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A Set-Theoretic Approach to Communication

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Abstract: During a communication act, the source sends a message to one or more addressees, *T*, using a channel and a code, *D*, so that the message will not be received by certain members of a population, *X*. It follows that a communication act can be represented through the system (T, D, X), where *T*, *D*, and *X* are parts of a population, *T* is not empty, and *T* and *X* are disjoint sets. Using such a model, we can approach some issues of the communication sciences from a set-theoretic perspective. In this study, the main types and effectiveness conditions of the communication acts are investigated.

Keywords: communication models, types of communication, effective communication

1. Set-Theoretic Modelling of Communication

The set theory is used for modelling different phenomena in various domains (Sneed, 1981: 451). We aim to extend this method and to build a model of communication inside of the set theory (Schneider: 2012: 10). Such an enterprise runs through the following steps:

1) The act of communication is defined. (1)
2) Using the definition, the act of communication is analysed through specific terms.
3) The extensional relations among terms resulting from the analysis of communication are displayed.
4) The extensions of terms and the relations among them are represented through the means of the set theory.
5) Specific issues of communication science are approached inside of the set-theoretical model (Schneider, 2012: 42).

We define the act of communication (Narula, 2006: 2) as the act of a sender, *E*, who sends a message, *M*, towards one or more addressees, *T*, (Huang–Wu, 2012: 116), using a communication channel, *C*, and a code or a language, *L*. Also, the sender could have the intention that the message do not reach certain individuals. For this reason, we have to recognize, besides addressees, the category of the excluded people, *X*. For instance, if *E* sends a letter to *T*, it is possible that *E* does not wishes that the letter be received by *X*.

The used channel allows the people from *C* to receive the message, and those who are able to decipher the code, *L*, will understand it. We call the domain, *D*, of an act of communication the intersection between *C* and *L* – namely, the set of people who can receive and understand the message, D = CL.

We have analysed an act of communication (Noth, 2011: 203) through the following terms:

1) Sender (or source), *E*, who is unique, sends message *M*. (2)
2) Addressees (or targets), *T*, to whom the message is destined.
3) Excluded people, *X*, who should not receive the message.
4) Domain, *D*, including the people who can receive the message.

Taking into account the extensions of those terms as parts of a certain population P, we can extensionally define the act of communication inside of the set theory (Sneed, 1981: 459):

An act of communication, *A*, is the system of classes (T, X, D), (3)
wherefore:
1) *T*, *X*, and *D* are parts of population P.
2) *T* is not an empty class.
3) *T* and *X* are disjoint classes.

Class *T* cannot be empty since when *E* intends to communicate he sends the message to somebody; therefore, if there were no addressees, we could not speak about a communication act. The classes of addressees and excluded people are disjoint because it would be contradictory that the same person be and not be the destination of the message during the same act of communication. Using the relations (3), the next theorem can be proved:

For an act of communication, *X* is a strict part of *P*. (4)
$T \cup X \subset P$.
$T \neq \emptyset$.
$TX = \emptyset$.
$X \neq P$.

The acts of communication can be represented calling for the same methods used for representing sets. For instance, we may use the graphical representation where extensions are displayed through closed areas inside of a rectangle, corresponding to population *P*. The ellipses corresponding to the terms used for analysing a communication act are so drawn to emphasize the relations among their extensions:

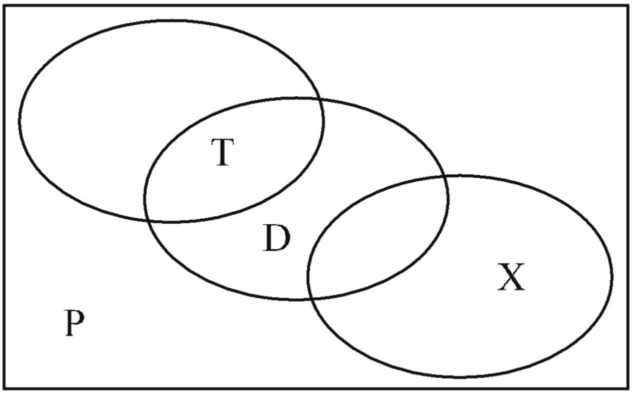

Figure 1. *Act of communication*

Using the algebraic method, the variables or parameters derived from the analysis of a communication act are connected through certain formulas. Generally, if *d*, *t*, and *x* were three some parts of the set *P*, then they would satisfy the relation:

$$dtx \cup dtx^* \cup dt^*x \cup dt^*x^* \cup d^*tx \cup d^*tx^* \cup d^*t^*x \cup d^*t^*x^* = P \qquad (5)$$

If we ask the variables from (5) to follow the conditions (3), we obtain a system of relations representing an act of communication:

$$dtx^* \cup dt^*x \cup dt^*x^* \cup d^*tx^* \cup d^*t^*x \cup d^*t^*x^* = P \qquad (6)$$
$$dtx^* \cup d^*tx^* \neq \varnothing$$
$$dt^*x \cup d^*t^*x \neq P$$

The relations (6) can be also written in the fallowing fashion:

$(d \cup d^*)(tx^* \cup t^*x \cup t^*x^*) = P$, where: (7)
$tx^* \neq \varnothing$, and
$t^*x \neq P$.

2. Forms of Communication

We may classify the acts of communication using the criterion of the values that the variables *x* or *t* can take. Let us review some types of communication acts. If *x* is the empty class (it takes the smallest value), then we can speak about open communication acts. In this case, there are no excluded people, and any member of population *P* can be a receiver without the interests of the sender to be affected. The open, or transparent communication acts are described through systems like (t, ∅, d), and the equations (7) are satisfied if P is not void:

$$(d \cup d^*)(t \cup t^*) = P \quad (8)$$
$t \neq \varnothing$ and
$P \neq \varnothing$.

We may graphically represent an open communication act as it follows:

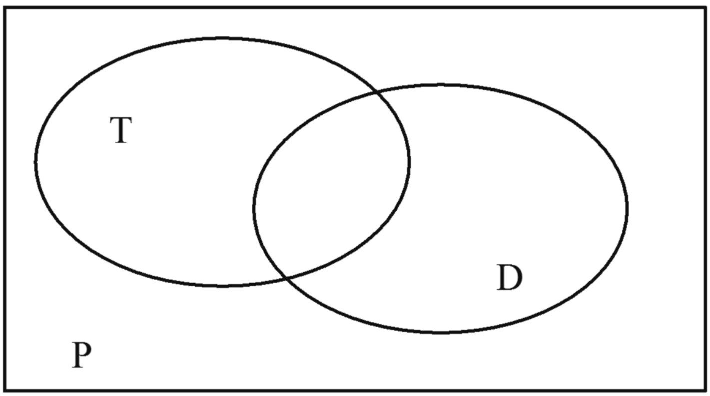

Figure 2. *Transparent act of communication*

If *x* takes the maximum value, x = t*, then we get a closed, or opaque communication act. Any member of population *P* is either a destination or an excluded member. This time, from the sender's perspective, the message should be received only by the addressees (Narula, 2006: 12). The closed communication acts correspond to the system (t, t*, d). The relations (7) take the form:

$$(d \cup d^*)(t \cup t^*) = P, \text{ where:} \quad (9)$$
$t \neq \varnothing$,
$x \neq \varnothing$, and
$x = t^*$.

Their graphic representation is:

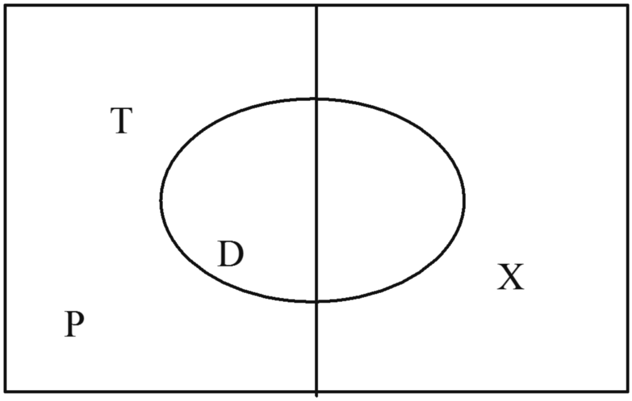

Figure 3. *Opaque act of communication*

In the case of the public, or mass communication, the addressees are not individualized; therefore, at the limit, the target of the communication act can be the entire population, t = P. It follows for that kind of communication that there are no excluded people, $x = \varnothing$, and a mass communication act is represented by the system $(P, \varnothing, d)$ so that:

$(d \cup d^*)P = P$, where: (10)
$P \neq \varnothing$.

We reach the expected result that, for public communication acts, *P* cannot be void. On the other hand, public communication acts are opened, or transparent, since there are no excluded people for them. The graphical representation of these acts of communication is the following:

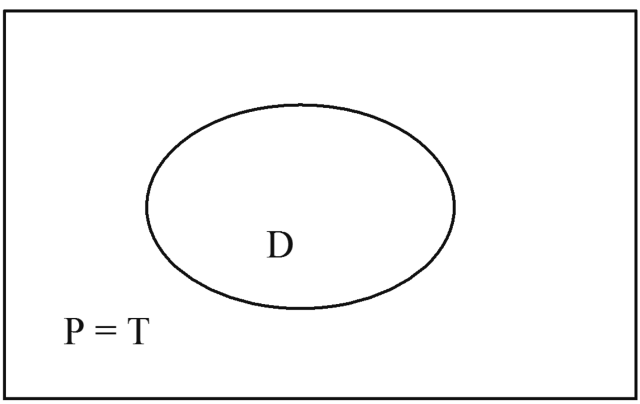

Figure 4. *Mass communication act*

If *t* is the empty class, we cannot speak of communication, as we previously saw. Hence, for $t = \varnothing$, an act of non-communication is performed (Narula, 2006: 7). This time, according to the intention of the sender, the message is destined to no one, and it is not sent. The corresponding system is $(\varnothing, x, \varnothing)$ or, for $x = P$, the system $(\varnothing, P, \varnothing)$ represents an absolute non-communication act, when every member of population P should not receive the message. Graphically, an act of non-communication looks as follows:

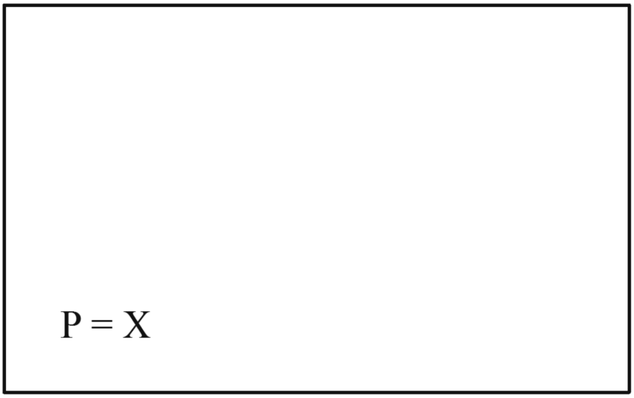

Figure 5. *Non-communication act*

3. Effective Communication

The act of receiving a message throughout a population is independent from the sending of the message; hence, every member of the population could receive the message. However, only the members of domain *D* have the ability to receive message *M*. Indeed, the members of *P* outside of *D* do not comprehend the message, or they do not decipher or understand it. Therefore, if we use variable *r* for the class of the receivers, the composition between the acts of communication and the receiving of a message is represented through the system (t, x, d, r) so that:

$$(dr \cup dr^* \cup d^*r^*)(tx^* \cup t^*x \cup t^*x^*) = P, \text{ and } t \neq \varnothing. \qquad (11)$$

The values of the receivers' class run from the empty class, when no one receives the message sent during an act of communication, to *D*, when every member of the domain receives the message. The acts of sending and receiving of a message have the following graphic representation:

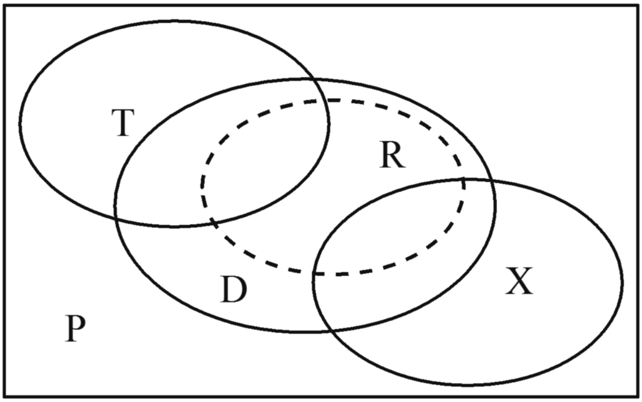

Figure 6. *Sending and receiving messages*

The goal of the sender is that all addressees and no excluded people should receive the sent message. If the goal of the sender is achieved, we say that the communication act is *effective*. Therefore, the conditions of the effectiveness for an act of communication are the following:

C1. $t \subset r$, (12)
C2. $x \subset r^*$.

The sender can accomplish these conditions only using the domain since he cannot control the receivers. Concerning *C1*, he disposes only of a necessary condition, according to the inference: $r \subset d, t \subset r / t \subset d$. We notice that since the first premise is a tautology, the second, which is just the condition *C1*, is sufficient to infer the relation expressed by conclusion. In other words, in order that *C1* be satisfied, the domain has to be extended enough to include all addressees. If there were addressees outside of the domain, *C1* would certainly not be accomplished, and the communication act would not be effective. In turn, if the domain includes all addressees, it is possible that *C1* be satisfied, but we cannot be sure about that. The sender has no means to certainly satisfy *C1*; therefore, it has no possibility to perform an effective act of communication with certainty.

On the other hand, *C2* can be satisfied since there is a sufficient condition for *C2* that can be fulfilled by the sender. This time, he may use the inference: $r \subset d, x \subset d^* / x \subset r^*$, where the condition *C2* is the conclusion, and the first premise is a tautology; therefore, the second premise is a sufficient condition for *C2*. To satisfy *C2*, it is sufficient that the sender will maintain the class of excluded people outside of the domain. For instance, the sender could use a channel tight enough so that the excluded persons will remain outside of its area, or he could introduce a code so designed that the excluded people cannot decipher it. Therefore, there is no strategy to guarantee for the sender the fulfilment of his communicative ends.

Even if a communication act is not fully effective, it can have different degrees of effectiveness (Cobley–Schultz, 2013: 14). We can define various methods to calculate the effectiveness degree, starting from the system of relations satisfied by an effective act of communication (Tindale, 2013: 163). Taking into account that effectiveness does not depend on *d*, we arrive at the following relations of an effective communication act:

$$rtx^* \cup rt^*x^* \cup r^*t^*x \cup r^*t^*x^* = P \quad (13)$$
$$t \neq \varnothing$$
$$x \neq P.$$

The graphic representation of the effective communication act is the following:

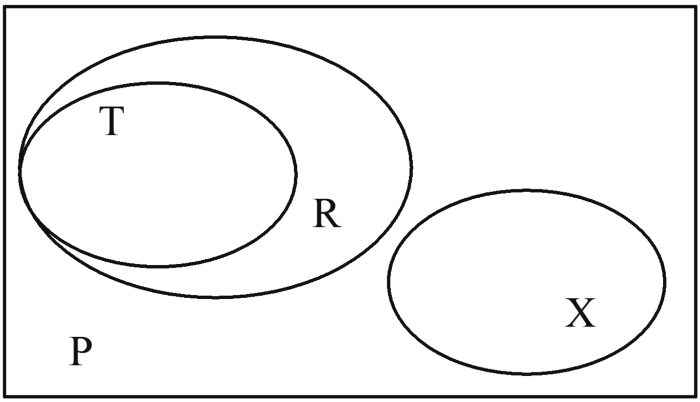

Figure 7. *Effective communication act*

From equation (13), it follows:

$$rtx^* \cup rt^*x^* \cup r^*t^*x \cup r^*t^*x^* = P \quad (14)$$
$$rx^*(t \cup t^*) \cup r^*t^*(x \cup x^*) = P$$
$$rx^* \cup r^*t^* = P.$$

Since the expression on the left is closer to *P*, as the degree of effectiveness is higher, we can evaluate the effectiveness degree using the formula:

$$G = card(rx^* \cup r^*t^*)/N, \quad (15)$$

where *card* means the cardinal number of a set, and *N* is the number of the members of *P*.

There are many cases when the amount of population *P* remains unknown. Therefore, another formula, where *N* is replaced by the number of addressees and excluded people, is also useful. We notice that for an effective act of communication, remembering that *r* and *x* should be disjoint classes, it takes place:

$$rt \cup r^*x \cup t^*x^* = P \quad (16)$$
$$rt \cup r^*x = P(t \cup x)$$
$$rt \cup r^*x = t \cup x$$

Going further, we can infer the searched formula for the effectiveness degree:

$$G = card(rt \cup r^*x)/card(t \cup x) \quad (17)$$

Using these formulas, we can calculate the effectiveness degree for different categories of communication acts. For instance, a public communication act is more effective if the number of receivers is greater:

$$G_{public} = card(rP \cup r^*\varnothing)/card(P \cup \varnothing) = R/N, \quad (18)$$

where *R* represents the number of the receivers.

The sender can acquire a greater efficiency, making the domain larger to increase the number of possible receivers. He can use a channel accessible to any member of population *P* and a code adapted to that population. For instance, the effectiveness degree of a television transmission is the same as the rating of that transmission if the population consists of the owners of receiving devices. In this situation, the rating of that emission is just the ratio between the number of receivers and the number of the owners of receiving devices (Wimmer–Dominick 1987: 308).

Using the above formulas, we can also calculate the effectiveness degree of a non-communication act, (∅, P, d):

$$G_{noncom} = card(r\varnothing \cup r^*P)/card(\varnothing \cup P) = (N - R)/N. \quad (19)$$

If *E* sends no message, i.e. if *d* is void, then *r* is also void, and the act of non-communication has its highest effectiveness. Instead, although *E* intends to keep the message hidden, but he sends it in some way, there are chances that the message be received, and the effectiveness will be lower.

When all members of *P* receive the message, namely N = R, the effectiveness degree can be calculated using the following formula:

$$G = card(Px^* \cup \varnothing t^*)/N = (N - card(x))/N = (R - card(x))/R. \quad (20)$$

The highest efficiency is reached if there are no excluded people for an open act of communication. Instead, in similar conditions, closed communication acts have the lowest effectiveness degree.

If all elements of *P* do not receive the message, the effectiveness degree is given by the formula:

$$G = card(\varnothing x^* \cup Pt^*)/N = (N - card(t))/N \quad (21)$$

This time, the highest efficiency is reached when *t* is empty – namely, for the non-communication acts. The public communication acts are not effective in such a case; their effectiveness degree is zero.

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