $\gamma \in \{y, e\}$ complies. Then $\alpha^*(\gamma, w) = nc$, $\alpha^*(\gamma, s) = c$, $\mu_1^*(\gamma, nc) = 0$, and $\mu_1^*(\gamma, c) = 1$ holds. Existence requires

$$0 \geq \Delta\pi(w) + \lambda \tag{9}$$

for the weak individual. This condition is violated because of (2), (3), and (5).

Proof: No Bad Pooling Equilibrium

Consider the bad pooling equilibrium in which nobody complies in age group $\gamma \in \{y, e\}$. Then $\alpha^*(\gamma, \theta) = nc$ for $\theta \in \{w, s\}$ and $\mu_1^*(\gamma, nc) = \mu_0(\gamma)$ holds. The out-of-equilibrium belief is some $\mu_1^*(\gamma, c)$. Existence requires

$$\big(\mu_0(\gamma) - \mu_1^*(\gamma, nc)\big)\lambda \geq \Delta\pi(w) \tag{10}$$

for the weak individual. (5) implies

$$\Delta\pi(w) > \lambda \geq \big(\mu_0(\gamma) - \mu_1^*(\gamma, nc)\big)\,\lambda \tag{11}$$

so that the equilibrium never exists for any out-of-equilibrium belief $\mu_1^*(\gamma, c)$.

Proof: Natural Separating Equilibrium

Consider the separating equilibrium in which only the weak individual complies in age group $\gamma \in \{y, e\}$. Then $\alpha^*(\gamma, w) = c$, $\alpha^*(\gamma, s) = nc$, $\mu_1^*(\gamma, nc) = 1$, and $\mu_1^*(\gamma, c) = 0$ holds. Existence requires

$$\Delta\pi(w) \geq \lambda \tag{12}$$

for the weak individual, and

$$\lambda \geq \Delta\pi(s) \tag{13}$$

for the strong individual. These conditions are the conditions in (5).

Proof: Good Pooling Equilibrium

Consider the good pooling equilibrium with universal compliance in age group $\gamma \in \{y, e\}$. Then $\alpha^*(\gamma, \theta) = c$ for $\theta \in \{w, s\}$ and $\mu_1^*(\gamma, c) = \mu_0(\gamma)$ holds. The out-of-equilibrium belief is some $\mu_1^*(\gamma, nc)$. Existence requires

$$\Delta\pi(w) \geq \left(\mu_1^*(\gamma, nc) - \mu_0(\gamma)\right) \lambda \tag{14}$$

for the weak individual, and

$$\Delta\pi(s) \geq \left(\mu_1^*(\gamma, nc) - \mu_0(\gamma)\right) \lambda \tag{15}$$

for the strong individual. (2) yields that the incentives for the strong individual imply the incentives for the weak individual. (3) implies that the condition for the strong individual is automatically satisfied as long as $\mu_0(\gamma) \geq \mu_1^*(\gamma, nc)$. If $\mu_1^*(\gamma, nc) \leq \mu_0(\gamma)$ is not ruled out by the equilibrium refinement, equilibrium existence is guaranteed.

However, only the belief $\mu_1^*(\gamma, nc) = 1$ is reasonable if and only if

$$\pi(s, nc) + \lambda \geq \pi(s, c) + \mu_0(\gamma)\, \lambda \tag{16}$$

while at the same time

$$\pi(w, c) + \mu_0(\gamma)\, \lambda > \pi(w, nc) + \lambda \tag{17}$$

which in combination yields

$$\frac{\lambda - \Delta\pi(s)}{\lambda} \geq \mu_0(\gamma) > \frac{\lambda - \Delta\pi(w)}{\lambda} \tag{18}$$

where the second inequality always holds because (5) implies $\lambda < \Delta\pi(w)$.

If $\mu_0(\gamma)$ is sufficiently small, the refinement implies $\mu_1^*(\gamma, nc) = 1$ so that non-compliance must be interpreted as a deviation by a strong individual. The above equilibrium existence condition for the strong individual then becomes

$$\Delta\pi(s) \geq \left(1 - \mu_0(\gamma)\right) \lambda \tag{19}$$

which is violated because

$$\Delta\pi(s) > \lambda \geq \left(1 - \mu_0(\gamma)\right) \lambda \tag{20}$$

by (5). Thus, the above pooling exists if and only if the reasonability refinement is not binding, which yields the equilibrium existence condition in the result.

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