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# Shareability: novel perspective on human-media interaction

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Interpersonal communication in the twenty-first century is increasingly taking place within digital media. This poses the problem of understanding the factors that may facilitate or hinder communication processes in virtual contexts. Digital media require a human-machine interface, and the analysis of human-machine interfaces traditionally focuses on the dimension of usability. However, interface usability pertains to the interaction of users with digital devices, not to the interaction of users with other users. Here we argue that there is another dimension of human-media interaction that has remained largely unexplored, but plays a key role in interpersonal communication within digital media: shareability. We define shareability as the resultant of a set of interface features that: (i) make sharing of materials with fellow users easy, efficient, and timely (sharing-related usability); (ii) include features that intuitively invite users to share materials (sharing-related affordances); and (iii) provide a sensorimotor environment that includes perceptual information about both presented materials and the behavior of other users that are experiencing these materials through the medium at hand (support to shared availability). Capitalizing on concepts from semiotics, proxemics, and perceptual and cognItive neuroscience, we explore potential criteria to asses shareability in human-machine interfaces. Finally, we show how these notions may be applied in the analysis of three prototypical cases: online gaming, visual communication on social media, and online distance teaching.

KEYWORDS

**shareability, usability, human-media interaction, interpersonal communication, online gaming, social media, online teaching**

## Introduction

Interpersonal communication in the twenty-first century is increasingly taking place within digital media. According to recent estimates, approximately 66% of the world population is now using the internet (Kemp, 2022), and world internet users spend several hours online each day. Social media occupy the largest single share of this time, averaging almost 2 and half hours daily (35% of the our connected time; Clement, 2020). These social phenomena have been greatly sped up by worldwide lock-downs during 2 years of the SARS-Covid 19 pandemic, which has favored the extension of digitally mediated interpersonal communication to older generations, its widespread use in smart working arrangements, and its application to distance teaching via newly developed applications (e.g., Legrenzi and Jacomuzzi, 2020). Videoconferencing applications are now routinely used not only for work-related meetings, but also for at-a-distance family gatherings or for keeping up with distant friends. Performances by musicians recording their parts within a digital medium while being in different locations abound on platforms such as YouTube. Users of media such as Instagram or Facebook routinely share pictures showcasing themselves, their meals, their holiday sites, books they are reading, or their latest work or travel mishap – patiently waiting for reactions in the form of likes, emoticons, text comments, or replay images. A large part of our social interactions thus no longer occur within real life exchanges but within virtual media constrained by human-machine interfaces. This is a novel development in our cultural evolution, which calls for novel conceptual tools to understand it and improve it where appropriate.

Current analyses of human-machine interfaces focus on usability (Nielsen, 1993). However, the notion of usability encompasses features that are relevant to understanding interactions of users with digital devices, and is only marginally useful to understand the human-human interactions which are the focus of our interest here, namely, the interactions of users with other users within digital media. Although this second interaction is conceptually distinct from the first, it is nonetheless fundamentally constrained by it. In this paper, we propose that a key element of such constraints rests in a largely unexplored, separable dimension of human-media interaction: shareability. Specifically, we propose that shareability can be conceived as an hidden dimension which is relevant to understand digital interfaces that are designed for secondary human-human interactions, such as sharing of multimedia contents, teleconferencing, online teaching, and gaming. Capitalizing on a set of concepts from semiotics, proxemics, and perceptual and cognitive neuroscience, here we propose a conceptual analysis of the psychological dimensions underlying shareability. We suggest that such an analysis will prove useful to develop qualitative and quantitative methods to asses shareability and to develop criteria and guidelines for design.

To this aim, in this perspective paper here we do four things. First, we offer a brief review of concepts and methods in usability assessments. Second, we introduce models of communication as they apply to digitally mediated interpersonal interactions, showing how these point to features of communication that are poorly captured by usability dimensions and highlighting how the sharing of experiences plays a key role in these communication processes. Third, we introduce the notion of shareability as an additional dimension of human-media interactions as substrates for secondary interpersonal communication. Taking stock on this tripartite conceptual analysis, we then identify domains that are relevant to asses shareability in human-media interfaces and that may ultimately form the basis for design criteria and guidelines. In the fourth and final section, finally, we show how these considerations apply to the analysis of three prototypical cases: online gaming, visual communication on social media, and online distance teaching.

## Usability

Scientific interest in the usability concept is rooted in studies of human-machine systems, human factor engineering, and cognitive ergonomics (Badre and Laskowski, 2001). Between the 1970s and 1980s, a flurry of psychological research on human-computer interactions strove to understand the impact of computer science on human operators. These attempts defined the relationship of man and computer by exploiting Licklider (1960) concept of symbiosis. According to Licklider (1960), human computer-interactions involve an interdependent relationship between two agents aimed at achieving the same goal: on one side, the human operator with is more engaged in global tasks, overall strategic decisions, and creative solutions; on the other side, the computer (or, more accurately, software running on the computer) which is able to perform local rote functions rapidly and accurately. From these analyses, two parallel and linked notions emerged: the "user interface", often also called the GUI (Graphic User Interface) and its usability (Badre and Laskowski, 2001). According to Nielsen (2003), usability can be defined as a "quality attribute", which "captures to what extent an interface is easy to use".

Six features are typically listed (Cronholm and Bruno, 2009; Nassar, 2012) as the key factors affecting usability in human-computer interfaces:

(i) *consistency* in adopted conventions and commands, such that users will need to learn them only once; ease of learning, both for first-time users and for users that come back after idle periods;
(ii) *control*, such that users are enabled to autonomously define how the interaction unfolds, for instance, by moving across screens or undoing previous operations;
(iii) *error management*, including features aimed at preventing errors as well as procedures to assist in fixing them;
(iv) *relevance* of content, such that the interface does not distract or mislead users;
(v) *flexibility,* such that the interface allows for alternatives and shortcuts in performing tasks;
(vi) v*isibility* of the current status, such that the interface provides feedback about what is going on and the ongoing stage in the task at hand.

Interfaces that fare well on the above-listed features are believed to engender an experience of "cognitive ease" in users, that is, an overall perception that things naturally function without effort or mishaps. Notably, the experience of cognitive ease has proven relevant beyond measurements of user satisfaction in relation to specific tasks. Stimulus conditions that are processed more fluently, quickly, and with fewer errors have been related both to aesthetic preference (e.g., Winkielman et al., 2015) and to preferences in decision making in a variety of domains (e.g., Kahneman, 2011; Jacomuzzi, 2022). As such, therefore, cognitive ease also plays a role in psychological wellbeing in general. The usability of the interface is of course not the sole determinant of ease of use in a human-computer interactions. Other obvious factors are related to hardware specifics, such as processor speed and available memory, the quality of internet connections, as well as contextual factors such as seating arrangement, lighting, environmental noises. Usability, however, identifies what features of the interaction are fundamentally constrained by human cognitive abilities, and most specifically by perception, attention, memory, and reasoning.

## Interpersonal communication

The study of factors that make interpersonal communication possible is central in semiotic studies and remains at the center of interdisciplinary debate in several disciplines such as philosophy,

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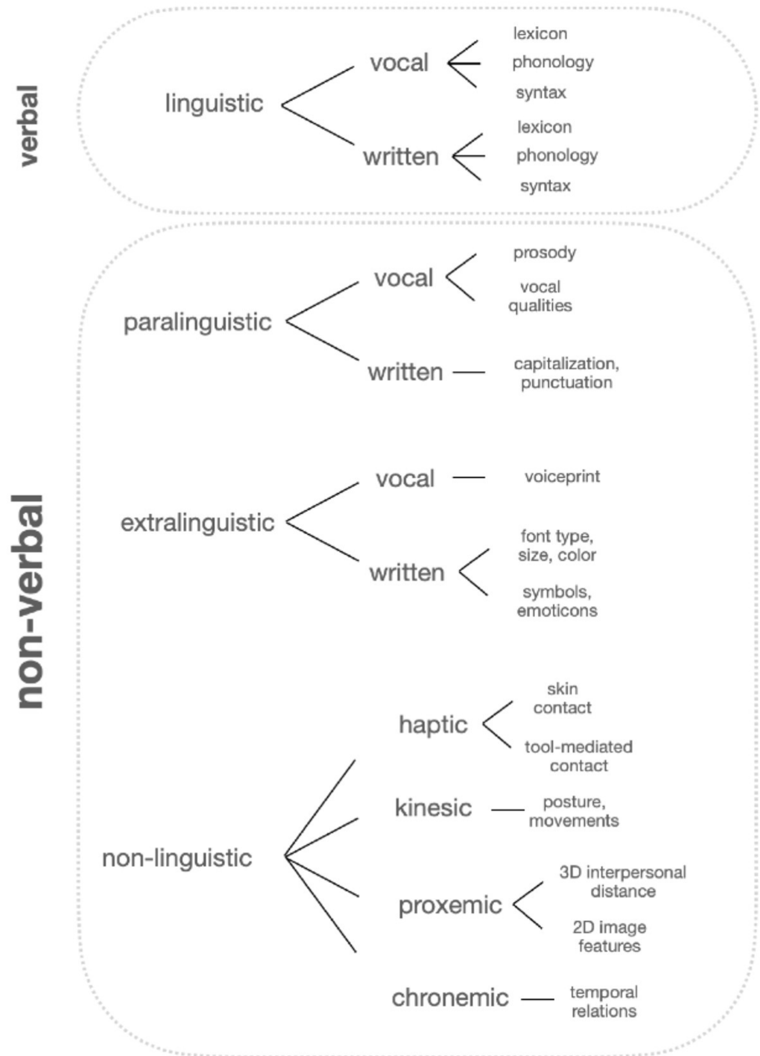


FIGURE 1
A proposed taxonomy of means of communication in presence as well as within digital media.

anthropology, psychology, mathematics, sociology, and cognitive neuroscience. In semiotics, a process of communication is defined as the transmission of some content from a sender to a receiver, by means of a medium in an environment (see e.g., Allwood et al., 2002). Within this scheme, a sender has three fundamental ways of linking communicated content to a referent: by symbolic, iconic, or indexical information (Peirce, 1902; Nöth, 1990). Symbolic information is information which is related to a referent by social conventions. For instance, in face-to-face interpersonal communication our words function as symbols for their referents. Similarly, when exchanging text messages written words symbolically relate to referents. Iconic information, conversely, is information that relates to a referent due to a similarity in structure. In face-to-face interpersonal communication our hand gestures may iconically depict the referent of our words. Similarly, graphical elements such as folders, thumbnail pictures of files, buttons, or sliders iconically depict referent objects within the interface. Indexical information, finally, is information that links to a referent by a causal relation. Indeed, in face-to-face interpersonal communication our voice quality, our pose, or our facial expressions may convey information about our attitude and feelings with regard to the communicated content. Similarly, gestures such as pointing or gazing may convey information about the specific referent of a message.

The above modes of linking contents to referents are related to the general distinction between verbal and non-verbal communication. Although overviews of this distinction have been proposed (e.g., Nöth, 1995; Andersen, 1999), we note that taxonomies predating the advent of digitally media now fall short of providing a complete picture. A novel attempt is presented in Figure 1 (Please note that, to avoid undue complication, we assume that language is conveyed in writing or orally, and therefore do not consider communication via sign language). In our proposal, verbal communication consists of linguistic forms of expressions, that is, of symbolic forms that involve a lexicon, phonological and grammatically rules, and syntax. Non-verbal communication, conversely, includes all forms of expression that are not related to language (Luria, 1999). These come in several kinds, and many have acquired higher prominence in digitally mediated communication. Specifically, drawing from Anderson et al. (2001), Anolli (2002), and Hall et al. (2019) here we distinguish between three main categories of non-verbal communication: the paralinguistic, the extra-linguistic, and the non-linguistic. Although they do not properly involve speech, the first two remain related to language production and for this reason they can be used both in vocal and in written form, in the latter conveying information that tends to be more iconic than symbolic. Specifically, vocal paralinguistic communication involves prosody and vocal qualities such as loudness and articulation. Similarly, vocal extra-linguistic communication involves vocal features such as one's voiceprint, the set of anatomical and motor features that make the individual voiceprint of an individual, making it recognizable to others. When communicating within digital media, written forms are for instance instantiated by the use of capitalization to suggest rising one's voice (paralinguistic), of ellipses to suggest hesitation (paralinguistic), of symbols or emoticons to inform about one's mind state (extralinguistic).

The third non-verbal category is instead unrelated to language, and therefore involves information that is conveyed either iconically or indexically through channels that do not take a written form. Non-linguistic forms of expressions consists of gestures, of body movements, and of the management of spatial and temporal relations. These have been termed kinesics, haptics, proxemics, and chronemics. These forms of expression are believed to have roots in territorial behaviors by non-human animals (Hediger, 1955; von Uexküll, 1957) and have been codified in detail by Hall (1966) who specifically focussed on how we use space, time, and movement to invite intimacy or maintain distance, define the nature of social relationships, and suggest intentions. In particular, space-related behaviors have been investigated extensively (Aiello, 1987; Moore et al., 2010). For instance, it is known from classic (Middlemist et al., 1976) as well as more recent work (Kennedy, 2010; Caruana et al., 2011) that manipulations of interpersonal distances produce measurable psychophysiological responses recruiting specific brain structures. It is generally accepted that non-verbal communication complements the verbal components, generating a coherent series of signs which contribute to the processing and decoding of a message (Anolli, 2012). Finally, it is important to stress that individuals may communicate non-verbally by actions that initiate voluntarily and under conscious control (non-verbal communication proper, or "communicative" acts), or by unintentionally and unconsciously giving off signals that may be perceived and interpreted by others (Ekman and Friesen, 1969; Wiener et al., 1972; non verbal behavior or "informative" acts).

Thus, communicating messages from senders to receivers typically include both verbal and non-verbal components. Both imply that a shared code is used to generate the message, on the sending side, and to understand it on the receiving one. Such a shared code implies learned rules and semantic information, which are stored in long-term memory systems of the communicating dyad. However, important information that is potentially used for encoding and decoding a message is also provided by the context of the communication act, which does not occur in a vacuum but within environments that provide perceptual stimulation and opportunities for action. In pragmatics, this notion has been described in terms of the relationship between text and context (Morris, 1938; Austin, 1962), and the distinction between communication (the contents that are exchanged) and meta-communication (Watzlawick et al., 1967; Bateson, 1973; contextual information about the exchanged content). A key aspect of the environmental context of communication is that the environment does not merely offer perceptual stimulation to the sender and the receiver, but it typically offers it to both. Said otherwise, in typical communicative contexts there may be opportunities not only for *individual* perceptual experiences, but also for *shared* perceptual experiences. These opportunities enrich the communicative context in a crucial way, as they transform it from a two-way to a three-way system, involving not only the dyadic exchange between sender and receiver, but establishing a triangular set of relations between sender, receiver, and environment.

## Shareability

We define shareability as a quality attribute of human-media interfaces in systems that support interpersonal communication. Specifically, we porpose that shareability can be defined as the attribute that captures to what extent the interface allows, encourages, and supports sharing experiences by users.

Shareability is related, but distinct, from the notion of sharing behaviors as investigated in sociology, anthropology, and consumer behavior. Features of sharing behaviors set them apart from shareability proper as they remain rooted in conventions of gift giving, hosting, and collective rituals (Gregory, 1982; Mauss, 1990), which predate the advent of digitally-mediated communication. Sharing behaviors remain nonetheless directly linked to shared experience, and thereby indirectly to shareability, as social behaviors that involve sharing of goods, resources, or foodstuffs within social groups are likely to foster their collective consumption or use, and thereby their shared experience. It has been suggested that this form of sharing serves the function of overcoming personal boundaries and effectively expanding individual selves into collective entities such as a family, a circle of friends, or a team of co-workers (i.e., the "aggregate extended self", Belk, 2010).

We also warn readers that our proposal differs from the current usage of the term. In contemporary dictionary entries, shareability is defined as the "quality of being shareable" or "the likelihood of being shared", typically in reference to social media, websites, or other digital applications. Such usage is epitomized by sentences like: "images work better than text in terms of shareability". Used in this way, shareability is the property of a specific content item to be shared. In our proposal, instead, we suggest that the notion of shareability should be extended to global analyses of user interfaces within media that include opportunities for communication.

In what follows, we refine our notion of shareability. Specifically, we propose that shareability in a human-machine interface be assessed as the resultant of contributions from three properties of a user interface: sharing-related usability

(SRU), sharing-related affordances (SRA), and support to shared experience (SSE). The rationale for this tripartite distinction is based on the following reasoning. First, to support an adequate level of shareability, interface features supporting sharing-related behaviors must be easy to use. Said otherwise, the interface must score high in usabiity in relation to these specific features (SRU), which include a wide range of hardware and software features of digital devices. Second, the usability of sharing-related features depends critically on the interface affordances in relation to sharing behaviors (SRA). Said otherwise, Interfaces scoring high on shareabiity should encourage users to share content, that is, they should include sharing *nudges* (Thaler and Sunstein, 2008; Legrenzi and Jacomuzzi, 2021) in their design. Third, if content is to be shared through the interface, a key aspect is the extent to which this content can be genuinely experienced jointly during the interaction, rather than merely communicated to the interacting partners for independent examination. Said otherwise, a key aspect of a shareable interface is the extent to which it supports natural and genuine shared exeriences (SSE). As we conceive of SRU, SRA, and SSE as properties of the interface, and not of the device used to access it, we describe them in general terms that may be applied to any supporting device, be it a smart phone, tablet, computer, or other. However, given that different devices offer different possibilities for input/output (depending on screen size, screen type, keyboard type, support to vocal commands, front or back cameras, and so on), however, we also discuss the relevance of hardware-level constraints on each of these properties.

Table 1 provides a synopsis of concepts that are relevant to define SRU, SRA, and SSE. When appropriately validated, we suggest that items assessing adherence to guidelines along these lines might become a standard component of QoE ("quality of experience") questionnaires and related tools for interface evaluation (Patrick et al., 2012). Table 1 includes the overall focus of each property, as well as main constraints on the hardware and software level. We offer also a tentative assessment of the relevance of each property for the overall shareability of an interface. Specifically, we suggest that SRU is important, but not critical to achieve a satisfactory level of shareability. This is the case because features potentially supporting SRU, such as a fast internet connection or an efficient operating system, would remain essentially useless to promote shareability if the interface is not designed appropriately to support SRA and SSE. Conversely, interfaces scoring low on SRU may still be relatively shareable if sharing is easy and natural (SRA) and especially if the interface enables to users to perceptually access not only shared contents, but also cues about other users' access to those contents (SSE). As this is possible (although less efficient) even if the interface scores low on SRU or SRA, we propose that the SSE property is the most important of the three. More specific examples relevant to this issue are provided in the Case Studies section at the end of the paper.

## Sharing-related usability

To share contents on digital media, users will need to interact with electronic devices such as a smartphone, touchpad, or computer, and they will do so through a human-machine interface. For this reason, the shareability of the interface will be constrained by the interface's overall usability. We suggest that the overlap between the two dimensions be assessed in terms of sharing-related usability. The SRU dimension of shareability will thus capture to what extent the interface includes features for sharing content, as well as features that make such sharing is easy, efficient, and timely. In general, all six main criteria for usability assessments (see previous section on Usabiiiy) wil apply here: consistency and ease of learning of conventions and commands related to sharing materials; user control of the corresponding processes; management of errors in these processes; relevance of context to avoid misleading users in sharing operations; flexibility in performing relevant tasks; and visibility of the status of ongoing relevant operations. For instance, graphic elements that control operations such as sharing one's screen with other users, or sending specific materials to some or all, should be easy to locate on the interface. The effect of activating the related processes should be apparent, feedback should be provided concerning the unfolding of the activated operations, and users should have control over how these operations take place. Menus and pop-up windows related to these operations should be evaluated for visibility and possibly coordinated auditory feedback to best achieve these goals. Hardware requirements to support these features should also be evaluated. For instance, the resolution of the output screen, the quality of additional components for input and output such as webcams, microphones, touchpads, mices, and joysticks, the connection speed as well as the processor speed of the device will all affect the usability of sharing-related components of the interface.

## Sharing-related affordances

To be shareable, human-machine interfaces should include features that are designed to intuitively invite users to share materials. This implies that all elements that control sharing operations should not only be easy to locate and visible, but that they should also be designed to encourage users to use them. For instance, a button controlling screen sharing during an online meeting should be placed in a prominent position on the interface and should be designed to naturally suggest the appropriate action. In addition, the design of the interaction should match a natural sharing operation between users. For instance, screen sharing with another user could be controlled by dragging an icon representing one's screen onto a thumbnail representing the other user rather than pressing a generic button labeled with verbal information. At the hardware level, key constraints on design options relating to the SRA dimension of shareability are set by the characteristics of available output devices. For instance, haptic or auditory feedback, or both, when users move a cursor across the screen could draw attention to potential actions represented at some location by appropriate graphic elements, or suggest action alternatives.

To the above aims, designing for shareability should take stock on research in psychology and cognitive neuroscience on the perception of affordances. Coined by Gibson (1979), the notion of affordance refers to the perception of possibilities for action, such as, for instance, the perception that a staircase can be climbed on foot (Warren, 1984). In Gibson's words,

10.3389/fcomp.2023.1106322

TABLE 1 Properties that affect shareability in a human-machine interface.

| | Overall focus | Hardware-level | Software-level | Relevance |
|---|---|---|---|---|
| Sharing-related usabillity | Does the interface allow content sharing? Is sharing easy, efficient, and timely? | Bandwidth, operating system, screen | Interface design as related to sharing materials and to user awareness of shared contents | Moderately important |
| Sharing-related affordances | Does the inferface naturally encourage users to share content? | Output devices, such as screen or loudspeaker | Design and management of sharing operations on interface | Important |
| Support to shared experience | Does the interface support genuine shared experiences between users? | Input/output devices, such as a touchmonitor or webcam | Interface features supporting awareness of what other users are doing or attending to | Very important |

"affordances are what the environment offers to organisms, for ill or for good" (Gibson, 1979). Thus, affordances refer to ways that organisms may perceptually understand functions and meanings. In contrast to traditional conceptions of recognition, however, such perceptual understanding is not mediated by learned knowledge stored in memory, but emerges spontaneously from the mutuality of perceiving organisms and their environment. For instance, it has been documented that perceptual judgments of staircase climbability is almost perfectly predicted by a biomechanic model parametrizing the judge's leg length and body-related energy expenditure (Warren, 1984). Thus, rather than being an intrinsic property of the stairs or a mental representation in the perceiver brain, climbability is and emergent property of the organism-environment system. It emerges from the relationship of the observer's action capabilities, on one side, and the three-dimensional structure of the object as specified in the structure of ambient light to the viewpoint, on the other. It can thus be argued (see, for instance, Pickering, 2007) that the affordance notion is fundamental in biosemiotics, the idea that signification is ubiquitous in biological and physical systems and that this offers a radically novel systems approach to understand meaning.

Not surprisingly, affordances have now a prominent theoretical role in contemporary neuroscience (de Wit et al., 2017). Most relevant to the aims of the present paper, however, are adaptations of the affordance concept to design (Norman, 1988) and especially to HCI engineering (e.g., Kaptelinin, 2014). The relevance for usability in these domains is obvious. In the words of Donald Norman: "Affordances provide strong clues to the operations of things. Plates are for pushing. Knobs are for turning. Slots are for inserting things into. Balls are for throwing or bouncing. When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction needed" (Norman, 1988). In these contexts, the notion was thus extended to include not only actual things and operations, but also their iconic representations in human-machine interfaces. By directly suggesting appropriate action possibilities, affordance-driven interface design will score high on ease of learning, control of operations, and error prevention.

## Support to shared experience

There are empirical and theoretical grounds to conclude that sharing experiences modulates cognitive processes in profound ways and that this may be a key element of successful communication. For instance, Boothby et al. (2014) compared sensations evoked by pleasant (sweet chocolate) and unpleasant (bitter chocolate) stimuli in the presence of a confederate that either shared the experience (i.e., received a piece of the same chocolate for tasting) or not (i.e., engaged in evaluating art reproductions in a book). They found that sweet chocolate was liked more, and bitter chocolate disliked more, in the shared condition relative to the unshared. In addition, they observed that shared experience was associated with greater "absorption" in the situation and enhanced reports of being "on the same wavelength" with the other individual. Similar amplification effects have been reported in several other studies. Boothby et al. (2016, 2017) replicated the amplification effect of shared experience, generalized it to visual experiences, and provided evidence of moderation by both social (confederates that were strangers vs. acquaintances of participants) and spatial (confederates in the same vs. different room) distance. Wagner et al. (2015) reported a similar amplification effect for both positive and negative emotions during shared as opposed to unshared experience, and Shteynberg et al. (2014) reported emotion amplification in "group attention" attention conditions that involved shared experience. Taken together, these results provide evidence that shared experiences are amplified and that this effect is related both to enhanced attentional focus ("absorption") on the shared stimulus, and to enhanced attention to the mental content of the other individual sharing the experience ("mentalizing").

At first blush, parallel processes directing attention to contrasting targets, i.e. to objects, on one side, and to other minds, on the other, may be predicted to compete for cognitive resources (Boothby et al., 2014). One may thus predict that simultaneously engaging absorption and mentalizing mechanisms may hamper cognitive easy rather than promote it. However, it is equally reasonable to assume that, rather than competing for attentional resources, absorption and mentalizing may converge to make processing more fluid and effortless. During a shared experience, sources of information are available not only about the experienced object, but also about the co-experiencer. Thus, the mental content of the other individual to some degree also becomes part of one's experience, while at the same time focus on the object of the experience provides a natural link to one's mind to the other mind in the triadic relation. The theoretical implications of such a systemic framework for the analysis of shared experiences have been developed in a classic paper by Bozzi and Martinuzzi (1989) who addressed the issue of the accuracy and precision of perceptual reports in shared, as opposed to unshared experience conditions;

in theoretical treatments of the origins of human cognition and communication (e.g., Tomasello, 2008); in studies of coordinated action (e.g., D'Ausilio et al., 2012; Sinigaglia and Butterfill, 2021) and in analyses of the construction of common representations of physical and social environments. This final idea is epitomized by the notion of "shared reality" in the work of Echterhoff et al. (2009), and in the distinction between sharing-out (the mere sharing of goods) and sharing-in (sharing as a means of constructing an aggregate extended self) as detailed in the seminal work of Belk (2010).

Implications of shared experience for interpersonal communications are further supported by data suggesting that shared experience facilitates social learning (Shteynberg and Apfelbaum, 2013). In contexts whereby individuals learn with others, sharing experiences during the learning process favors the construction of common representations, evaluations, and beliefs. It has been argued that establishing these common knowledge bases facilitates comprehension, remembering, and problem-solving (Shteynberg and Apfelbaum, 2013). The relevance of these findings for interpersonal communication within digital media has accordingly gained momentum within the social networking and social computing communities. For instance, Cesar et al. (2014) have argued that to move beyond the current "talking heads" paradigm and enable truly natural and immersive shared experiences, video-mediated communication systems must be able to understand both the context of the shared activity as well as the social layer of the interaction. In such environments, the system's ability to adaptively support opportunities for shared experience may be critical to achieving a satisfactory communication.

Thus, empirical findings from psychology and cognitive neuroscience suggest that shareable interfaces should enable genuinely shared experiences of shared contents. This requires a virtual environment that will allow users to actually perceive, rather than merely suppose or infer, that other users are also experiencing the same materials. We suggest that such interfaces should be designed to provide perceptual information about both shared materials and the behavior of other users that are experiencing these materials through the medium at hand. Thus, evaluations of the SSE dimension of shareability should focus on the availability and reliability of such information. In terms of hardware, this might be related to input and output devices that could be exploited to this aim. For instance, webcams or motion capture cameras could be exploited to capture facial expressions, body movements, and gaze of users. This data could be used to provide symbolic or iconic information to other users about the direction of attention by fellow participants while content is being shared.

## Conclusion: case studies

To conclude the present perspective paper, we show how the notions set forth here may be applied to interfaces for three forms of digitally mediated interpersonal communication: online gaming, visual communication on social media, and online distance teaching. We suggest that evaluations of the shareability of the relevant interfaces (respectively, gaming virtual worlds, social media, and virtual classroom platforms) fares well in explaining why the first two have enjoyed a considerable degree of success worldwide, while the third has been the object of widespread dissatisfaction and criticism.

### Online gaming

Online gaming is designed to provide genuinely social interactions (Ducheneaut et al., 2006). For instance, in the Massively Multiplayer Online Game (MMOG), millions of players can participate simultaneously within the same virtual world (Barnett and Coulson, 2010). Players immerse in this world as avatars, sporting physical and behavioral characteristics that can be customized (Plass et al., 2015), within spaces constructed to virtually reproduce aspects of real-life socialization (Kolo and Timo, 2004). This space continues to exist beyond individual players' online presence, as the community of players continues to move the game forward, to the point that when reconnecting an individual player may find the game reality dramatically changed. In addition, this space is given a "vertical" structure, such that players can always encounter new parts of the virtual world and continue with new challenges (Ducheneaut et al., 2006). The virtual world of the game therefore captures both the temporal unfolding and the continuous availability of new opportunities for perceptual experience in real life.

As a form of digitally mediated interpersonal communication, online gaming is unique in that players interact with virtual representations of some aspects of reality, but also experience how other players interact with such representations in the form of their avatars (Gandolfi et al., 2021). For instance, to achieve certain goals or perform certain actions, avatars with different specializations may need to interact, as when the doctor provides a cure, or a craftsman builds a weapon. Such interactions are made possible by commands to enact social gestures (Kolo and Timo, 2004), both verbally and non-verbally. For instance, verbal communication is enabled in three alternative modalities: the "say" mode, that is, writing in a chat visible to all nearby players who are close; the "tell" mode, privately chatting with a specific player regardless of his or her location; and the "group" mode, chat message aimed at a specific group, defined on the basis of previous interactions and aimed at the pursuit of the same goal (Barnett and Coulson, 2010). At the same time, non-verbal communication is possible both by extra- or para-linguistic aspects of written texts, but also by proxemic and chronemic manipulations of spatial and temporal relations between avatars and objects within the virtual space, as well as by kinesic informations from the movement, posture, and expressions of the avatars. For instance, players can have their avatars smile and direct that social gesture toward a specific player. In this way, players experience not only the unfolding of a game narrative, but they have a strong feeling of being part of this narrative along with co-players (Plass et al., 2015).

These features of online gaming naturally lead to contexts that are rich in sharing-related affordances and that enable shared experiences between gamers.

Thus, online gaming platform are geared for shareability, and they are so by design. Affordances of virtual objects mimic those of real-world counterparts, naturally leading to rich sharing-related affordances. Verbal and most notably non-verbal communication is possible online while participants experience the same virtual worlds on their respective screen, strongly supporting the possibility of shared experiences. Overall shareability within gaming applications is therefore generally high, with the the quality of the online connection remaining the main limiting factor. Online gaming makes the player feel part of a community, establishing social networks where the creation of friendships is common (Ducheneaut and Moore, 2004). Not surprisingly, by all estimates the popularity of online gaming continues to grow at an impressive rate, generating revenues exceeding 200 billion US dollars in the last year (Global Games Market Report, 2022).

## Visual communication on social media

Starting with the new millennium, the practice of sharing snippets of one's life on social media has become increasingly widespread. Well-established trends include the sharing of digital self-portraits ("selfies"), often in the context of places one is visiting or activities one may be currently engaged in; of meals or drinks ("food porn") one has proudly prepared or is enjoying in a restaurant; and even of images of sexual nature ("sexting"), between couples or when flirting with occasional sexual partners. There is little doubt that these forms of visual communication are now largely accepted and practiced by an ever increasing number of individuals. For instance, searching for the hashtag "selfie" on the social media application Instagram currently returns more than 450 million entries, whereas a Google search for the same keyword yields almost one and a half billion hits. According to some estimates, about 62,000 photos are posted worldwide that could be classified as food porn (Mejova et al., 2016). Food porn images have been argued to determine visceral and cerebral attraction in viewers (Mallari and Kerner, 2017). According to some studies, the quality of such images could even be considered a factor in increasing obesity (Kenny, 2011). Due to its nature, the prevalence of sexting in the general population is harder to estimate, but there is evidence that it has been increasing over the last decade (Van Ouytsel et al., 2015), in conjunction with claims that couples in several countries increasingly report negative assessments of their sex life (Gewirtz-Meydan et al., 2018). Sexting has also been associated with attempts to compensate for missed opportunities to meet in person during the pandemic (Gleason et al., 2021). Taken together, social phenomena such as these have contributed to a worldwide increase in online sharing of images on social media and chat applications.

Given the nature of this form of social interaction, its manifest success seems to pose a problem for our analysis. Selfies, food porn, and often even sexting images are shared with other individuals who are both physically and virtually elsewhere, and that are most likely to experience them at times that are not those when the images were created (and therefore experienced by posters). In addition, sharing of images within digital media may be directed to specific individuals, but is often also directed to a somewhat less specific community of potential viewers (as in the case of a "friends" or "followers" circle), or even to an undefined universe of users (as in the case of fully public posts). Yet, these behaviors have often been related to the need to connect with others in a community (Klein et al., 2016) and to achieve endorsement by members (Diefenbach and Christoforakos, 2017). An analysis of social media applications such as WhatsApp, Telegram, or Facebook may provide clues to resolve the apparent problem.

The interfaces of social media platforms has evolved to include simple and quick options to capture and immediately post images. In addition, these options are well supported by hardware components that are now widely available, such as front- and back- cameras on smartphones, and by worldwide connectivity. Such an evolution of social media imples that operations that support sharing in media applications are generally fast and easy to master (SRU). In addition, the relevant controls feature prominently in the interface and encourage users to do the sharing (SRA). Most important for the current analysis, it can be argued that these media fare quite well in supporting shared experiences (SSE), albeit of a novel and somewhat peculiar nature. Once an image has been shared on one of these platforms, posters have opportunities to garner information about reactions by potential viewers in the form of likes, text comments, and often also response images. Even though these may occur at a later time with respect to the posting, they do establish a triadic relationship between the shared image, the poster, and the viewer. It has been argued that this form of communication represents a novel aspect of our cultural evolution, innovating both on our use of proxemic and chronemic aspects of non-verbal interpersonal communication. The proxemic component of such communication manifests itself when the image is created, in the form of compositional choices that modulate the use of pictorial space within the image. It has been reported that such choices result in stable, and measurable, trends in the composition of selfies (e.g., Bruno et al., 2015) and in general trends in the composition of images on certain platforms (e.g., the notion of "instagrammism"; see Manovich et al., 2017). The chronemic component manifests itself in temporal relations that inform about responders; for instance on their present occupations, or their engagement in the shared experience, which determine the timing of posted reactions. In relation to selfies, it has been proposed that such social behaviors may be accounted for by a duplex model of non-verbal communication, involving both a (semiotically primary) human-media interaction between a selfie-taker and a digital device, and a (semiotically secondary) human–human interaction between the taker and potential viewers (Bruno et al., 2020). This model may however be extended to all forms of image sharing on digital media, forming part of the theoretical basis for shareability assessments.

## Virtual classrooms

During the SARS-CoV-2 pandemic, universities and schools worldwide were forced to move classrooms to virtual spaces. This forced teachers to adapt to distance learning paradigms, that is "instructional methods ... [whereby] ... the teacher and the learners are separate in space and possibly time" (Teaster and Blieszner, 1999, p. 741). According to UNESCO (2020), this sudden change affected more than a billion learners, i.e. more than 70% of students in almost 200 countries. To this already astonishing number one should then add teachers, educators, tutors, as well as student family members who were asked to suddenly deal directly or indirectly with new technologies which were often wholly unfamiliar to them. Even by conservative estimates, adding this second group could easily almost double the total of individuals affected by the the new distance learning paradigm worldwide. Thus, the adoption of virtual classrooms during the pandemic lockdown periods might be justly regarded as an unprecedented worldwide natural quasi-experiment on interpersonal communication in a teaching context.

The outcomes of the experiment have however proved largely unsatisfactory. When involved in online teaching, students have often been reported to experience loneliness and anxiety, lose confidence in their own abilities, and perceive learning environments as alien (Baxter, 2012). In addition, students express discomfort for missed interactions between classmates, between teachers and students, and with technical resources which have been shown to predict both school performance and the perceived quality of learning (Del Arco et al., 2021; Siregar and Siagian, 2021). It has been often suggested that key factors in such negative experiences were mostly of technical or logistic nature. Indeed, students often did not have access to adequate devices, lacked private spaces to attend the lessons, or had access to poor internet connections, which caused teaching to take place with interruptions or interferences. In addition, teachers, students, and family members were exposed to unfamiliar, user-unfriendly platforms that took time and effort to learn. These issues would be examined, in a shareability assessment, with regard to SRU dimension. However, although these limitations undoubtedly impact on the shareability of interfaces, we doubt that they were critical and we strongly suspect that problems were reported also by students who did not lament technical or logistic issues. A much more critical factor, in our opinion, was that current online teaching interfaces do not encourage sharing of contents (SRA) and provide scarce opportunities for shared experiences (SSE).

Distance learning platforms allow for content sharing, such as, for instance, screen sharing to show slides or video. However, relevant controls are often hard to find in the interface, or require privileges that need to be enabled by whoever started the meeting, or are set such that the default state of the system is not optimal for interpersonal communication. A prototypical example is the default state of the Google Meet application (as well as most similar software) which involves seeing one's own image captured by one's device front camera, along with images of the other videoconference participants (or a subset thereof). As a consequence, one often spends a large amount of time looking at oneself (George et al., 2022), especially while speaking, instead of looking at the faces, and therefore at the reactions, of the individuals one is speaking to. It has been suggested that self viewing is one of the factors contributing to cognitive fatigue in videoconferencing (Baileson, 2021; Ngien and Hogan, 2022), that it negatively affects the quality of interpersonal online communication (Shin et al., 2022), reducing rating of meeting satisfaction (Kuhn, 2022). In addition, even if sharing does take place, for instance, by starting a slide show for the lecture, the platform does not expose students to how classmates respond to these materials, nor do they offer teachers ways of gauging how students respond. In other words, such platforms fall short of providing a shared and contextualized experience of the materials that are shared. This represents a serious limitation, as shared experiences represent a central aspect of successful learning and of the development of interpersonal, metacognitive, and coping skills (Lipman, 2003; Arbaugh et al., 2008; Garrison and Vaughan, 2008; Akyol and Garrison, 2009; Del Arco et al., 2021; Siregar and Siagian, 2021).

That shared experience and the co-construction of meanings should be predictive of academic performance as well as of student perception of the quality of learning is consistent with various well-understood psychological mechanisms. During shared experiences, students can acquire a sense of connection and involvement with others (Kehrwald, 2008; Oztok and Brett, 2011). Thus, shared experience can foster meaningful relationships with tutors and peers, developing confidence, self-efficacy, and self-esteem, as well as favoring feelings of affiliation and connection to a group, class, or institution (Goodenow, 1993; Tovar and Simon, 2010; Vaccaro et al., 2015; Milani Marin and Jacomuzzi, 2021). Such feelings have been grouped under the rubric of "sense of belonging", arguably "one of the most important needs for all students to function well in all types of learning environment" (Jackson et al., 2010; Peacock and Cowan, 2019). In the virtual online classroom, however, social presence is mediated by audio and video content in virtual space. This is unnatural on several counts: the user is included into his or her own field of vision, favoring a fixation on one's (irrelevant) image; bodies are dislocated in a digital non-space; users have no cues to infer gestural and non-verbal interpersonal communicative content.

Most seriously, little information is provided about the experiences of other participants. During a lesson, a student may see only some classmates, or only the teacher; images are often enclosed in small boxes, making it difficult to access important non-verbal information. Sharing of information related to the one's own experience is possible only through comments and reactions, and group discussion do not take place naturally (for example, conditions tend to hide who wants to speak at any given time, and to hinder the natural turn taking of a normal conversation). This impedes learning by constructive group dialogues, including peer and tutor feedback, through cognitive engagement with materials that immerse learners in realistic problem-solving tasks (Garrison, 2017), and through shared metacognition (Garrison and Akyol, 2015). Teachers, who are responsible for orchestrating the learning processes, have a hard time intercepting emotional and cognitive needs of students as they have little access to the context in which they are and to the relational dynamics of the group (Akyol and Garrison, 2009). Finally, little information is available about the direction of attention by participants. Joint attention is a triadic process, between the subjects and the observed object, and is favored by verbal and non-verbal messages. There is evidence for this ability from 9 months on Bruner (1975). The emergence of shared attention constitutes a fundamental moment in development, facilitating learning (Legerstee, 2005). In typical development, both children and their parents often use verbal and non-verbal behaviors to establish episodes of joint attention. Using non-verbal communication (gestures, fixations, and vocalizations) children are able to both direct their attention toward an object observed by the other, and to divert the attention of the other toward the object of his interest. This ability then persists throughout life and becomes one of the bases for shared experiences in social learning (Shteynberg and Apfelbaum, 2013).

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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