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ARTICLE

Transposing purposeful human action theory and task performance research into the design context

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Abstract

Purposeful human action theory and empirical task performance research inform our understanding of human action and how human action may be improved. The findings of these fields are often assumed to be generalizable across all areas of human activity. Several design theories, however, characterize design as a distinct regime of human action with ill-structured, wicked, and messy qualities. This perspective suggests that insights from other fields about purposeful action and task performance may not be applicable in design. This research addresses the gap between assumptions about human action uniformity across disciplines and design's distinctive characteristics as an ill-structured domain. We proposed analogical reasoning as both an operational framework and an explanatory mechanism for transposing theories from well-structured contexts to design contexts. We demonstrated this approach with two investigations: Testing Kirsh and Maglio's theory of epistemic and pragmatic actions in design contexts and exploring an approach to testing Bavelas's empirical performance studies in design contexts. Our results showed that while some principles of purposeful human action theory and empirical task performance research remain relevant in design contexts, they could also require substantial adaptation. Without adaptation, the findings of both fields may be inapplicable or even misleading when applied to design. We hope this research contributes clarity to the development of design theory as well as to theory applications in design research, education, management, and practice.

Keywords: Purposeful human action; Task performance; Ill-structured problems; Analogy; Research into design

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1. Introduction

Our understanding of human action, and how human action may be improved, is informed by, among other things, purposeful human action theory and empirical task performance research. Purposeful human action theory is developed and applied in a range of disciplines, including psychology, ethics, anthropology, management, and

economics, aiming to describe the factors of collective and individual human action.¹ It seeks to “establish the reasons for actions” by explaining how and why humans engage in intentional, goal-directed behavior.^{2(p15)} In studies of human action, research frameworks typically operationalize complex tasks into smaller and more manageable tasks, with well-defined success criteria and metrics to evaluate actions. Researchers seek plausible patterns of human actions and decision-making processes that lead to goals efficiently. Insights gained from analyzing these smaller tasks were then scaled up and generalized to account for human actions in more complex tasks in broader contexts.³

Task performance research is conducted across multiple fields, including operations management, industrial and organizational psychology, and behavioral science.⁴⁻⁷ It investigates how individuals and groups perform tasks, taking into account both the “action (i.e., behavioral) aspect” and the “outcome aspect” of performance.⁸ The primary aim of task performance research is to determine factors influencing the efficiency and effectiveness of individual or group tasks by identifying “what they are doing right, what they are doing wrong, and where improvements in performance can be made.”^{9(p.306)} For this purpose, researchers commonly employ both basic and applied research¹⁰ to examine a wide range of factors affecting performance. These include personal factors such as attitudes, abilities, and background; situational factors such as workgroup structure, power relationships, facilitation, and type or degree of technological support; task characteristics such as complexity and degree of uncertainty; as well as characteristics of work outcomes such as variability of quality over time, and breadth.¹¹ To assess performance, strategies include “ratings, simulations, outcomes under the control of the individual, or big-data capture.”^{7(p68)} These different strategies enable the examination of performance across multiple contexts, contributing to the development of wide-ranging theories and “multidimensional models of performance.”^{7(p48)}

Purposeful action theory and task performance research both tend to generalize their propositions beyond the specific circumstances from which they originate. Contributions from both fields tend to approach human actions as independent of their (supposedly uniform) disciplinary and professional context. However, such generalized, context-independent conceptions of purposeful human action and task performance contradict portrayals of design practice as different from other work contexts. Such portrayals include the characterization of design problems as ill-structured, in contrast to well-structured problems;¹² the characterization of reflective

open-ended, transdisciplinary, synthesizing practice (including design) as “messes,”^{13(p99)} that is, “dynamic situations that consist of complex systems of changing problems that interact with each other,” and “swampy;”^{14(p42)} and the characterization of design problems as “wicked,” in contrast to “tame” non-design problems.^{15(p160)}

Rittel and Webber’s^{15(p160)} characterization of planning problems as “wicked,” as opposed to “tame,” is a well-established example and a suitable representative for the portrayals of design mentioned. Rittel and Webber proposed the distinction between wicked and tame problems in their critique of using rational, scientific methods for societal challenges, as discussed by Cross¹⁶ and Rittel.¹⁷ Design practitioners, theorists, and educators commonly draw upon the wicked–tame distinction to highlight the challenges that distinguish design from other fields of practice. These challenges, however, often receive limited recognition in general education and professional practice. Despite Rittel and Webber¹⁸ using the term “planning” in their 1973 article, the notion of wickedness has since become closely associated with design. Rittel later stated that design problems “can be called ‘wicked problems.’” According to Rittel¹⁹ and Rittel and Webber,¹⁵ wicked problems are, in essence, open-ended challenges subjected to conflicting criteria that interact reflexively with attempts at solving them, are not amenable to rational solution procedures or clear criteria for successful resolution, and therefore demand creative solutions with inevitable repercussions for multiple stakeholders. In contrast, tame problems are those with relatively straightforward solutions, as rational procedures and unambiguous criteria for their successful solutions can be established or readily available. Rittel and Webber’s wicked–tame distinction, Simon’s ill-structured–well-structured distinction, Ackoff’s notion of “messy” problems, and Schön’s notion of “swampy” problems are all used to divide the broader category of “problems” into design problems on the one hand and non-design problems on the other. For brevity, we will refer to these simply as “ill-structured” and “well-structured” problems (or problem contexts).

Taking design in this sense as a distinct regime of human action and task performance that deserves and depends upon specific aptitudes and sensibilities, one cannot assume explanations of human action originating in other contexts apply equally to design. Nor can predictors of successful task performance in other contexts be assumed to reliably predict success in design. Kirsh^{3(p422)} underscores this with an observation that follows the wicked–tame and the well-structured–ill-structured problem distinctions:

[T]he tasks for which a directed graph representation might be constructed range from

highly structured activities, such as playing solitaire, solving an algebraic problem, or making a curved surface in a graphics program, all cases where there are a small number of possible actions at each choice point, to less formal tasks, such as cooking, cleaning, driving to work, and even writing an essay, for which the actions available at an arbitrary choice point are more difficult to enumerate and success is more difficult to measure.

Accordingly, much design theory is formulated, and much empirical research into/about design^{20,21} is conducted, within the disciplinary context of design research and based on observations of design practice.

Assuming purposeful human action and task performance should be studied and guided differently within and outside of design, the design and non-design distinction presents itself as a possible variable in cross-disciplinary comparative research. The question arises as to what extent the already-existing bodies of design-agnostic purposeful human action theory and task performance research may justifiably be generalized and applied in the context of design. This question defines the scope of this study. It can be approached by suitably adapting, refuting/verifying, and possibly, refining existing purposeful human action and task performance research contributions within design contexts. The lack of such work constitutes a considerable research gap and an opportunity for empirical research in design. To pursue these, design researchers must suitably transpose the hypotheses and experimental designs of existing design-agnostic task performance studies into design contexts. Such transpositions take the shape of analogical reasoning, as is commonly used in design practice.

2. Methods

Hypotheses and experimental designs of existing design-agnostic purposeful human action theory and task performance studies can be transposed into design contexts in several consecutive steps. First, relevant theories or studies established in well-structured contexts would be identified, and their key components and assumptions analyzed. Second, analogies between the well-structured context and the design context would be developed, and analogical prompts formulated. These prompts could then be used to formulate new hypotheses relevant to design contexts. Third, experiments would be designed and performed to test the transposed theories or studies in the design context, followed by the possible refinement of the original theories based on the results of these experiments. This sequence of steps was proposed as a general guide rather than a rigid or formal set of instructions. The first

and third steps were heavily dependent on given research interests and objectives, as they require adaptations on a case-by-case basis accordingly. The second step, however, followed a standard form of performing a form of analogical reasoning commonly used by design researchers in creative practice, followed by formulating prompts that could be used to formulate new hypotheses. The remainder of this section outlines this second step in detail.

Analogies are comparisons across entities that may have little in common, yet are seen as sharing similarities that are worthwhile to connect. They allow understanding and explaining relatively unfamiliar “target domains” in terms of familiar “source domains.”²² Furthermore, analogies enable the formation of innovative relationships between ideas, allowing for more critical reflection on assumptions, improved scrutiny of ideas, legitimization of ideas, increased possibilities of creative relationships development, and recognition of non-trivial commonalities. In this way, analogies enable inferences, abstractions, and thus the generation of new insights.²³⁻²⁵ Accordingly, the ability to draw analogies has been described as a fundamental aspect of human cognition.^{26,27}

Vosniadou and Ortony²⁸ noted that analogical reasoning is, to some extent, dependent on particular bodies of knowledge in whose context they were expressed. Holyoak and Thagard²⁹ pointed out that the intentions behind analogies framed analogical thinking, possibly triggered new questions, and allowed the formulation of new intentions. This, in turn, may affect the way a given analogy was used. With the potential to inspire (consecutive) questions, analogies are essential “metacognitive tools” for creativity and discovery.³⁰⁻³² By comparing a relatively well-known source domain to a relatively unknown target domain, “we can engage in exploratory processes that allow us to see the target in new ways and look for things that we hadn’t previously considered.”^{30(p337)} In this way, analogies could be used for creativity and discovery in the practices of science and design.^{32,33} This use of analogy has been the focus of numerous empirical studies.³⁴ For instance, Casakin and Goldschmidt³⁵ investigated the designerly use of visual analogies, noting that analogies were catalysts for enhancing designerly skills. Ball *et al.*³⁶ examined the spontaneous use of analogy and demonstrated its prevalence in creative, real-world problem-solving in the practice of both expert and novice designers. Analogies, in short, are thought of as catalysts for (creative) thinking. They offer means to facilitate and explain understanding, and to sustain creative inquiries by stimulating consecutive questions.

Analogical reasoning is commonly employed in the formulation of creative design prompts (sometimes referred

to as design cues).^{37,38} Here, we focused on a particular form of analogical design prompt, which could be described as an amalgamation of *formal analogies* and the *Indian Rule of Three*. The *formal analogies* are of the form *A is to B as C is to D*, which is to say that the relationship between *A* and *B* resembles that between *C* and *D*.³⁹ For example: “A fish is to water as a bird is to air.” The *Indian Rule of Three* is a long-term staple of middle school mathematics education used to solve proportionality problems. A typical example is “If 6 mangoes cost 8 copper coins, how much will 15 mangoes cost?”⁴⁰ or, in a generalized form,

$$A \triangleq X$$

$$B \triangleq ? \quad (I)$$

While the *Indian Rule of Three* prompts for single, correct solutions of quantitative proportionality, the form of the analogical design prompt discussed here aims to stimulate divergent explorations of unexpected, qualitatively rich possibilities. It has the general form “If this kind of *x* is like that kind of *y*, then what kind of *x* is like that kind of *y*?” A prompt of this kind was used in the design of a project titled *ComEputer* by a bachelor’s student of industrial and product design, Kuen Yee Pierre Pang, in 2007 at the School of Design, The Hong Kong Polytechnic University.⁴¹ *ComEputer* is shown on the right of [Figure 1](#). Pang embarked on this project with an interest in technical objects and interfaces, a collection of steampunk and junk art references, and an ambition to “challenge the consumerist denial of the beauty of life.” To give the project a more specific direction, the project’s supervisor prompted Pang: “If a Mac Mini computer is like an aerodynamic speed skater, then what kind of computer would be like Captain Jack Sparrow?” In the following weeks, this question was found to have served three distinct purposes: It helped the teacher formulate a creative challenge (prompt and give direction to the design process); it facilitated explorations in response to the challenge (guide the design process);

and it helped account for creative choices made (report on the design process). These purposes were accomplished with visual representations of the design prompt in the generalized form of the *Indian Rule of Three* as shown on the left of [Figure 1](#).

This form of the analogical prompt is applicable not only in the practice of design but also in academic design research. More specifically, among three kinds of design research distinguished by Frayling²⁰ and Findeli,²¹ it is particularly applicable in research into/about design where it can be used to transpose existing purposeful human action theory and task performance research from non-design contexts into design contexts. This can help refute or verify, as well as differentiate or correct, previously established insights. In such transpositions, said analogical prompts can serve both as an operational heuristic (enabling the identification and structuring of opportunities for research and theory formulation) and as a *post facto* explanatory rationale (reporting and justifying motivations and frameworks of research and theoretical propositions). Generalized, said transpositions have the following form: “If insight *x* arises from inquiry *y* in non-design contexts, then what insights arise from applying a suitable analog of inquiry *y* in design contexts?” The second half of this analogical prompt can then be used to craft an if-then statement pertinent to the design context to serve as a hypothesis to be tested empirically.

3. Results

We presented two research into/about design studies based on such transpositions, one being a test of a theoretical distinction in purposeful human action theory by Kirsh and Maglio, which is currently being conducted as a PhD project, and the other being a possible test of a task performance study by Bavelas, outlined at a preliminary level. We had chosen these two bodies of work for the purposes of this discussion because they were based on two

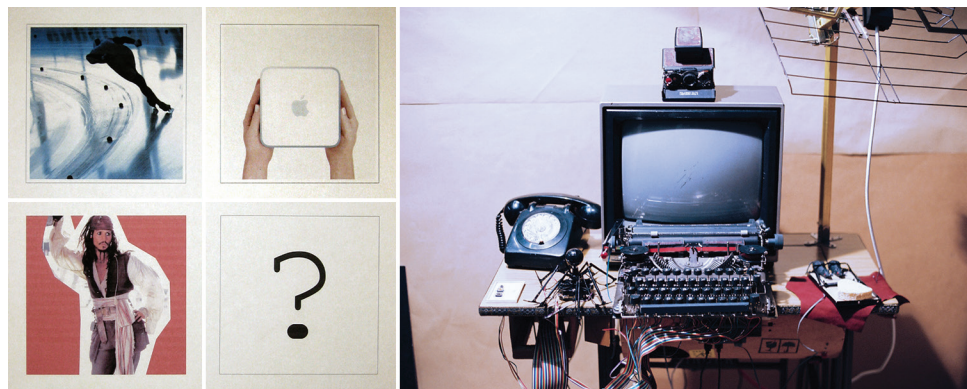


Figure 1. Detail of final presentation board (left) and functional prototype (right) of *ComEputer* designed by Pierre Pang under the supervision of Thomas Fischer

well-known empirical studies whose experimental designs rested on obviously well-defined, closed-ended tasks. The generalizability of findings implied in either study may not apply to design, given that design was characterized as a distinct regime of human action with ill-structured, wicked, and messy qualities. To test the generalization of their findings, we transposed and adapted both studies for re-evaluation in design contexts.

3.1. Epistemic and pragmatic actions

Kirsh and Maglio⁴² published a series of studies in the 1990s and early 2000s, in which they put forward their distinction between epistemic and pragmatic actions. This distinction challenged earlier conceptions of purposeful human action as linearly goal-directed, with planning (i.e., “problem exploration and analysis,” according to Cross¹⁶) being a prerequisite to subsequent execution (i.e., “solution synthesis,” according to Cross⁴³). An example of this linear view on purposeful human action is Archer’s description of design as a process consisting of an analytical, a creative, and an executive phase.⁴⁴ Schön,⁴⁵ Suchman,⁴⁶ Kirsh and Maglio,⁴² Glanville,⁴⁷ and, to some extent, Rittel and Webber¹⁵ noted that this linear and comparatively reductionist view was prevalent across early theories of design, reflecting attempts to scientize and prescribe design practice and research.¹⁶ In contrast, more recent theories described human action in general and designed activity in particular, as circularly “argumentative,” “reflective,” or “conversational.”^{15,43,45,47-49} Kirsh and Maglio⁴² challenged the above-described earlier theories of purposeful human action by testing the assumption that “the point of action is always pragmatic” and that “understanding” necessarily precedes “acting.” To this end, they conducted an empirical study of players tackling the well-structured classic video game Tetris. We outlined our transposition of Kirsh and Maglio’s experiment from the well-structured context into the ill-structured context.

In Tetris play, various shaped pieces fall from the top and stack up at the bottom of the game’s visual interface as illustrated in Figures 2 and 3.⁴² As it falls, the player can rotate and move each piece horizontally. The goal is to fill horizontal rows without gaps, thereby dissolving them. The process of a piece coming into play at the top, traveling downward while being manipulated by the player, coming to rest at the bottom, and potentially resulting in the dissolution of rows is called a Tetris episode. A game consists of consecutive episodes during which the speed of the falling pieces increases gradually. During each episode, the preferable target position (or one of multiple equally preferable positions), and the shortest path toward it is unambiguously clear in principle. Their identification, however, becomes cognitively more and more taxing as the

game speeds up. This results in an increasing portion of pieces being misplaced and lines not being dissolved. Once the full height of the interface is filled with undissolved rows, no more pieces can enter from the top, ultimately ending the game.

Employing an implementation of the game that was modified to record player actions during game play, Kirsh and Maglio⁴² observed that players did not always move pieces directly toward their preferred positions. Instead, players frequently moved pieces temporarily away from their preferred positions. Kirsh and Maglio⁴² divided these player actions into two categories, which they labeled as *pragmatic actions* and *epistemic actions*. They described *pragmatic actions* as directly pursuing clearly determined goals (Figure 2). In contrast, Kirsh and Maglio⁴² as well as Loader⁵⁰ described epistemic actions as probing the game environment with a view to improving understanding of possible goals and actions to achieve them, as shown in Figure 3.

This categorization of human action reflects Glanville’s⁴⁷ later distinction between “understanding in order to act” and “acting in order to understand.” Kirsh and Maglio noted that typical Tetris play was characterized by an interplay of the two kinds of action and that earlier linear and reductionist theories failed to account for the differences or the interplay between both categories. Kirsh and Maglio⁴² extended their findings beyond problem-solving in Tetris play, stating that “if epistemic are found in the time-limited context of Tetris, they are likely to be found almost everywhere” and that their distinction “holds generally throughout all of human activity.”^{42(p548)}

The ongoing PhD project described here⁵¹ tested this generalization. Designing, with its ill-defined goals and absence of predefined and predeterminable units and criteria of analysis, differs notably from Tetris play.¹⁵ This allowed transposing Kirsh and Maglio’s study from the domain of well-structured problems to that of ill-structured problems with the following research-about-design prompt: *If observations of Tetris game play expose epistemic and pragmatic actions, then what kinds of action can be discerned in the ill-structured context of design?* Figure 4 illustrates our extension of Kirsh and Maglio’s theory formulated in the well-structured context of Tetris to the ill-structured context of design.

We conducted an empirical lab study of six designers. Of these, two were digital design novices, two had intermediate skills, whereas the remaining two had advanced skills (according to their self-categorization in a pre-observation questionnaire). We asked the subjects to design a space partitioning and shelving system for a retail space using Grasshopper in Rhino3D. The design briefly

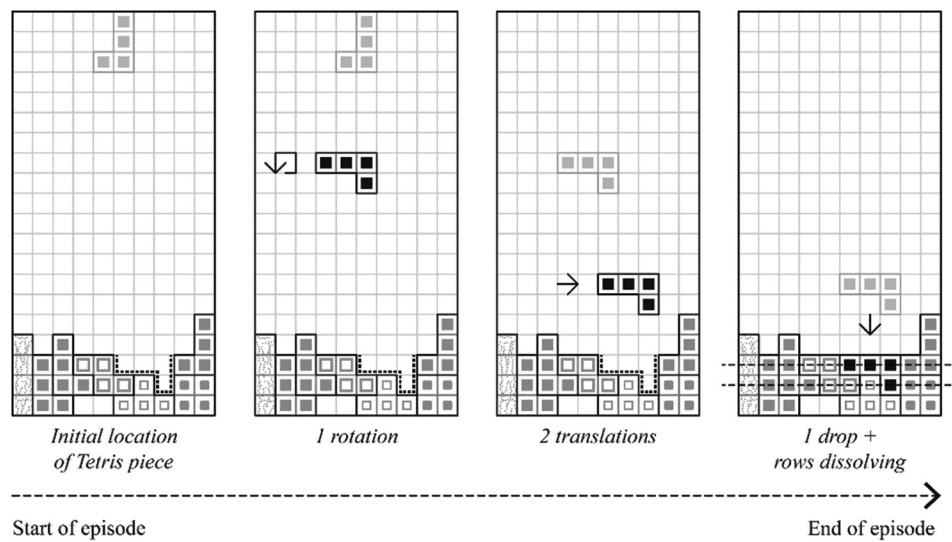


Figure 2. Tetris episode exemplifying pragmatic actions

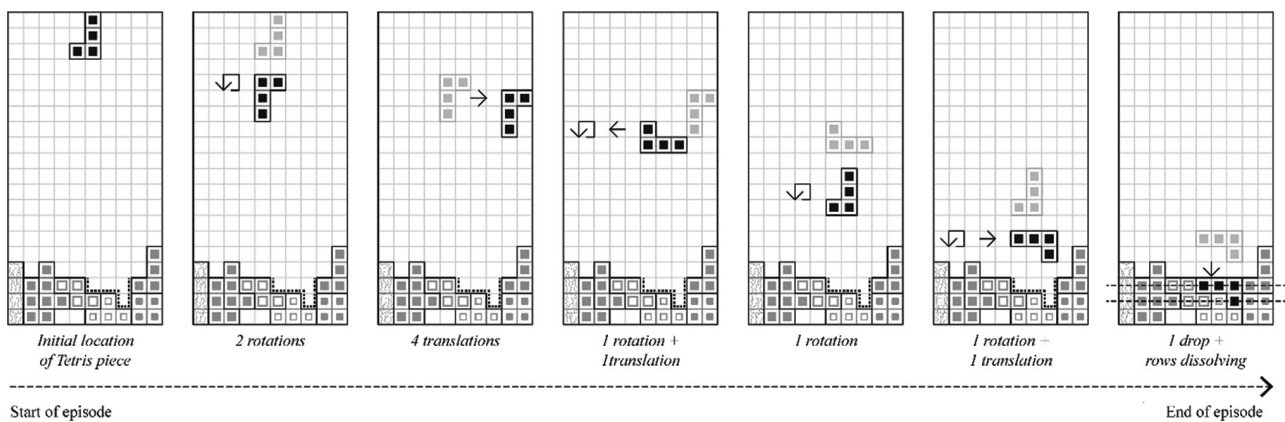


Figure 3. Tetris episode exemplifying epistemic actions

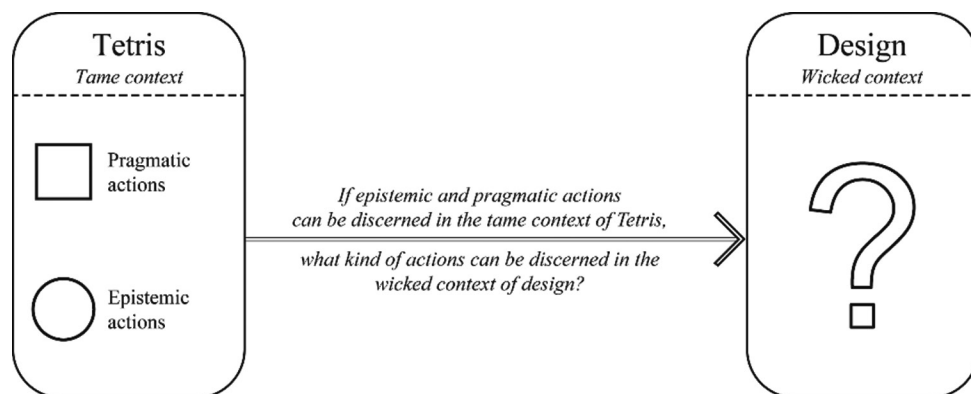


Figure 4. Transposition of Kirsh and Maglio's theory into the digital design context

asked for a paneled approximation of a double-curved surface on the back and a compartment configuration on

the front of the space partitioning and shelving system.

This required subjects to develop suitable geometry rationalization strategies during their design processes. To capture the development of these strategies, we asked the subjects to concurrently think-aloud during their digital design processes.⁵²⁻⁵⁴ Following initial supervised technical setup stages, we observed the design processes of all six individual subjects remotely via video conferencing software. Each of the six design processes lasted between 60 and 105 min. During these processes, we collected qualitative data in the form of audio and video recordings, which were transcribed and consolidated in two parts: *Records of observable actions in the external environment (freehand sketching as well as interactions with Rhino3D and Grasshopper)* and *transcripts of recorded think-aloud thought process verbalizations*.

In contrast to Tetris, with its well-defined goals and metrics, the design here was characterized as ill-defined and open-ended goals with an absence of units to measure and analyze actions.^{15,55} For this reason, design processes could neither be segmented into predefined temporal episodes nor evaluated in terms of known, well-defined goals.⁵⁵ To identify different types of action, and to understand their possible interplay in the design process, we aimed to analytically discern pragmatic and epistemic design episodes by determining links between pragmatic and epistemic “objectives” (i.e., goal setting) and “fulfillments” (i.e., goal attainment).^{56,57} To this end, we analyzed the datasets we acquired using a coding scheme (Table 1) based on Schön’s⁴⁵ reflective practice theory and the linkography method developed by Goldschmidt^{58,59} (Table 2). Linkography is a method used to visually represent and analyze the “how” and “what” of design processes. The coding scheme represents each design episode identified by the coder as consisting of “microlevel” actions starting with a subject’s setting of an objective, followed by “move experiments” toward fulfilling the stated objective, then by a reflection on the

extend of fulfillment of that objective, leading to another cycle with the same pattern.^{60,61}

We transcribed, segmented, and coded the observed design processes and recorded these data in protocol tables. These tables are structured temporally along vertical time axes, as shown in Table 2. Once coded, we linked actions using the linkography notation. In this diagramming approach, recorded actions and ideas from segmented protocol data are mapped and linked chronologically, resulting in bottom-up, quantitative depictions of design activity within distinct time frames.⁶¹ Using this method, we determined links such as “backlinks” and “forelinks” among the recorded actions, as shown in the “Linkograph” column of Table 2.⁶¹

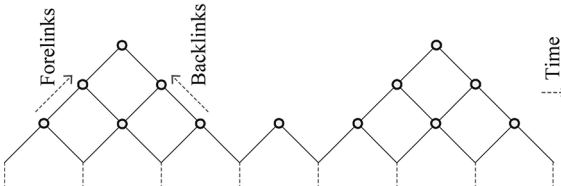
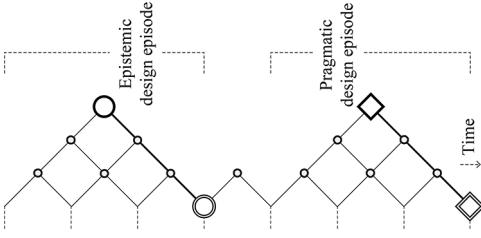
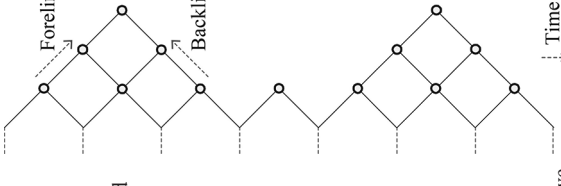
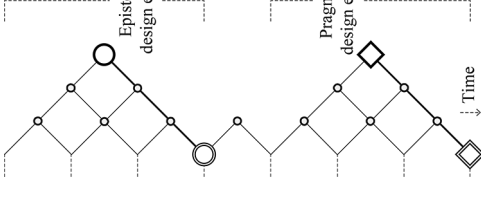
Based on the initial version of these linkographs, we further examined pertinent verbalizations of identified design objectives as well as their respective possible fulfillments to categorize each as either epistemic or pragmatic. For this categorization process, we employed a reasoning approach known as “inference to the best explanation.”⁶⁷⁻⁶⁹ The “evidence” we used for this categorization included qualitative indicators from the recorded design protocols, and quantitative indicators (i.e., backlinks and forelinks) from the linkographs. For example, a subject verbalized an objective to “act in order to see what the action leads to,” and engaged in “explorative moves” (“What if...?”), we categorized the respective objective as epistemic.^{70(p145)} In contrast, if a subject verbalized an objective to act “in order to produce an intended change,” and engaged in “move-testing” actions (“Let’s do x.”), we categorized the respective objective as pragmatic.^{71(p146)}

To categorize the fulfillments, we examined instances in which subjects reflect on their designed “geometry” (i.e., “proposal” or “solution”) present in one of the observed external environments. If we observed the geometry remaining “fixed” (i.e., it had stopped evolving) and forming

Table 1. The coding scheme employed in this study

Actions		Definitions	Interplay of actions	
Setting of an objective		An act involving a designer verbalizing an aim to change their design situation in order to attain “desirable” or “good enough” outcomes. ^{62,63} In other words, “goal setting.”		
Moving		An act involving a designer pursuing actions based on their initially set objectives in order to “generate both a new understanding of the phenomena and a change in the situation,” that is, creating outcomes. ⁶¹		
Perceiving a fulfillment		An act involving a designer seeing that outcomes resulting from their previous move actions are “desirable” or “good enough.” ^{56,64} In other words, “goal attainment.”		
Reflecting		An act involving a designer listening to their design situation’s “back-talk” ⁶⁵ and “possibly coming up with a completely unexpected, new insight.” ⁶⁶		

Table 2. Protocol table, linkograph, and extended linkograph

Time	Transcribed data		Pre-analysis phase		Coding phase		Analysis and descriptive categorization	Analysis phase	
	Partial verbatim data	Actions observed in external interfaces	Contextual description of activities	Descriptive and process coding	Codes	Linkograph		Extended linkograph	
00:15:43	I will try different stacking configurations of the compartment units for the front side of the shelving system. I think I will generate around 3 configurations and choose one of them later on.	In Rhino, the subject permutes different compartment units in order to find a possible stacking configuration.	In this phase, the subject is designing different stacking configurations of compartment units. They verbalize an aim to generate three different stacking configurations from which they will choose later during the design process.	Setting an objective to design and permute different compartment units. [RH] The subject is stacking and arranging different units together to form different clusters. Reflecting on the outcome.	O M R F	It appears as if the subject aims to act in order to generate tentative design artifacts. The design objective can be described as epistemic.			
00:16:31	Generates three stacking configurations of compartment units.								
00:25:18	Now that I have a configuration, I can extrude it to create a solid. I will just do this manually... No need to use Grasshopper here.	In Rhino, the subject extrudes the 2D curves of the stacked units.	In this phase, the subject verbalizes an aim to generate a solid extrusion of a previously generated outcome.	Setting an objective to extrude the 2D curves. [RH] The subject is performing solid extrusions of the 2D curves. Reflecting on the geometry.	O M R F	The objective is not forelinked to explorative moves. It seems there is a possible range of design artifacts that can be expected from the objective – it can be described as pragmatic.			
00:31:43	Generates a solid extrusion from the 2D curves of the stacked compartment units.					The subject's verbal data and linkographic links indicate that the geometry is not forelinked to any other variations of itself. Therefore, it can be described as pragmatic.			

a part of the overall shelving system, then we would label it a pragmatic fulfillment (“That’s good enough, let’s keep it.”) In contrast, the subject would be labeled as an epistemic fulfillment (“I see a way to improve this.”) if we observed the geometry to be subject to further reconsideration and change. We then revised the linkographs with our descriptive categorization of each action, extending it with a more differentiated notational vocabulary. In this extended notational vocabulary, we represented pragmatic objectives and fulfillments as squares, and their epistemic counterparts as circles (as shown in the “Extended Linkograph” column in Table 2). We identified a minimum of 70 and a maximum of 110 design episodes in the six design protocol datasets.

In the extended format, our linkographs showed that epistemic and pragmatic actions were not necessarily mutually exclusive. We often observed pragmatic design objectives yielding epistemic fulfillments and vice versa. On several occasions, design episodes turned into dead-ends (“This doesn’t work; let’s see if there are better ways forward.”), which we visualized using the + symbol in the two diagrams shown on the right of Figure 5. Overall, we found the design episodes we identified to fall into a total of six distinct relationships starting with either pragmatic or epistemic objectives and ending with pragmatic, epistemic fulfillments, or dead-ends.

To some extent, these findings are in accordance with Kirsh and Maglio’s distinction between pragmatic and epistemic actions and reassert the distinction’s merit in the rejection of earlier linear purposeful human action theories. However, our findings also show that Kirsh and Maglio’s distinction, originally formulated based on observations made in the well-structured context,

has slightly more than a reductive, descriptive value in the context of design. We argue that the six analytical categories of design episodes shown in Figure 5 account better for the empirical observations we make in the ill-structured design context than the binary distinction proposed by Kirsh and Maglio. Thereby, our work not only extends an established distinction between epistemic and pragmatic actions in design; it also offers an extended linkography notation that supports both kinds of action in design and promises general utility for empirical design research.

3.2. Communication patterns in problem-solving groups

The second project is outlined here at a preliminary, speculative level to indicate the broader applicability of the described approach. Similar to the test and refinement of Kirsh and Maglio’s purposeful human action theory, it transposes an experimental task performance study of problem-solving groups conducted by Bavelas⁷² from the well-structured problem domain to the ill-structured domain. Based on earlier work that resulted in models of the mathematical properties of group structures and earlier experimental work based on these models,⁷²⁻⁷⁵ Bavelas’ study investigated groups of five collaborators tasked with the solution of closed-ended (i.e., well-structured) problems using experimentally controlled communication patterns (Figure 6). The independent variable investigated was the groups’ experimentally determined communication pattern, with its effects on the dependent variables, namely the groups’ task performance and “morale.”⁷² The groups were asked to perform one of two closed-ended tasks, with group members communicating using written messages

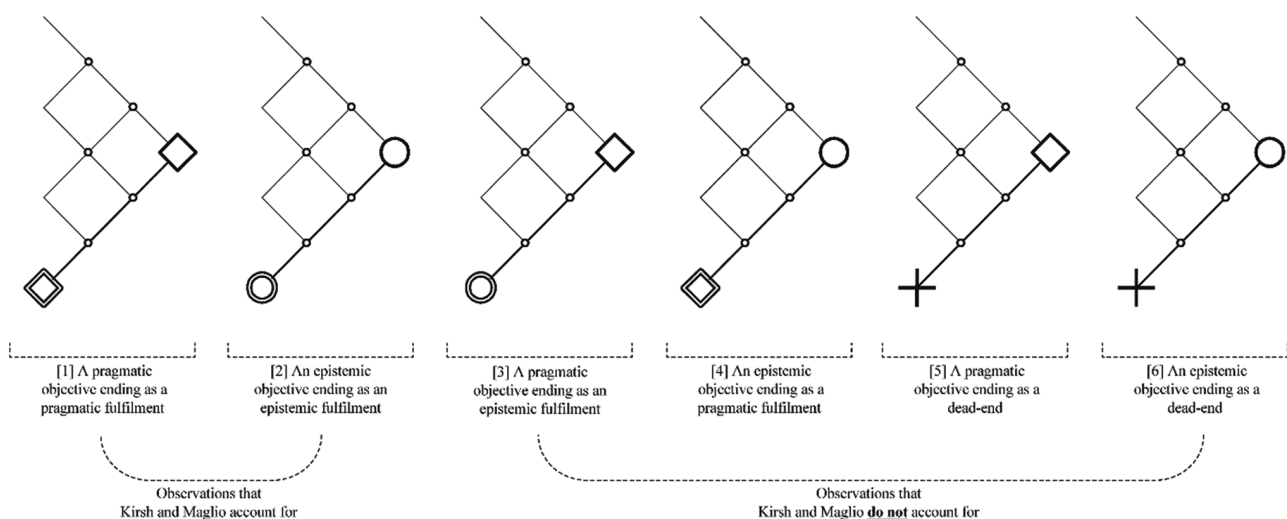


Figure 5. Six different relationships between objective setting and objective (non-)fulfillment in observed design episodes

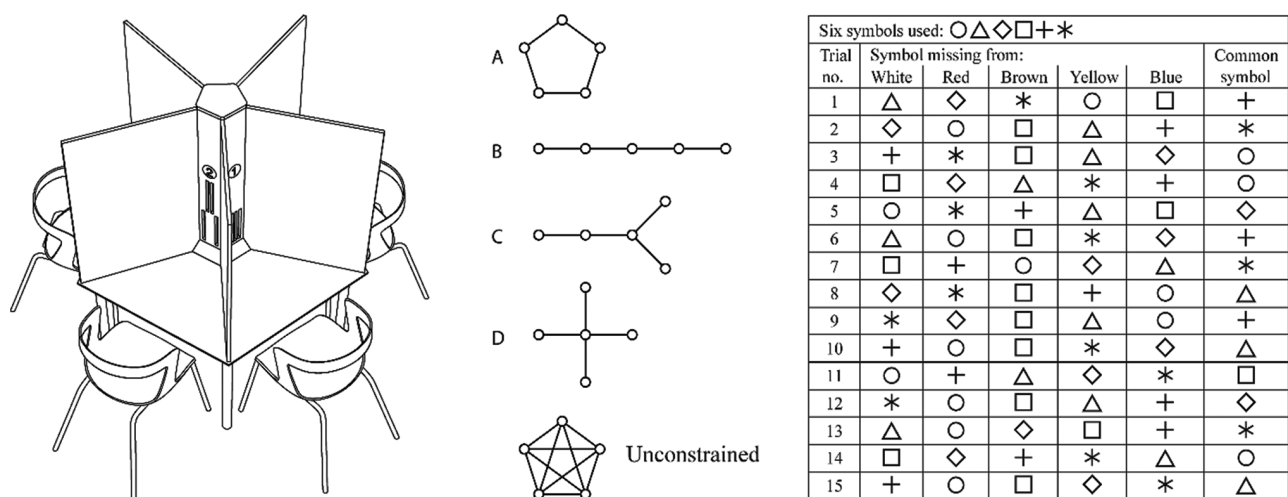


Figure 6. Experimental setup used in Bavelas' study (left, based on Guetzkow and Simon⁷⁷), communication patterns (center, redrawn from Leavitt⁷⁴), and possible combinations of symbols on the cards (right, redrawn from Leavitt⁷⁴)

via prescribed channels that determined each group's communication pattern.^{74,76}

The first task assigned to the groups was to identify a missing card from a deck of six cards. Each of the six cards showed five symbols of a set of six symbols, as indicated on the right of Figure 6. With one of these six cards removed randomly, the remaining five cards had only one symbol in common. At the beginning of each group observation, every group member received one of the five selected cards. The group members were seated in five booths in a pentagonal configuration, as shown on the left of Figure 6. They were asked to identify the missing card using written messages only. Messages could be exchanged only via some channels established by the experimenters ahead of each group observation by opening and or closing slots in the partition walls between the five booths, shown on the left of Figure 6. The selection of open slots corresponded to the group communication pattern (Figure 6) of each given experimental session. The task was considered accomplished when all members of the group signaled that they had the answer.

The second task was identical to the first task, but the differences between the symbols on the cards were significantly more subtle, increasing the difficulties for them in describing the symbols. Both tasks were closed-ended in the sense that in either case, there was one and only one correct solution.

Bavelas observed significant effects of the communication patterns used (primarily representing the degree of centralization or decentralization) on both groups' task performance effectiveness and the task satisfaction perceived by group members. Some of these effects on

task satisfaction had been observed to be considerable, including significant frustration, disengagement, and even the disintegration of workgroups, and hence the non-accomplishment of group objectives.

This raised the following design research prompt: *If different group communication patterns result in varying levels of task performance and satisfaction in well-structured problem solving, then what effects do different group communication patterns have on task performance and satisfaction in the ill-structured context of design?* With the goal of the card-identification task being well-defined, it would be worthwhile to conduct an analogous study of the effects of communication patterns within groups tackling ill-structured design tasks, with a view to effective task completion and task satisfaction, and possibly other dependent variables such as tendencies toward cooperation versus collaboration within groups, as well as the creative or innovative value of the design outcomes.⁷⁸ Further possible independent variables that could be studied include levels of subjects' expertise (i.e., design experience) and, given the contemporary prevalence of online project work, the mode of work online versus offline. This is illustrated with a schematic view of two possible experimental settings, offline and online, in Figure 7. In the online variant, subjects would be placed separately, connected via a computer network with experimentally configurable communication patterns.

4. Discussion

Based on a review of related literature, we argued that much research into purposeful human action, task performance, and how they may be improved has emerged from studies set in well-structured task performance contexts. Explicitly or implicitly, insights gained through such work suggest

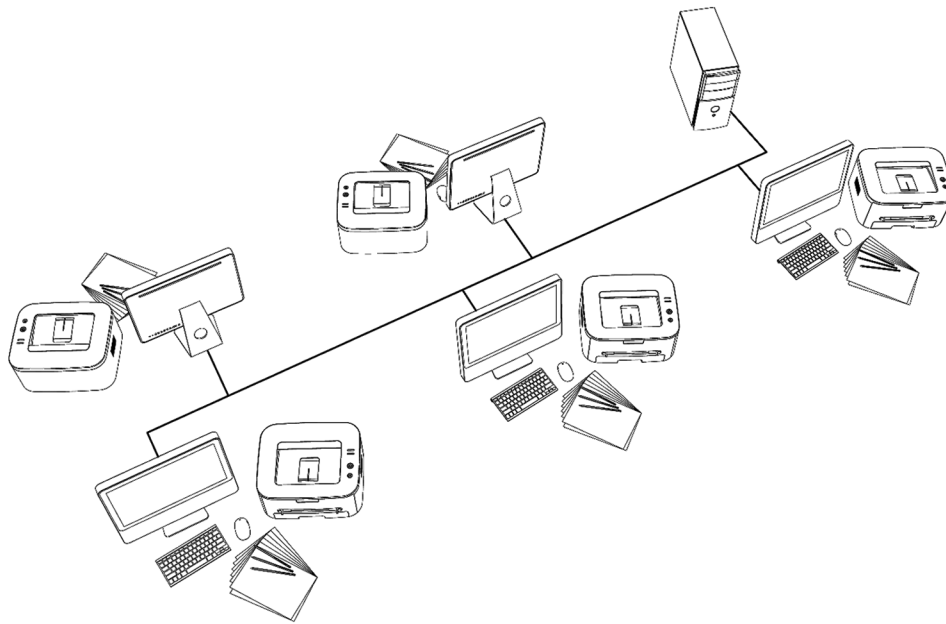


Figure 7. Online setting for a study analogous to the description of Bavelas' experiment by Guetzkow and Simon⁷⁷

generalizability across all human task performance contexts. Examples can be found in purposeful human action theory and empirical task performance research. Design, however, has repeatedly been characterized as constituting a distinct regime of human action and task performance deserving and requiring specific aptitudes and sensibilities. This calls into question the generalizability and, therefore, the validity of the “design agnostic” purposeful human action theory and empirical task performance research that developed in well-structured task performance contexts. We argued that this questionability constitutes not only a considerable research gap but also an opportunity for empirical research into/about design. To enable the pursuit of these, we proposed a standard form of analogical reasoning to serve both as an operational heuristic and as *post facto* explanatory rationale. This analogical reasoning guided the transpositions of existing theories of purposeful human action and empirical task performance research from well-structured contexts into ill-structured contexts. We demonstrated this approach with the transposition of two projects.

One of the projects was a purposeful human action theory proposition by Kirsh and Maglio. Based on observations of Tetris play, Kirsh and Maglio distinguished between epistemic (acting in order to understand) and pragmatic (understanding in order to act) actions. Furthermore, they postulated a mutual interdependency between the two types of action, challenging earlier conceptions of purposeful human action that held understanding must necessarily precede acting. We

transposed Kirsh and Maglio's study into the context of design and observed not only the two interdependent kinds of action described by Kirsh and Maglio but also a more differentiated outcome. Specifically, we observed “design episodes” that began with epistemic objectives and ended with pragmatic fulfillments, and vice versa. Additionally, we observed design episodes that began with either epistemic or pragmatic objectives but ultimately reached dead-ends, contributing neither epistemic nor pragmatic fulfillments to the remaining design processes. Instead of Kirsh and Maglio's distinction between the two kinds of action, our observations suggested a distinction of six different relationships between objective setting and objective (non-)fulfillment.

The second project we proposed for a transposition from a well-structured context into an ill-structured context was an empirical task performance study by Bavelas. In this study, groups of five were tasked to jointly perform a closed-ended deductive reasoning task by exchanging messages only via experimentally controlled patterns of communication. Bavelas observed significant effects of the communication patterns used on both group's task performance effectiveness and task satisfaction perceived by group members. Some of these effects on task satisfaction were considerable, including significant frustration, disengagement, and even the disintegration of workgroups, and hence failing the group objectives. We discussed a preliminary, speculative on transposing a well-structured context into an ill-structured context from offline to online communication.

Although the transposition of existing purposeful human action theory and task performance research is necessary and important, it is likely to encounter conceptual and practical challenges. We concluded by briefly outlining three potential challenges. First, much of the existing research on purposeful human action theory and task performance originates from well-structured contexts, with clearly defined units of observation and unambiguous analytical criteria. Such clarity is absent in the ill-structured context of design. For example, “Tetris episodes” offer clear beginnings and endings of (i.e., the appearances of new bricks on top of the screen and the end of their falls) as well as clear criteria for success or failure in Tetris play. In typical design work, however, such correspondents are not readily available. Identifying units of observation and analytical criteria in the ill-structured context of design tends to be challenging, as it requires significant subjective interpretation from the researcher. This is common in research into/about design, and the issues of reliability and generalizability remain an ongoing challenge.

Second, testing the validity of existing research across varied disciplinary and professional contexts is subject to the conflict between rigor and relevance.⁷⁹ Rigor requires the control of variables of research laboratory standard with clear observational units and unambiguous analytical criteria, which is typically available in well-structured contexts. In contrast, practical relevance requires proximity to applied (in this case, design) practice. In this tension between rigor and relevance, key aspects that contribute to ill-structured contexts such as multi-stakeholder social entanglements and implications of design, can be in conflict directly with core criteria of rigorous research.

Last but not least, the need for the proposed transposition of existing purposeful human action theory and task performance research from well-structured contexts into ill-structured contexts may be seen as part of the broader “replication crisis” of academic research, constituting a need for “conceptual replication,” aiming “to assess [the] generalizability, as well as [the] veracity, of [an earlier] result.”^{80(p492)} This alignment of the proposed research to replication research may conflict with the “imperative for originality” sometimes encountered in design research.^{81(p.247)} As a result, it may limit research interest in, and possible funding support for, the research approach proposed here.

5. Conclusion

We have presented a strategy for the transposition of purposeful human action theory and task performance

research from well-structured contexts into the ill-structured domain of design. In accordance with several previous characterizations of design, we argued that there is a gap between assumptions of human action uniformity across disciplines and design’s distinctive characteristics as an ill-structured domain. We proposed analogical reasoning as both an operational framework and explanatory mechanism to adapt purposeful human action theory and task performance research originated in well-defined contexts for study in design contexts.

Our examinations of Kirsh and Maglio’s epistemic and pragmatic actions theory and Bavelas’s communication patterns studies show that while some of their principles remain relevant in design contexts, others require substantial adaptation and testing for application in design. In the case of Kirsh and Maglio’s binary distinction between epistemic and pragmatic actions, such adaptations led us to propose a more differentiated set of six analytical categories. Similarly, our preliminary work on communication patterns suggests avenues for adaptation and testing in design.

Some challenges emerged in our attempts to transpose existing purposeful human action theory and task performance research to design: The absence of clear observational units and analytical criteria in ill-structured contexts, the tension between research rigor and practical relevance, and the potential conflict between replication and the imperative for originality in design research. Despite these challenges, this approach offers promising and potentially valuable opportunities to refine existing theories and develop more nuanced understandings of design processes. We hope that, by bridging the gap between well-structured theories and ill-structured design contexts, this work contributes to the development of design theory and offers practical insights for design research, education, management, and practice.

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Author contributions

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Writing – original draft: All authors

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Ethics approval and consent to participate

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Consent for publication

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Availability of data

Data supporting the findings of this study are available from the corresponding author.

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