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# A six-stage framework for evolutionary IS research using path models: Conceptual development and a social networking illustration

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# A six-stage framework for evolutionary IS research using path models

## Conceptual development and a social networking illustration

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**Abstract**

**Purpose** – The purpose of this study is to fill a gap in evolutionary theorizing in the field of information systems. Evolutionary theorizing has recently been added as a useful tool to the research repertoire of information systems investigators. However, the literature on evolutionary theorizing and related empirical research lacks a clear framework that explicitly shows how information systems researchers can go, step-by-step, from a generic model of the evolution of traits in our ancestral past to a more specific model depicting the effects of technology facilitation of those traits among modern humans. The purpose of this study is to fill this gap through a framework composed of six stages.

**Design/methodology/approach** – To discuss and illustrate the framework, the authors develop an easy-to-understand generic path model explicitly depicting relationships among variables related to events that occurred in our evolutionary past. We then incrementally adapt this generic path model, eventually arriving at a focused path model depicting causal relationships among social networking site use, job satisfaction, organizational commitment and job performance. In doing so, the authors also develop a theoretical model about how social networking site use can affect job performance, where a positive total effect is predicted via positive intermediate effects on job satisfaction and organizational commitment.

**Findings** – To discuss the final stage in the framework, the authors present an illustrative example where the focused path model is tested based on a study of the effect of Facebook use on job performance among 178 working professionals across the USA. This illustrative example provides general support for the theoretical model.

**Research limitations/implications** – The counterintuitive hypothesis that Facebook use is associated with increased job performance is supported.

**Practical implications** – Social networking site use by organizational employees is likely to be associated with improved job performance.

**Originality/value** – This study provides a clear framework that shows how researchers can go from a generic evolutionary path model in our ancestral past to a more specific model comprising technology effects in modern humans.

**Keywords** Evolutionary biology, Path analysis, Theory development

**Paper type** Research paper

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## Introduction

Evolutionary theorizing has recently made an entrance in the field of information systems (IS) as a new research tool (Abraham *et al.*, 2011; Blau and Barak, 2012; Kock, 2009; Kock and Chatelain-Jardón, 2011; Vlahovic *et al.*, 2012; Zahedi and Bansal, 2011). We predict that the use of evolutionary theorizing will increase in the field of IS in the future, but only if clear theory development frameworks are made available to guide that theorizing and related empirical assessment. There are a number of reasons why evolutionary theorizing can be an attractive approach for IS researchers, two of which are particularly noteworthy.

The first is that evolved responses tend to be uniformly observed across different cultures, and IS are increasingly global, often including features that are used across cultures. That is, evolved responses are often the reason for common observed behavioral patterns in the context of technology use across cultures, even when behavior is quite different overall. The existence of evolved behavioral patterns does not mean that all people behave the same way toward technology, but rather that often the commonalities in behavior have a hidden evolutionary basis (Kock, 2009).

The second particularly noteworthy reason why evolutionary theorizing can be an attractive approach is that evolved behavioral responses are often tied to subconscious mental mechanisms, and thus are frequently not self-evident and even counterintuitive. Evolutionary theorizing can help explain behavioral responses that would otherwise appear strange, disconnected from reality, and contradictory with commonsense assumptions.

Evolution is a process whereby genotypes associated with traits that enhanced reproductive success in our evolutionary past first appeared at random and then spread through populations through selection forces. The environments of our evolution, although varied, often incorporated common characteristics across generations and populations that were very different from those found in our modern world (Barkow *et al.*, 1992; Buss, 1999).

The literature on evolutionary theorizing currently lacks a clear framework that explicitly shows how IS researchers can go, step-by-step, from a generic view of the evolution of traits in our ancestral past to hypotheses about the effects of technology facilitation of those traits among modern humans. To fill this gap, we show, through a multi-stage theory development and empirical analysis framework, that path models can be used to explicate the evolution of traits in our ancestral past, and also to better understand their expression in modern humans through modified path models derived from those ancestral path models. Moreover, we show that modified path models can demonstrably be used to predict the effects that technologies that facilitate the expression of evolved traits will have in modern tasks and environments.

The stages of the theory development and empirical analysis framework are exemplified through an illustrative example where a focused path model is developed, based on a generic ancestral path model, and used to hypothesize relationships among social networking site use (SNUse), job satisfaction (JSaft), organizational commitment (OComm) and job performance (JPerf). The illustrative example also includes an analysis of data from 178 working professionals across the USA, all of whom used Facebook to various degrees.

## Evolution by selection and path analysis

A mathematical view of evolution is important in evolutionary theorizing in general (Kock and Chatelain-Jardón, 2011; Smith, 1998). One of the key reasons for this importance is that it can help prevent naïve speculations (Buss, 1999; Cartwright, 2000) based on assumptions about our evolutionary past. With only "loose" verbal arguments, evolution can be used to explain (and thus predict) almost anything (Smith, 1998).

Another key reason for the importance of a mathematical view of evolution, particularly in the context of IS research, is that it enables us to demonstrate that a diagrammatic tool that is widely used among IS researchers, namely path modeling, can be directly and explicitly used by researchers to incrementally go from expectations about what happened regularly with our ancestors in the ancient past to expectations about IS-related patterns of behavior among modern humans. We demonstrate in this section that path modeling, with all of its important mathematical properties, presents a very good fit with such incremental evolutionary IS theorizing.

A third reason for the importance of a mathematical view of evolution, which is related to the first (preventing naïve speculations), is that it allows for a precise understanding of the effect of sexual selection. While arguably our illustration (presented later) does not explicitly take advantage of this modeling capability in connection with sexual selection, it is still a useful element of the theory development framework we lay out. With this precise understanding, one can explicitly model the evolution of costly traits, whereby traits that influence survival success in a negative way evolve because of the traits' overall impact on reproductive success (Kock, 2011; Zahavi and Zahavi, 1997).

Discussed in this section are two fundamental mathematical tools widely used in the understanding of evolutionary phenomena, namely the Price Equation and the method of path analysis (Price, 1970; Wright, 1934, 1960). These tools have been developed, and their use extensively illustrated, by two pioneering evolutionary biologists who helped establish the foundations on which much evolution-based research builds: George Price and Sewall Wright, respectively.

For any population of organisms where selection pressures exist, including our human ancestors, phenotypic traits with a genetic basis (e.g. social behavior) will evolve in the population via selection if and only if equation (1) is satisfied. This is the famous Price Equation (Price, 1970), named after George Price. The Price Equation is one of the most fundamental and widely used mathematical formulations in evolutionary biology (Frank, 1995; El Mouden *et al.*, 2014):

$$\bar{W} \cdot \Delta \bar{Z} = Cov(W, Z) + E(W \cdot \Delta Z) \qquad (1)$$

All of the terms in the equation refer to numeric variables. The term $Z$ refers to a variable tracking the presence or absence in an individual in the population of a certain phenotypic trait that has a genetic basis. This would normally be coded in a dichotomous fashion, such as $Z = 1$ for presence of the trait and $Z = 0$ for absence, corresponding to presence or absence of the genotype that is associated with the trait. The term $W$ refers to the "fitness" of an individual, which is typically measured by the number of surviving offspring or grandoffspring of the individual. Fitness is assumed to be a linear regression function of each trait (Frank, 1997; Rice, 2004).

The covariance term in the Price Equation refers to population change caused by survival and/or mating success being increased or decreased by a trait. Traits can increase or decrease the survival and/or mating success of the individuals that possess the traits. If a trait decreases survival and/or mating success, it will often disappear from the population, although there are instances in which such a trait will spread throughout the population as a costly trait (Kock, 2011).

The expectation term in the Price Equation refers to change caused by factors such as mutation and recombination (McElreath and Boyd, 2007; Rice, 2004), which are not directly related to selection. Given this, the expectation term is usually set to zero when one wants to isolate the effects of environmental and sexual selection in analyses aimed at understanding the evolution of traits. Setting this term to zero leads to equation (2), which is a simplified version of the Price Equation, and in fact the most widely used in analyses of the evolution of traits through selection (Frank, 1995, 1997; Kock and Chatelain-Jardón, 2011; Rice, 2004). This applies to both natural and sexual selection.

$$\bar{W} \cdot \Delta \bar{Z} = Cov(W, Z) \tag{2}$$

Standardization of $W$ and $Z$ would lead to the two dimensionless variables $w$ and $z$. The standardized equivalent of $W$ can be obtained by subtracting its mean and dividing the result by the standard deviation of $W$. The same can be done for $Z$. Expressing $W$ and $Z$ in terms of $w$ and $z$ and performing further algebraic operations using covariance properties leads to equation (3).

$$\begin{aligned}&\bar{W} \cdot \Delta \bar{Z} = Cov(w \cdot S_W + \bar{W}, z \cdot S_Z + \bar{Z}) = Cov(w \cdot S_w, z \cdot S_Z) = S_W \cdot S_Z \cdot Cov(w, z) \Rightarrow \\ &\bar{W} \cdot \Delta \bar{Z} = S_W \cdot S_Z \cdot Cov(w, z)\end{aligned} \tag{3}$$

The product on the left side of this resulting equation will always be greater than zero for any trait that is undergoing evolution in a population of organisms. The same applies to the product of the standard deviations of $W$ and $Z$ (i.e. $S_W \cdot S_Z$), on the right side of the equation. Thus, a fundamental requirement for the evolution of any fitness-related trait through selection is that the covariance term in the equation be also greater than zero. This is expressed through the inequality in equation (4):

$$Cov(w, z) > 0 \tag{4}$$

This equation is particularly useful because it is expressed in terms of the standardized variables $w$ and $z$, instead of the related non-standardized variables $W$ and $Z$. Since it is expressed in standardized terms, this equation can be used in the context of path analysis, a method developed by one of the founders of the field of population genetics, and main contributor to evolutionary biology, Sewall Wright (Duncan, 1966; Kenny, 1979; Mueller, 1996; Wright, 1934, 1960).

We combine the Price Equation with the method of path analysis by making use of a property of path models, which is that the covariance between any two variables in a model equals the sums of the products of the path coefficients along all paths connecting the two variables. Even in models of moderate complexity, there may be many paths connecting pairs of variables. This effectively allows us to use path modeling, in a step-by-step model adaptation process, to develop and test theoretical IS models that have an evolutionary basis.

## The six-stage framework for evolutionary IS research

Table I summarizes our proposed multi-stage framework for evolutionary IS research, which is composed of six stages. Each stage is discussed in more detail later. This table summary is provided here to set the stage for our subsequent discussion. The framework starts with Stage 1. This stage builds on the combination of the Price Equation with the method of path analysis discussed above. In Stage 1, a generic model with a trait affecting fitness via various intermediate effects is drawn. This generic model can be used broadly, as a starting point, for various evolutionary IS research efforts.

In Stage 2, we adapt the generic model to include a main evolved trait of interest and intermediate effects in ancestral humans. This main trait of interest should meet two key requirements:

| Stage | Description | Example |
| --- | --- | --- |
| 1 | Draw generic path model that can be used to represent the evolution of any trait in ancestral humans | A generic model with a trait affecting fitness via various intermediate effects is drawn. This same generic model can be used in various evolutionary IS research efforts |
| 2 | Adapt model to include main evolved trait of interest and intermediate effects in ancestral humans | The model is adapted to show the effect of social behavior on fitness in ancestral humans via intermediate effects on satisfaction with hunter-gatherer group belonging and commitment to hunter-gatherer group |
| 3 | Adapt model to include domain-related variables leading to a non-IS theoretical model that applies to modern humans | The model is adapted to show the effect of social behavior on job performance, in connection with modern humans, via intermediate effects on job satisfaction and organizational commitment |
| 4 | Adapt model to depict the role of technology facilitation of evolved trait in connection with modern humans, making it an IS model | The model is adapted to show the effect of technology facilitation of social behavior on job performance, in connection with modern humans, via intermediate effects on job satisfaction and organizational commitment |
| 5 | Adapt model to depict the role of a class of technologies that can act as facilitators of evolved trait in connection with modern humans | The model is adapted to show the effect of social networking site use on job performance, in connection with modern humans, via intermediate effects on job satisfaction and organizational commitment |
| 6 | Adapt model to depict the role of a specific technology that acts as a facilitator of evolved trait in connection with modern humans. Then empirically test the model | The model is adapted to show the effect of Facebook use on job performance, in connection with modern humans, via intermediate effects on job satisfaction and organizational commitment. The model is empirically tested with data collected from working professionals, all of whom are Facebook users |

**Table I.**
The six-stage framework for evolutionary theorizing

(1) it can reasonably be expected to have evolved among our ancestors via selection; and
(2) its expression can reasonably be expected to be facilitated by a class of technologies used by modern humans.

The latter requirement is aimed at ensuring that the adapted model will later progress toward a model that is within the scope of IS research.

For example, the model could be adapted to show the effect of social behavior on fitness in ancestral humans via intermediate effects on satisfaction with hunter-gatherer group belonging and commitment to hunter-gatherer group. Social behavior appears to have evolved among our ancestors via selection (Alexander, 1974; Bergstrom, 2002). Additionally, social behavior can be facilitated by web-based social networking sites (Livingstone, 2008; Moqbel, 2012), a class of technologies used by modern humans.

In Stage 3, we adapt the model from the previous stage to include domain-related variables that can form the basis for a domain-specific theory in connection with modern humans. For example, the model could be adapted to show the effect of social behavior on JPerf, in connection with modern humans, via intermediate effects on JSaft and OComm.

In Stage 4, we adapt the model from the previous stage to depict the role of technology facilitation of the evolved trait in connection with modern humans, effectively bringing the model within the scope of IS research. For example, the model could be adapted to show the effect of technology facilitation of social behavior on JPerf, in connection with modern humans, via intermediate effects on JSaft and OComm.

In Stage 5, we adapt the model from the previous stage to depict the role of a class of technologies that can act as facilitators of the evolved trait in connection with modern humans. For example, the model could be adapted to show the effect of SNUse on JPerf, in connection with modern humans, via intermediate effects on JSaft and OComm.

Finally, in Stage 6, we adapt the model from the previous stage to depict the role of a specific technology that acts as a facilitator of the evolved trait in connection with modern humans. The model is then empirically tested. For example, the model could be adapted to show the effect of Facebook use on JPerf, in connection with modern humans, via intermediate effects on JSaft and OComm. The model could then be empirically tested with data collected from working professionals, all of whom are users of Facebook to various degrees.

Each of these stages is discussed in detail in the sections that follow. We illustrate the discussion of the stages based on a theoretical and empirical study of the causal relationships among SNUse, JSaft, OComm and JPerf.

*Stage 1: Generic model*

A generic path model that can be used to represent the evolution of almost any trait is provided in Figure 1. Here a trait is represented by the variable “a”. An example of trait would be social behavior, which may be low or high in individuals of a population owing to the presence in the population of two key genotypes, coded as 0 and 1, respectively. This trait causes intermediate effects represented by the variables “x” and “y”.

Only two intermediate effect variables are depicted. This is done for simplicity; there could be a set of intermediate effects measured by a set of variables “x”, “y”, “z”, “w”, etc. It is also assumed in the path model that “x” affects “y”. The reverse could be the case,

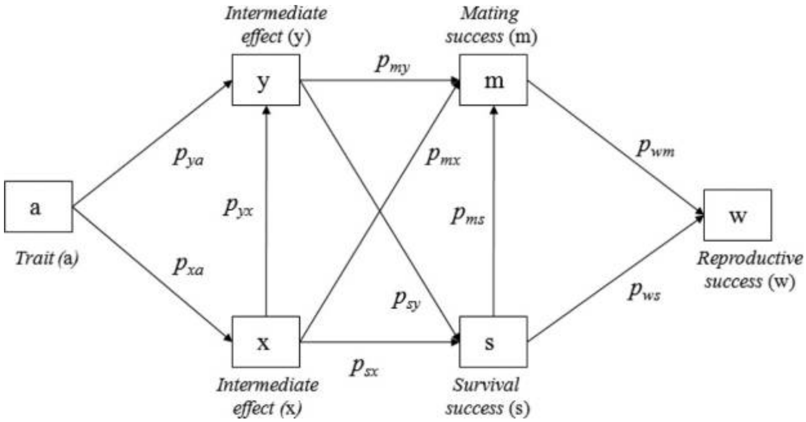



**Figure 1.**
Path model in our evolutionary past

or "x" and "y" could be independent from one another (likely a less common scenario). Moreover, there could be other intermediate effect variables in between "m" and "s" and "w", with a more complex causal network describing their associations. Even with these simplifications, the model above would arguably be enough as a departure point for most evolutionary theorizing applications in the field of IS.

In the model, both intermediate effects have an impact on mating success (m) and survival success (s), which in turn have effects on fitness, or reproductive success (w). The latter, reproductive success (w), is the ultimate currency of evolution. Mating success (m) could be measured by the total number of copulations in which an individual has participated during his or her lifetime. Survival success (s) could be measured as the age of an individual at the time of death. The path coefficients connecting all of these variables are represented by the variables $p_{ya}$, $p_{xa}$, $p_{my}$, $p_{mx}$ and so on, as shown in the model.

Survival success (s) is shown in the model as pointing at, or affecting, mating success (m) because organisms must be alive to mate. That is, successfully surviving to the age of reproductive maturity precedes the act of mating. This is true even when mating is frequently followed by death, as is the case when sexual cannibalism occurs in several insect species, e.g. the black widow spider (Breene and Sweet, 1985; Forster, 1992).

*Stage 2: Main evolved trait*

In this stage, we adapt the generic model to include a key evolved trait of interest and its intermediate effects in ancestral humans. Two key requirements should be met by such a trait. First, the trait should reasonably be expected to have evolved among our ancestors via selection. Second, the trait's expression should reasonably be expected to be facilitated by a class of technologies used by modern humans. Social behavior meets both requirements, as it appears to have evolved among our ancestors via selection (Alexander, 1974; Bergstrom, 2002), and it can be facilitated by web-based social networking sites used by modern humans (Livingstone, 2008; Moqbel, 2012).

For a trait (a) such as social behavior to evolve in a population of individuals, the condition expressed by the inequality in equation (4) must be satisfied; that is, the covariance between "a" and "w" must be greater than zero. Since the covariance between any two variables in the model equals the sums of the products of the coefficients along all paths connecting the two variables, equation (5) must be satisfied for the trait (a) to evolve in the population:

$$Cov(w,\ a) > 0 \Rightarrow$$
$$p_{ya} \cdot p_{my} \cdot p_{wm} + p_{xa} \cdot p_{sx} \cdot p_{ws} + p_{ya} \cdot p_{sy} \cdot p_{ws} + p_{xa} \cdot p_{mx} \cdot p_{wm} + \cdots > 0 \quad (5)$$

For the sake of simplicity, this equation does not show the sums of all of the paths with multiple segments in the model, of which there are several. It shows only four paths with three segments each. In path analysis, coefficients usually known as "total effects" are the sums of the products of the path coefficients in all paths with multiple segments connecting all pairs of connected variables in a path model with or without latent variables. The total effect of "a" on "w", which must be greater than zero for the trait measured by "a" to evolve (as expressed in equation (5), is the sum of the products of the path coefficients in all paths with multiple segments connecting the variables "a" on "w". This positive total effect characterizes a gene-induced trait that leads to a net gain in reproductive success.

This seems to have been the case with social behavior, which is a complex human trait that has been theorized to have evolved in the context of group living (Alexander, 1974; Bergstrom, 2002) consistently with the model depicted in Figure 2. Social behavior can be seen as a complex trait that is made up of many facets, or sub-traits, which evolved as individual traits themselves.

This simple model depicts evolution of social behavior through two fairly general intermediate effects, on satisfaction with hunter-gatherer group belonging (x) and commitment to hunter-gatherer group (y). The former (x) refers to an individual's satisfaction with being part of a group. The later (y) refers to an individual's commitment to the success of the group as a whole. The model highlights the interplay between individual and group effects that is characteristic of modern views of social evolution (Bergstrom, 2002; Fletcher and Zwick, 2007; Henrich, 2004).

Genotypes associated with increased social behavior would have led individuals to "feel good" about belonging to a group (x), where social interactions could have been expected to occur frequently. This, in turn, would have reinforced the trait's effect on

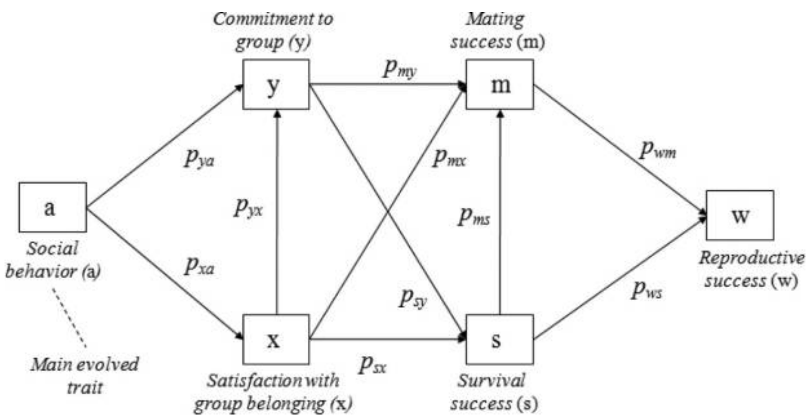



**Figure 2.** Evolution of social behavior

commitment to belonging to the group (y). Without the "feel good" element, commitment to group belonging may not have occurred.

Social behavior is not universal among animals because there are advantages and disadvantages to belonging to a group. While a group is likely to be more effective than individuals in isolation at hunting and fending off predators, greater proximity with others increases the risk of parasitic infections, and also leads to more intra-group competition for food and sexual partners (Alexander, 1974; Boaz and Almquist, 1997).

Modern humans who live in both cities and hunter-gatherer societies display complex forms of social behavior that are clearly outside the scope of basic kin selection (Hamilton, 1964a, 1964b). One example is reciprocal altruism among unrelated individuals, which is present in humans and many other animal species (Trivers, 1971, 2002). Propensity toward social behavior does not preclude propensity toward selfish behavior, as group living serves some selfish needs (Bergstrom, 2002), even as it curbs others.

The evolution of the many facets of gene-induced social behavior present in modern humans did not happen at once; it likely happened in a staggered fashion over long periods. The reason for this is that genotypes that code for traits appear in populations at random, in each case creating a dichotomy among the members of the population that could be expressed numerically as 0 (genotype absent) and 1 (genotype present). Initially only one individual (or a few, in the case of identical twins) possesses the genotype. Over time, if possessing the genotype leads to a net gain in reproductive success, as discussed in the previous section, the genotype will spread through the population over several generations.

With respect to social behavior, several genotypes likely appeared and subsequently evolved among our ancestors, leading to progressively more complex forms of gene-induced social behavior. Once a genotype appears in a population, it can spread to fixation (i.e. to the entire population) relatively quickly, over thousands, or even as little as a few hundred years (Hartl and Clark, 2007; Smith, 1998). What often takes much longer to happen, often millions of years, is the random appearance of a genotype that leads to a net gain in reproductive success to its host within the specific social and environmental context in which the host lives at a specific point in time.

As can be surmised from the discussion above, path models can be used to understand the evolution of traits in our ancestral past, which in turn allows us to better formulate hypotheses about those traits' expression in modern humans. As such, path models can be used to predict the possible effects that technologies that facilitate the expression of evolved traits have in modern environments. These and other related issues are discussed in the sections ahead. Appendix 1 further clarifies the practical implementation of the general path model discussed here using data created through a Monte Carlo simulation.

*Stage 3: Domain-relevant variables*

In this stage, we adapt the model from the previous stage to include domain-related variables that can form the basis for a theoretical model that applies to modern humans. A gene-induced trait that evolved in our evolutionary past can have an impact on measures that refer to modern humans, especially measures for variables that could be seen as modern analogs of ancestral success. From an organizational perspective, these include measures of success at one's job, i.e. JPerf measures.

However, such impact would not normally be related to the survival success (s), mating success (m) or reproductive success (w) of modern humans. The reason is that modern humans are no longer subject to the same selection pressures faced by our Stone Age ancestors. Having greater JPerf cannot reasonably be expected to be associated with having greater reproductive success. In fact, one could argue that the opposite is true, as greater JPerf is often associated with elements, such as access to birth control pills and devices, which are in turn inversely correlated with fertility (Bollen *et al.*, 2001; Hogan and Kitagawa, 1985).

At the same time, being successful at one's "job" in our ancestral past – where the "job" would be a contribution to the group (e.g. hunting or gathering foods, shelter preparation) – would bear at least some similarities to being successful at one's job in modern organizations. Diagrammatically, this replacement of ancestral success measures with measures of success in modern organizations is equivalent to collapsing the right side of the path model – which refers to the interplay of survival success (s), mating success (m) and reproductive success (w) – into a modern success analog in the context of organizations, such as JPerf (Jex, 1998).

This collapsing of the right side of the ancestral path model to obtain modern analogs of success in our evolutionary past must always be done cautiously, as it is the "weakest link" in most evolutionary theorizing efforts. Without this adaptation, one cannot transfer expectations based on evolutionary pressures in our ancestral past to predictions regarding modern human behavior. One check that is recommended at this point is whether empirical research supports the modern analog's relationship with the ancestral trait in modern environments. Note that in this stage the main trait is still the ancestral trait; the network of downstream effects of this trait is what changes.

Empirical research does support JPerf's relationship with the ancestral trait in modern environments. A strong predictor of JPerf is conscientiousness (Barrick and Mount, 1991), which is one of the "big five" personality dimensions (the others are extraversion, emotional stability, agreeableness and openness to experience). Low conscientiousness, in turn, is strongly associated with antisocial behavior (Ozer and Benet-Martinez, 2006). Therefore, it seems plausible to assume that social behavior is a predictor of modern JPerf, in this case either by mediating or by being mediated by conscientiousness.

In the context of modern organizations, new variables corresponding to satisfaction with hunter-gatherer group belonging (x) and commitment to hunter-gatherer group (y) would also have to be found to make the path model meaningful with respect to JPerf. Candidates for these could be satisfaction with one's job (x) and commitment to one's organization (y). Here the ancestral notion of a hunter-gatherer group is replaced by the modern notion of an organization. These path model adaptations are illustrated in Figure 3.

The resulting path model applied to the context of modern organizations is depicted in Figure 4. In this modern path model, social behavior (a) is hypothesized to influence JSaft (x) and OComm (y). JSaft (x) is hypothesized to influence OComm (y). The effects of social behavior (a) and JSaft (x) on OComm (y) are expected to exist when they control for one another (i.e. they are not redundant). JSaft (x) and OComm (y) are in turn hypothesized to influence JPerf (h), also in a non-redundant way.

Again, as this theoretical development process progresses, it is advisable to check intermediate models against results from relevant empirical research. Bateman and

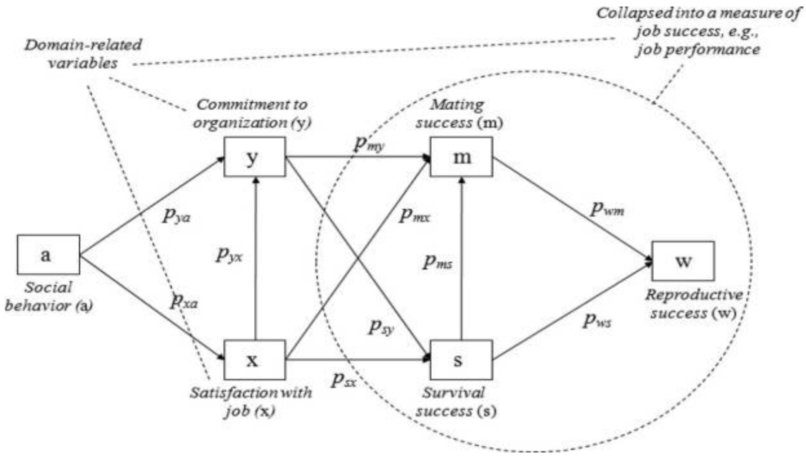



**Figure 3.**
Domain-related variables are included in the model

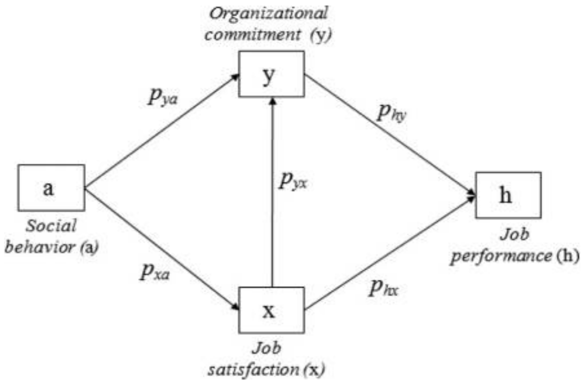



**Figure 4.**
Social behavior and job performance

Organ (1983) found a significant association between JSaft and JPerf, which appeared to be mediated by good employee "citizenship". Pritchard and Karasick (1973) also found a significant association between JSaft and JPerf, which they explained in part based on the effect of organizational climate on both variables. Judge *et al.* (2001) conducted an extensive meta-analysis of investigations addressing the relationship between JSaft and JPerf. Based on their meta-analysis, they estimated the mean true correlation between these two variables to be 0.3, which supports the hypothesis that JSaft is significantly associated with JPerf.

A widely cited study by Meyer *et al.* (1989) examined the relationship between JPerf of first-level managers in a large food service company and their OComm. They classified OComm in two categories:

(1) affective commitment (i.e. emotional attachment to, identification with and involvement in the organization); and

(2) continuance commitment (i.e. perceived costs associated with leaving the organization).

Their study found significant associations between both affective and continuance OComm and JPerf.

The empirical studies briefly summarized above (Bateman and Organ, 1983; Pritchard and Karasick, 1973; Judge *et al.*, 2001; Meyer *et al.*, 1989) provide general support for the intermediate effects related to satisfaction with one's job (x) and commitment to one's organization (y), which in turn are modern analogs of satisfaction with hunter-gatherer group belonging (x) and commitment to hunter-gatherer group (y). With this support, we can proceed with to the next stage of the evolutionary IS research framework.

*Stage 4: Technology facilitation*

In this stage, we adapt the model from the previous stage to depict the role of technology facilitation of the evolved trait in connection with modern humans. In the path model from the previous stage, which is applied to the context of modern organizations, one variable, namely social behavior (a), is preserved from the ancestral path model depicting the evolution of social behavior in the context of group living. All of the other variables are now modern analogs of corresponding variables (or, in one case, a set of variables) in the ancestral path model. This modern path model is now further adapted by replacing social behavior (a) with technology facilitation of social behavior (t), thus bringing it into the scope of the IS discipline. This is depicted in Figure 5.

This latest adaptation of the path model – the replacement of social behavior (a) with technology facilitation of social behavior (t) – assumes that modern technologies exist that can influence the expression of social behavior beyond what is possible without technology facilitation given certain constraints. Examples of constraints are geographical and time separation; i.e. being located in different places and interacting at different times. Many technologies can arguably fulfill such a role; one example would be asynchronous electronic collaboration technologies (Kock, 2001).

In the next section, we move to the next stage of the evolutionary IS research framework. There we focus on one class of technologies that arguably have been developed with the specific goal of facilitating social behavior in the context of geographical and time separation: social networking sites (Livingstone, 2008; Moqbel, 2012).

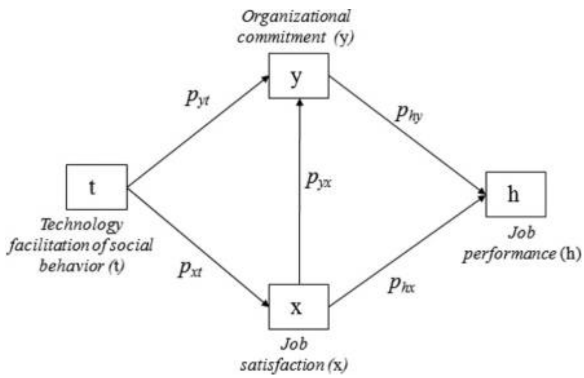



**Figure 5.**
Technology facilitation of social behavior and job performance

*Stage 5: Class of technologies*

To make the path model testable in modern organizational environments, we need now in this stage to replace the generic "technology facilitation of social behavior (t)" variable with a variable that is related to a class of modern technologies. Once this class of technologies and related variable are specified, the next step would be to test the resulting model by collecting data from users of one or more instances of this class of technologies.

Arguably a good candidate for the class of technologies that can act as facilitators of social behavior are social networking sites such as Facebook, which can arguably influence social behavior in two main ways that could lead to downstream effects on JPerf (Livingstone, 2008; Moqbel, 2012):

(1) by promoting social behavior among their users, leading to more social behavior toward members of the same organization (with or without technology mediation); and

(2) by facilitating technology-mediated social interactions among members of the same organization.

Figure 6 shows the new path model relating SNUse and JPerf. Here SNUse is hypothesized to positively influence OComm and JSaft, which in turn are hypothesized to positively influence JPerf. The double-lined arrow at the top also indicates that the total effect of SNUse on JPerf is hypothesized to be positive.

It should be noted that the theoretical model development process that has taken us down to this point, going from an ancestral path model to this model of hypothesized effects in modern organizational environments, assumes SNUse to be "general" use. What we mean by this is that it does not refer to SNUse only at work or during work hours.

The model hypothesizes that SNUse, whether at work or at home, will lead to intermediate effects on the job, which in turn will lead to an eventual effect on JPerf. While this hypothesis may appear counterintuitive, it is illustrative of evolutionary theorizing in general. Evolutionary theorizing frequently leads to hypotheses that are

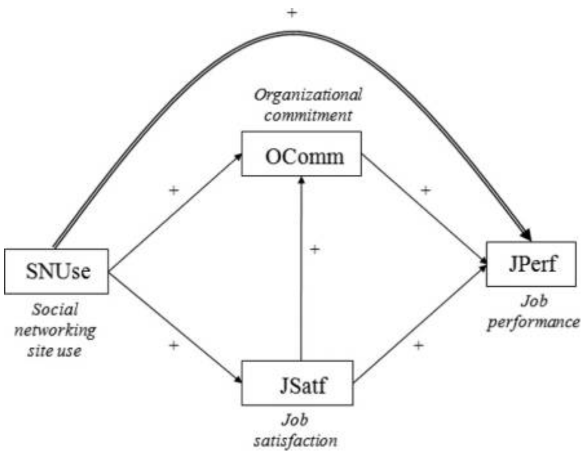



**Figure 6.**
Social networking site use and job performance

not self-evident, and whose rationale can only be clearly understood by looking at the various steps that led to them (i.e. that led to the hypotheses), from ancestral to modern humans (Cartwright, 2000; Kock, 2009).

Also, the model assumes that SNUse is a facilitator of an evolved trait, namely social behavior, which refers to a propensity that exists regardless of the use of any social networking tool. As such, the degree to which an individual engages in SNUse is assumed to be a measure of the degree of facilitation that social networking sites provide to the expression of a propensity (toward social behavior) that exists regardless of any technology.

The total effect hypothesis may appear to be redundant, but it should still be tested for two reasons:

(1) if one of the hypothesized intermediate effects does not hold, the total effect may still hold; and

(2) explicitly testing this total effect hypothesis leads to the estimation of the total effect of SNUse on JPerf, which may be a measure of interest in applications where one wants to predict JPerf based on SNUse.

The model proposed here, of hypothesized effects in modern organizational environments, would probably appear surprising to many; although a recent study provides partial support for it (Wu, 2013). The commonsense view of social networking, as far as JPerf is concerned and from the perspective of managers, is that it is largely a "waste of time" that would likely decrease one's JPerf (Moqbel, 2012). From an evolutionary perspective, however, one could make a convincing case that it could increase performance via intermediate effects on JSaft and OComm – as we have done here.

In the various path model versions discussed earlier, models referring to the evolution of traits in our ancestral past, each variable is represented as being measured directly through a single indicator. Modified path models for modern IS research, on the other hand, are likely to include variables that cannot be easily or reliably measured directly, such as perception-based variables. For example, the variable JSaft is likely to be measured as perceived JSaft.

Whenever variables cannot be measured directly, using multiple indicators is advisable for indirect measurement (Schumacker and Lomax, 2004). Indirectly measured variables are frequently called latent variables. Multiple indicators, often in the form of multiple question-statements answered on Likert-type scales (e.g. "1 – Strongly disagree" to "5 – Strongly agree") tend to reduce the biasing impact of measurement errors on the results.

Multiple indicators also allow for measurement quality assessment, primarily through calculation of validity and reliability coefficients obtained through a confirmatory factor analysis and related tests (Fornell and Larcker, 1981; Nunnally, 1978; Nunnally and Bernstein, 1994; Thompson, 2004).

*Stage 6: Specific technology*

In this stage, the final stage of our proposed evolutionary IS research framework, we adapt the model from the previous stage to depict the role of a specific technology that acts as a facilitator of evolved trait in connection with modern humans. The model is then empirically tested. Accordingly, this section discusses an illustrative study that supports our theoretical model of how SNUse can affect JPerf.

This study is a Facebook-focused replication of a previous exploratory investigation by Moqbel *et al.* (2013), where Facebook data were combined with data from similar sites that arguably do not provide the same level of support for the expression of social behavior (e.g. LinkedIn and Twitter). As such, we believe that this study is better aligned with our theoretical model.

Since we used different data, this study's results are not the same as those in Moqbel *et al.*'s (2013) investigation. The results briefly summarized in this section have not been published before, and in fact provide stronger support for our model than Moqbel *et al.*'s (2013) results. Nevertheless, this study is not presented here as a stand-alone empirical contribution, but rather as an illustration of our framework and of the applicability of our theoretical model. The data for this illustrative study was obtained from 178 working professionals across the USA, all of whom were users of Facebook to various degrees.

All of the constructs discussed here were operationalized as latent variables, with multiple indicators (Gefen *et al.*, 2000; Schumacker and Lomax, 2004). This also allowed us to build a model where we simultaneously tested relationships among latent variables, and relationships among indicators and latent variables (Kline, 1998). All of the latent variables included in the analysis were modeled as reflective (Chin, 1998; Diamantopoulos, 1999; Petter *et al.*, 2007).

Structural equation modeling (SEM) was used in the analysis. The structural analysis was preceded by several preliminary analyses, including a confirmatory factor analysis, with the goal of validating the measurement instrument (Kline, 1998; Thompson, 2004). WarpPLS 4.0 was used to generate estimates for assessment of the measurement instrument, confirmatory factor analysis and the SEM analysis proper (Guo *et al.*, 2011; Kock, 2010, 2013; Kock and Lynn, 2012). This software was used not only because it supports all of these assessments, but also because it is nonparametric in design, making no distributional assumptions. Several of our variables were not normally distributed, as indicated by two tests of normality: the classic Jarque-Bera test (Jarque and Bera, 1980; Bera and Jarque, 1981) and Gel and Gastwirth's (2008) robust modification of this test. Moreover, this software allows for a straightforward test of a total effect of one variable on another, which was required by our model.

Four main latent variables are included in this illustrative study, namely Facebook use, JSaft, OComm and JPerf. The question-statements used to measure the latent variables, answered on Likert-type scales, were adapted from past research; they are listed in Appendix 2.

The self-assessment of JPerf employed in this illustrative study is in line with most empirical studies of JPerf. This type of assessment has not traditionally led to significantly different results from performance scores assigned to employees by those to whom they report (Mabe and West, 1982; Iaffaldano and Muchinsky, 1985). Nevertheless, we also conducted a validation of the JPerf measure against annual performance evaluation scores received from immediate supervisors. Our validation suggested that the self-reported JPerf measurement used in this study was not only adequate, but probably more reliable than annual performance evaluation scores received from immediate supervisors, as the former presented significantly more variation. One possible reason for this is that, while self-assessments of JPerf were anonymous, supervisor assessments were not, as the supervisors were known to the professionals being evaluated.

The measurement instrument used in the analysis and the model were assessed using a comprehensive set of complementary quality tests. This assessment suggested that the measurement instrument and the model had acceptable discriminant and convergent validity, had acceptable reliability, had appropriately low levels of vertical and lateral collinearity and were generally free from common method bias.

Figure 7 shows the model with the main results. Facebook use was positively and significantly associated with JSaft ($\beta = 0.231$, $p < 0.01$). Facebook use was positively and significantly associated with OComm ($\beta = 0.119$, $p = 0.03$), after controlling for JSaft. JSaft was positively and significantly associated with OComm ($\beta = 0.669$, $p < 0.01$), after controlling for Facebook use.

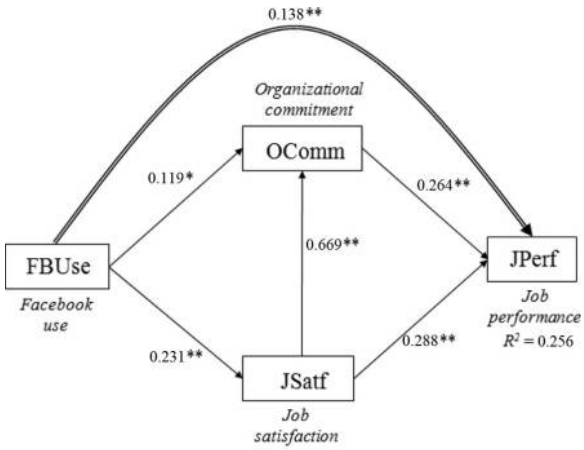
JSaft was positively and significantly associated with JPerf ($\beta = 0.288$, $p < 0.01$), after controlling for OComm. OComm was positively and significantly associated with JPerf ($\beta = 0.264$, $p < 0.01$), after controlling for JSaft. The model explained 25.6 per cent of the variance in the variable JPerf.

Finally, the total effect of Facebook use on JPerf was positive and significant ($\beta = 0.138$, $p < 0.01$). This is the sum of the products of the path coefficients in all paths with multiple segments connecting the variables Facebook use and JPerf. In this model, we have two paths with two segments, and one path with three segments, connecting these two variables.

## Discussion

As can be seen from the discussion of our proposed framework, and the illustrative study presented in the previous section, path models can be used to explicate the evolution of traits in our ancestral past, and also to better understand their expression in modern humans through modified path models derived from those ancestral path models. Moreover, modified path models can demonstrably be used to predict the effects that technologies that facilitate the expression of evolved traits will have in modern tasks and environments. Figure 8 depicts our six-stage framework for evolutionary theorizing.

As our illustrative study shows, predictions building on the evolutionary IS research framework proposed here can be both counterintuitive and match empirical results




**Notes:** $*p < 0.05$; $**p < 0.01$

**Figure 7.** Illustrative study results

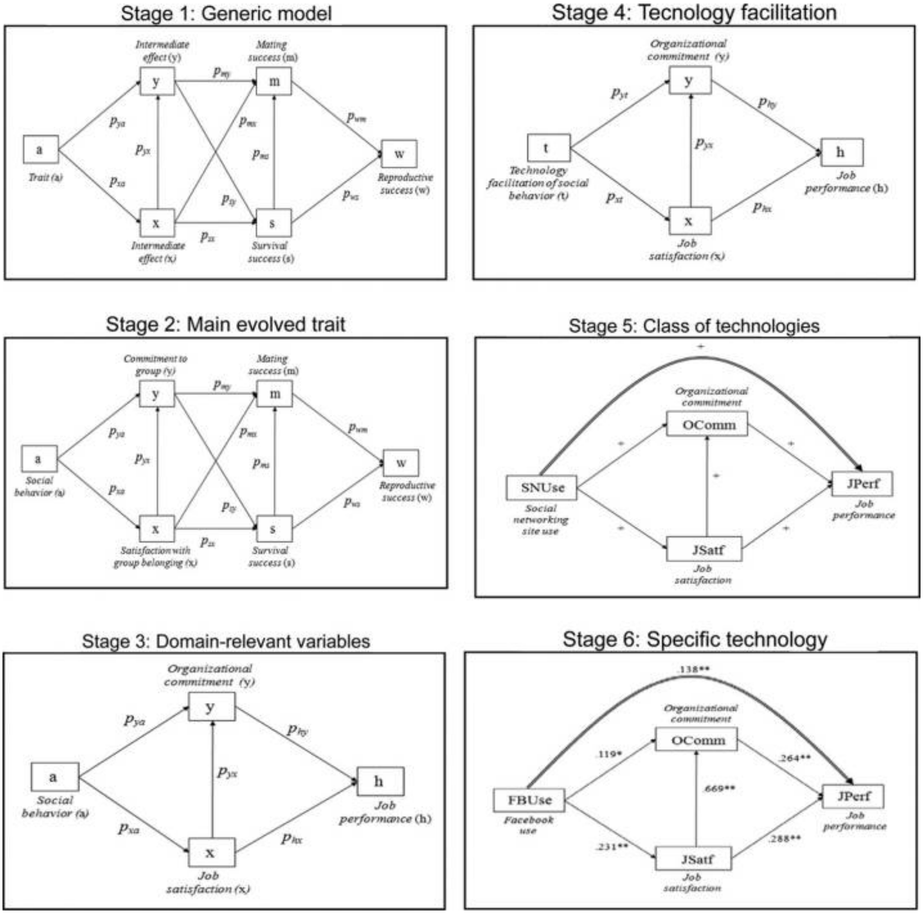



**Figure 8.**
The six-stage framework for evolutionary IS research

quite well. Nevertheless, it is important to recognize that genes do not "determine" human behavior. Genes only influence human behavior, through interactions with the environment (Cartwright, 2000; Kock, 2009). Therefore, the approach discussed here can only account for some of the behavior observed in modern humans.

This is exemplified by the fact that our illustrative model explained only 25.6 per cent of the variance in the variable JPerf. While this is a significant percentage of explained variance, 74.4 per cent of the variance in JPerf is unaccounted for by the model, and may be due to non-biological factors. Examples of non-biological factors are organizational cultures, management approaches and policies regarding the use of social networking sites by employees.

Evolutionary theorizing can also be an attractive approach for the prediction of future success of IS, because evolved responses tend to be uniformly observed across different cultures. However, it often does not explain all observed behavior. This highlights the need to combine evolutionary and non-evolutionary theories of behavior toward technologies (Kock, 2009) to better explain and predict future behavior.

**Limitations**

Some researchers in the field of IS would balk at the notion of evolutionary theorizing, questioning its validity based on the fact that ancestral humans have lived in natural environments that were too varied to have placed evolutionary pressure in any particular direction. While there has been much debate about this point (Kock and Chatelain-Jardón, 2011; Ridley, 2003; Vlahovic *et al.*, 2012; Zahedi and Bansal, 2011), it should be noted that our model of the ancestral evolution of social behavior is not tied to a particular natural environment. That is, the model assumes that social behavior would have evolved in any natural environment, as it is built on the assumption that social living evolved in part to enable ancestral humans to better cope with diverse environmental challenges.

Another argument that can be raised against evolutionary theorizing is that cultural influences often have a strong effect on behavior toward technologies, and that the existence of cultural differences goes against the more unifying evolutionary view that all humans share common traits. This is an argument that has been addressed before, notably by Kock (2009), calling for integration of evolutionary and non-evolutionary (e.g. cultural) IS theories. We echo this call here, by recommending replications of our research in different cultural contexts. As noted by Kock (2009), evolutionary theorizing assumes that modern humans share common evolved traits that can be used to explain a proportion of human behavior toward technologies, but not all of that behavior.

Recent research on the nature and nurture aspects of IS adoption and use (see, e.g. Bartelt and Dennis, 2014) highlights the possibility of the incorporation of IS into an individual's identity, expressed through automatic behaviors that have both evolutionary and cultural dimensions. There is a growing recognition that technologies not only augment individual behavior, but are seen as extensions of the phenotypes of the individuals who use those technologies (Jain *et al.*, 2015). This broader view of IS adoption and use has the potential to provide a unified lens that can capture the full complexity of modern human behavior toward technology, and should therefore inform evolutionary IS research.

**Conclusion**

Evolutionary theorizing and related empirical research have recently made an entrance in the field of IS (Abraham *et al.*, 2011; Blau and Barak, 2012; Kock, 2009; Kock and Chatelain-Jardón, 2011; Vlahovic *et al.*, 2012; Zahedi and Bansal, 2011). This extant literature on evolutionary IS research, when taken together, provides a broad set of guidelines for evolutionary theorizing and related empirical analyses in the context of human behavior toward modern technologies.

This literature, however, has one key limitation that we tried to address here. It does not explicitly show how IS researchers can incrementally progress from theorizing based on models for ancestral humans to empirically testing adapted models for modern humans. The discussion presented here addressed this limitation by developing an easy-to-understand generic path model depicting relationships among variables related to events that occurred in our evolutionary past, and then showing how this generic path model can be adapted into a focused model to generate predictions about the effect that SNUse can have on JPerf.

It was argued here that a mathematical view of evolution is important in evolutionary theorizing in general, and more specifically in the context of future IS success prediction, primarily because it enables us to demonstrate that a diagrammatic tool that is widely used among IS researchers, namely path modeling, can be directly and explicitly used by researchers to incrementally go from expectations about what happened regularly with our ancestors in the ancient past to expectations about IS-related patterns of behavior among modern humans. A mathematical view of evolution is important also because it can help researchers avoid naïve speculations about evolution. When researchers rely solely on "loose" verbal arguments, evolution can be used to explain (and thus predict) almost anything.

Accordingly, two fundamental mathematical tools were used as the main foundations for the development of the ancestral path model presented here, and of the framework for evolutionary IS research aimed at explaining and predicting the future success of IS. These mathematical tools have been, and continue being, widely used in the understanding of evolutionary phenomena. They are the Price Equation and the method of path analysis.

This paper arguably makes key contributions that can be used by researchers interested in understanding and predicting the future success of IS. Through a multi-stage framework for evolutionary IS research, it adds to previous discussions on theorizing about IS based on evolutionary biology and evolutionary psychology principles, and hopefully fills important gaps left by that literature. It also puts forth a theoretical model about how SNUse can affect JPerf, where a positive total effect is predicted via positive intermediate effects on JSaft and OComm.

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## Appendix 1. Simulated illustration of evolution by selection

Figure A1 shows a practical implementation of the general path model of evolution of traits by selection discussed earlier. It uses data created through a Monte Carlo simulation (Robert and Casella, 2005; Paxton *et al.*, 2001). The results are shown for illustration purposes. Path coefficients are listed next to the arrows linking pairs of variables.

Table AI, shown side-by-side, lists the number of paths for total effects (left) and the total effects among all pairs of variables (right). As it can be seen, there are a total of nine paths connecting the variables "a" and "w", each with multiple segments. These comprise the four paths with three segments each listed in equation (5). The total effect of "a" on "w" is 0.161. Since it is positive, the trait "a" will tend to evolve in the population, spreading from the original individual (or individuals) possessing the trait to other individuals in the population, over successive generations.

The negative path coefficient between "y" and "s" (−0.518) means that "y" has a strong negative effect on survival success (s). Let us assume that the variables "x" and "y" refer to

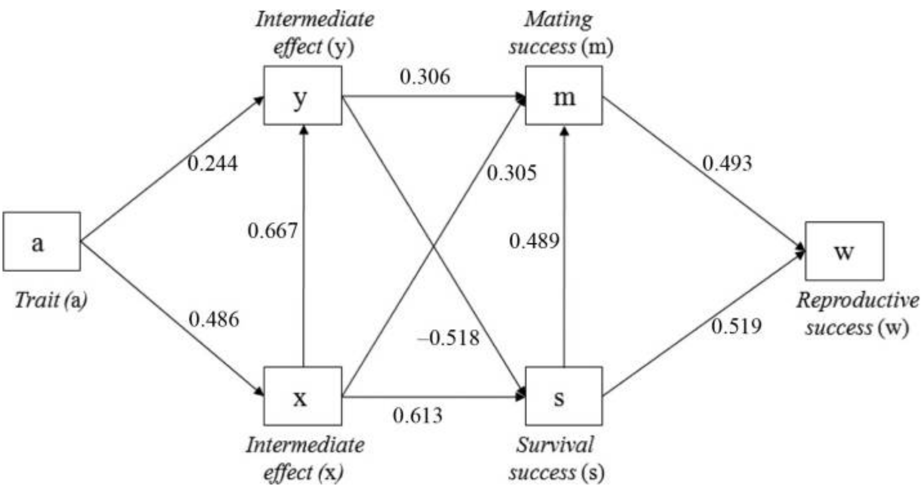


**Figure A1.**
Path model in our evolutionary past with coefficients

**Table AI.**
Number of paths (left) and coefficients (right) for total effects

| Variables | a | x | y | m | s | a | x | y | m | s |
|---|---|---|---|---|---|---|---|---|---|---|
| x | 1 | | | | | 0.486 | | | | |
| y | 2 | 1 | | | | 0.568 | 0.667 | | | |
| m | 6 | 4 | 2 | | 1 | 0.324 | 0.641 | 0.052 | | 0.489 |
| s | 3 | 2 | 1 | | | 0.003 | 0.267 | −0.518 | | |
| w | 9 | 6 | 3 | 1 | 2 | 0.161 | 0.454 | −0.243 | 0.493 | 0.759 |

**Note:** Total number of paths and total effect of "a" on "w" are shown in shaded cells satisfaction with hunter-gatherer group belonging(x) and commitment to hunter-gatherer group (y). In this case, commitment to hunter-gatherer group (y) could conceivably be associated with altruistic group-oriented behavior that detracts from one's own survival. However, here this does not prevent the trait measured by "a" from evolving, because the total effect of "a" on "w", via "x" and "y", is positive. Here the trait measured by "y" is an example of "costly" trait, or evolutionary handicap (Kock, 2011; Zahavi and Zahavi, 1997).

We can illustrate the link between sexual selection and costly trait evolution through a simple example. Altruistic group-oriented behavior that detracts from one's own survival is a general trait that is perceived as attractive by members of the opposite sex, particularly when possessed by males (Miller, 2000). As such, this trait would increase mating success in males who possessed it in our ancestral past, even as the trait decreased those individuals' survival success. If the net effect on reproductive success were positive, as illustrated in the model above, the trait would evolve as a costly trait (Kock, 2011).

The mathematical formalization of the evolution of costly traits presented here leads to a model that subsumes the famous but imprecisely stated "handicap principle". This principle has been verbally put forth by Zahavi (1975). While widely cited, its imprecision has led to much naïve speculation about the evolution of sexually selected traits (Miller, 2000; Zahavi, 1975; Zahavi and Zahavi, 1997), as well as criticism from population geneticists (Smith, 1994, 1998).

## Appendix 2. Measurement instrument used

The question-statements below were used for data collection related to each of the latent variables. They were answered on a Likert-type scale going from "1 – Strongly disagree" to "5 – Strongly agree". Only data from Facebook users were included in the analyses.

Facebook use:

- My social networking sites' account/s are/is a part of my everyday activity.
- I am proud to tell people I'm on social networking sites such as Facebook.
- Social networking sites have become part of my daily routine.
- I feel out of touch when I haven't logged onto social networking sites for a while.
- I feel I am part of the social networking sites community.
- I would be sorry if social networking sites shut down.

Job satisfaction (JSatf):

- I am very satisfied with my current job.
- My present job gives me internal satisfaction.
- My job gives me a sense of fulfillment.
- I am very pleased with my current job.
- I will recommend this job to a friend if it is advertised/announced.

Organizational commitment (OComm):

- I would be very happy to spend the rest of my career with this organization.
- I feel a strong sense of belonging to my organization.
- I feel "emotionally attached" to this organization.
- Even if it were to my advantage, I do not feel it would be right to leave my organization.
- I would feel guilty if I left my organization now.

Job performance (JPerf):

- My performance in my current job is excellent.
- I am very satisfied with my performance in my current job.
- I am very happy with my performance in my current job.

**About the authors**

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